

Version 1.4

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NOTE: For those who purchased a kit, you may jump ahead to the section *Building Your DIY Desktop CNC Machine* for instructions on assembly of your DIY Desktop CNC Machine. Those instructions, along with the product-specific instructions delivered with your kit, will guide you through building your DIY Desktop CNC Machine.



Introduction

First of all, thank you for your purchase of MyDIYCNC plans, kit or turnkey system. This manual and plans will provide you with a comprehensive set of instructions to complete your project and enjoy being productive with your DIY Desktop CNC Machine. Whether you are building your DIY Desktop CNC Machine from scratch or from one of our kits, we hope you find the process a creative and rewarding endeavor.

When you purchase a MyDIYCNC product you are automatically provided with a customer account on our website www.MyDIYCNC.com. Be sure to check out the resources, tech support options and downloads available to you through your registered account. Your account will provide you with all of the reference materials and software detailed in this document.

If you came by this document through some other means (other than purchasing it from MyDIYCNC) we hope you enjoy it and find it of value to your project. Please consider registering it on the MyDIYCNC website for a nominal fee which will give you access to tech support and the many additional features of this manual found online.

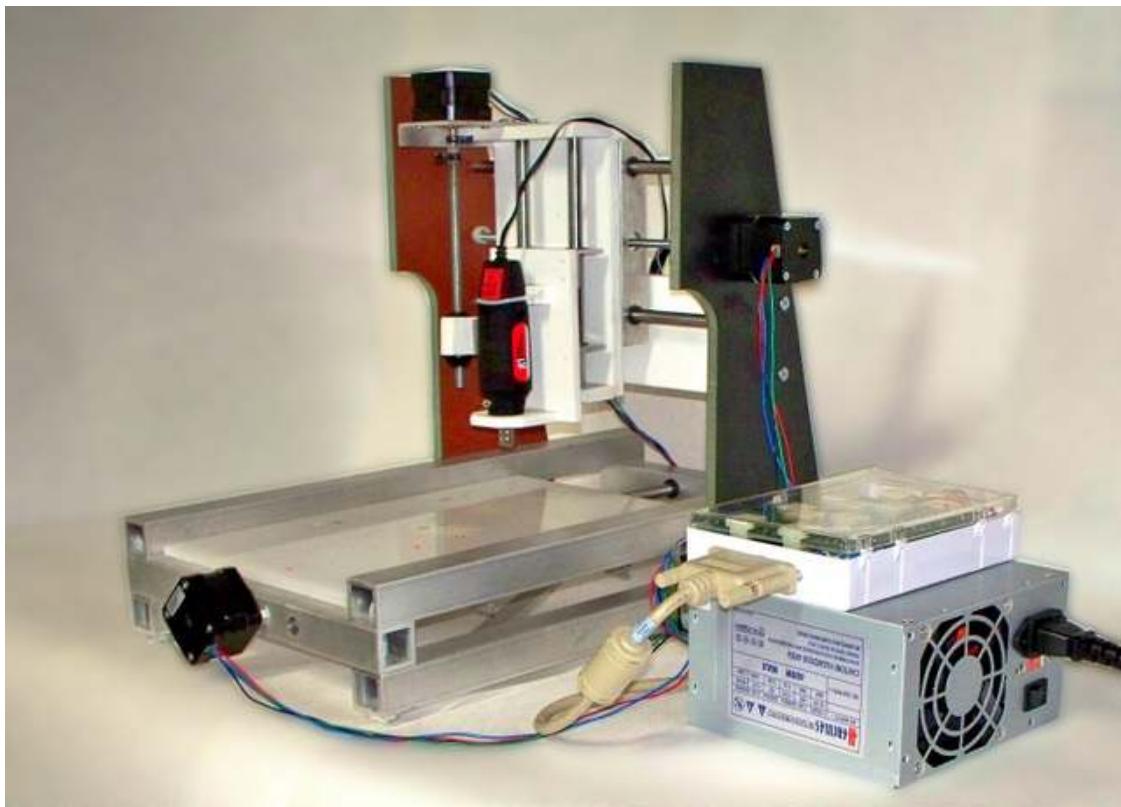
What is a CNC Machine ?

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 Desktop CNC Machine is to provide that powerful ability to go from concept design to physical product with an inexpensive, compact, adaptable desktop-size machine.



What is a DIY Desktop CNC Machine ?

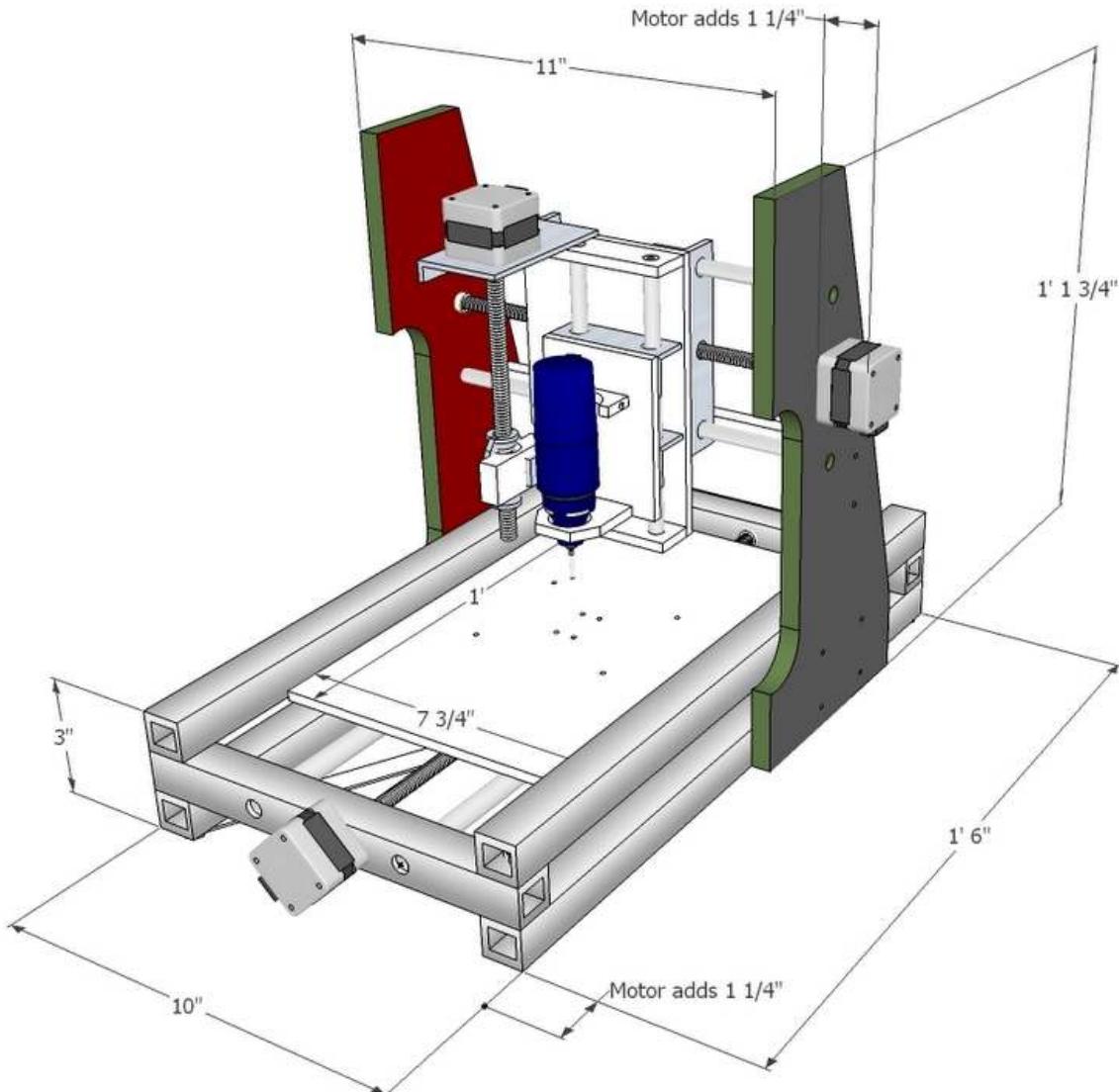
A DIY Desktop CNC Machine is a “personal” version of a CNC machine. It is controlled by your desktop computer and is designed for the hobbyist or enthusiast to create objects within a relatively compact space and at modest expense. To that end, the DIY Desktop CNC Machine is designed to provide a resolution 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.



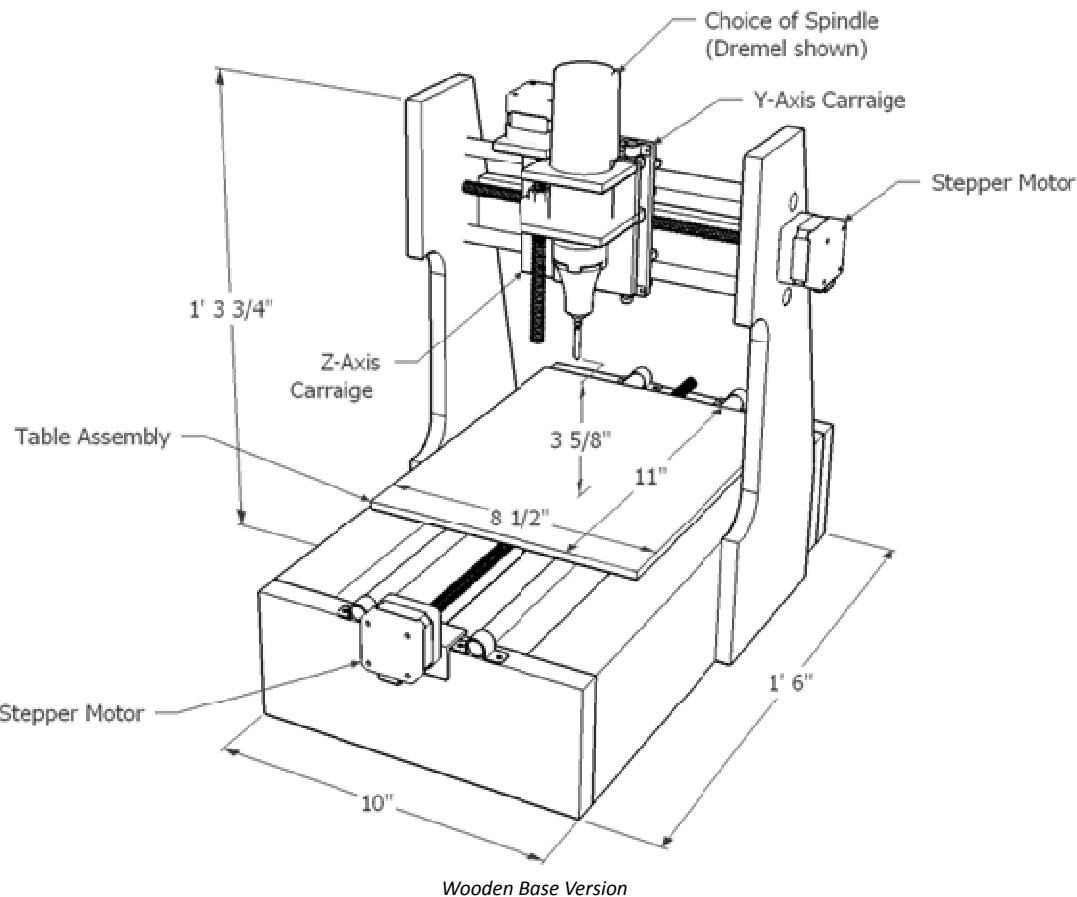
This document will walk you through the building of a DIY Desktop CNC Machine from scratch. If you purchased one of our kits, this manual will guide you through the assembly process and assist you in building whatever aspect your kit needs to be a complete system. If you purchased a complete turnkey system, you will find a comprehensive operator's manual further on in this document.

Specifications

Overall Dimensions



Metal Base Version



Working Area Dimensions (metal base version)

Table Dimensions	7 ¾" [197 mm] x 12" [305 mm]
Table Travel	9 ½" [241 mm] Modifiable to max 15" [381 mm]
Working Height Clearance	3" [76 mm]
Max Spindle Height	5" [127 mm]
Y axis travel	6" [152 mm]
Z axis travel	4" [102 mm]

Precision

One thousandth of an inch: 0.001" [0.0254mm] per full step, each axis.

Speed

Will vary with application

Max tested travel speed 16 IPM (inches per minute)

Power Requirements

Power Supply Requirements	220 VAC or 110 VAC, switch-selectable
As provided to the DIY Desktop CNC Machine by Power Supply	12 VDC, up to 4 AMPS 5 VDC, 500 mA
As provided to the MyDIYCNC Spindle by Power Supply	12 VDC No load: 700 mA Start Up: 600 mA Load: 1.2 A

MyDIYCNC Standard Spindle Specifications

Spindle Speed	16,000 RPM
Tool Holder	Collet with spindle lock for easy changes
End Mill Sizes (collets provided)	1mm 3mm 3/32" 1/8"
Included Power Supply	120V AC/DC adapter with 55" [1.4m] cord, barrel jack connection to spindle (for use if optional MyDIYCNC Spindle Control Module not used)
Dimensions:	4 13/16" L x 1 3/8" dia.

Possibilities

The possible uses of the DIY Desktop CNC Machine are limited only by your imagination. Further on in this manual you will read how to expand the DIY Desktop CNC Machine 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 Desktop CNC Machine was designed from the outset to be versatile, expandable and generally hackable by the user. The www.MyDIYCNC.com website's photo and video gallery provides many examples of the type of applications that the DIY Desktop CNC Machine can be put to.

Limitations

The current design of the DIY Desktop CNC Machine 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 3" tall, by 7.5" wide, by 8.5" 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 Desktop CNC Machine chassis dimensions.

The design brief of the DIY Desktop CNC Machine had a target precision resolution of one thousandth of an inch (0.001") to be delivered at low cost. To achieve this, the MyDIYCNC 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 Desktop CNC Machine 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.

Build Tools Required

To build your DIY Desktop CNC Machine you will need the following tools:



Chassis Build

- Philips screwdriver, large and small (for Metric M3 machine screws)
- 7/16" combination wrench (spanner)
- 7/16" wrench or socket
- Digital calipers to min .01" accuracy
- Accurate machinist's or carpenter's square
- Metal Saw (hacksaw, chop saw or metal band saw)
- Metal file
- C-clamps and bar clamps
- Duct tape
- Countersink tool
- Electric Drill (Drill press recommended)
- Complete set of drill bits (1/8" [3.18 mm] to 1" [25.4 mm])



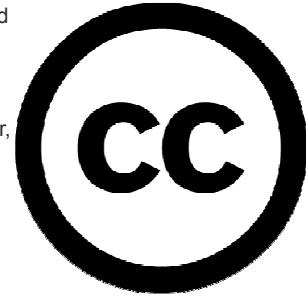
Electronics Build

- Soldering Iron
- Rosin-core solder
- Wire stripper
- Small side cutters (snips)
- Needle-nose pliers

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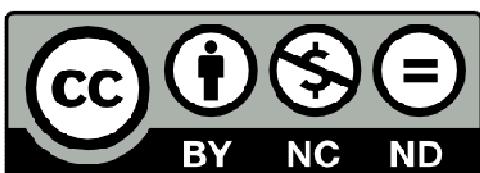


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Plans

Note: When you purchase the DIY Desktop CNC Machine Plans and Manual you automatically receive a privileged access account to the MyDIYCNC website. Through your account you will find additional sections and appendices related to this document and referenced throughout the manual and plans. These sections are kept on the website so that you can easily access them from anywhere, and they can be updated as new versions come out, instantly and seamlessly.

Make sure you have a current registered user login account at www.MyDIYCNC.com to access these sections.

User login

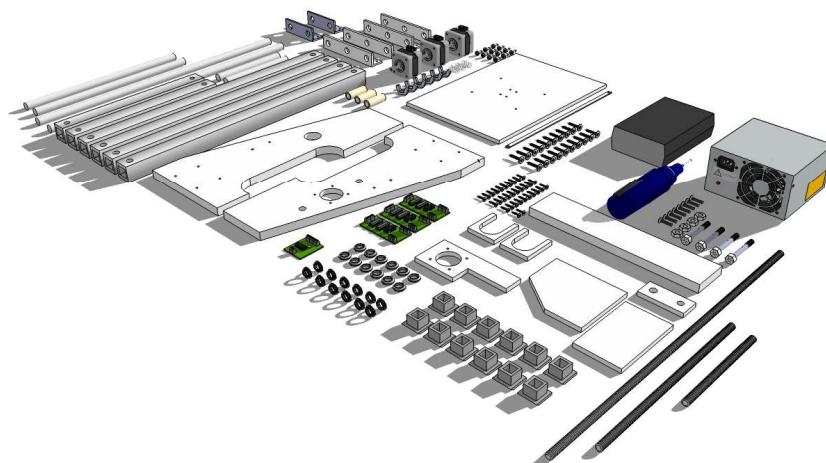
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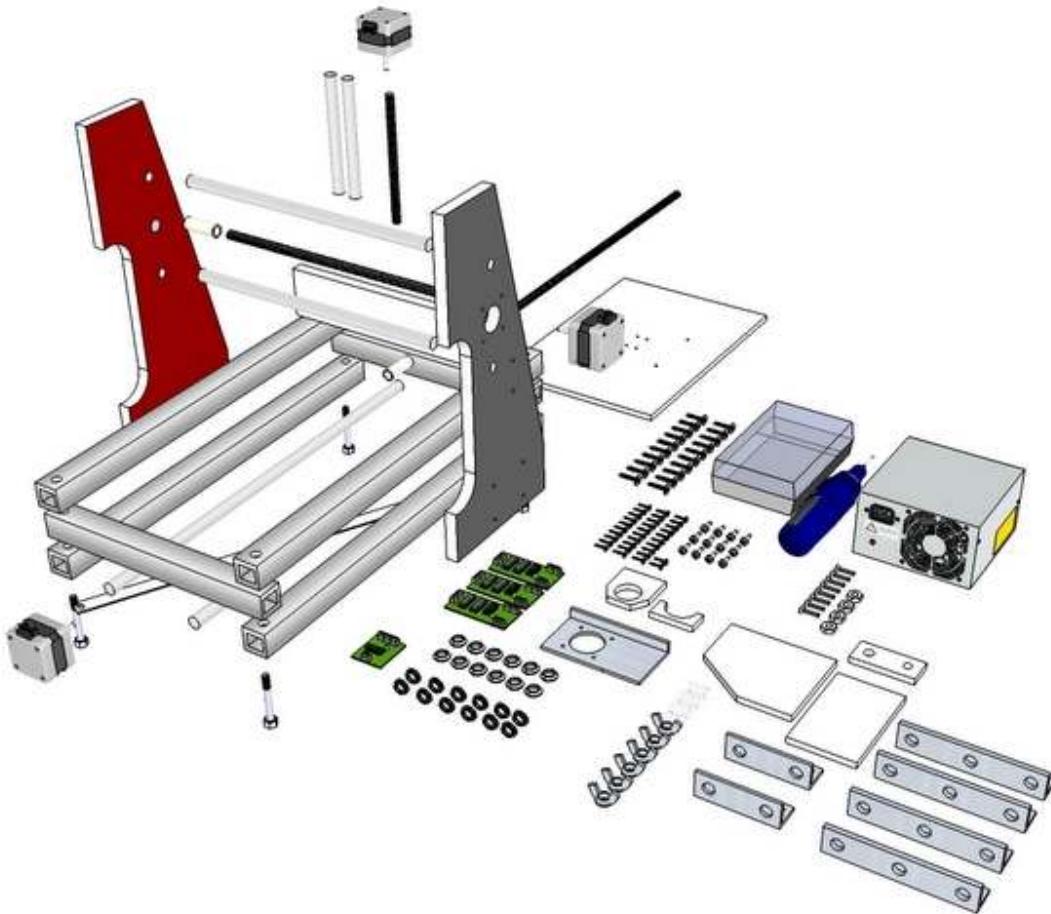
Log in

Log in using OpenID
Create new account
Request new password

Exploded Views



Complete Kit Components



Exploded view of a complete DIY Desktop CNC Machine

Chassis Frame

These plans include drawings and instructions for constructing a DIY Desktop CNC Machine 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 Desktop CNC Machine 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.

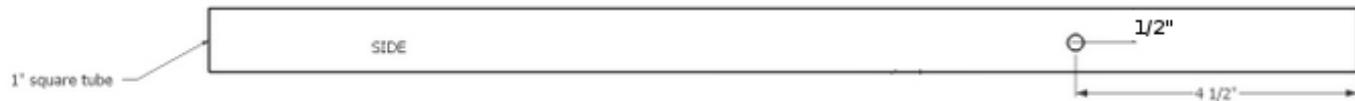
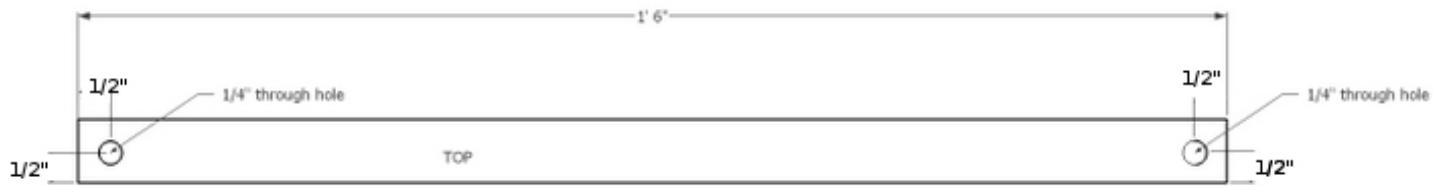
Use a good metal drill bit for drilling the required holes, preferably one with a pilot point. The chassis rails can be clamped (or in the absence of a clamp, tightly bound together with tape) to drill through pairs simultaneously.

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.



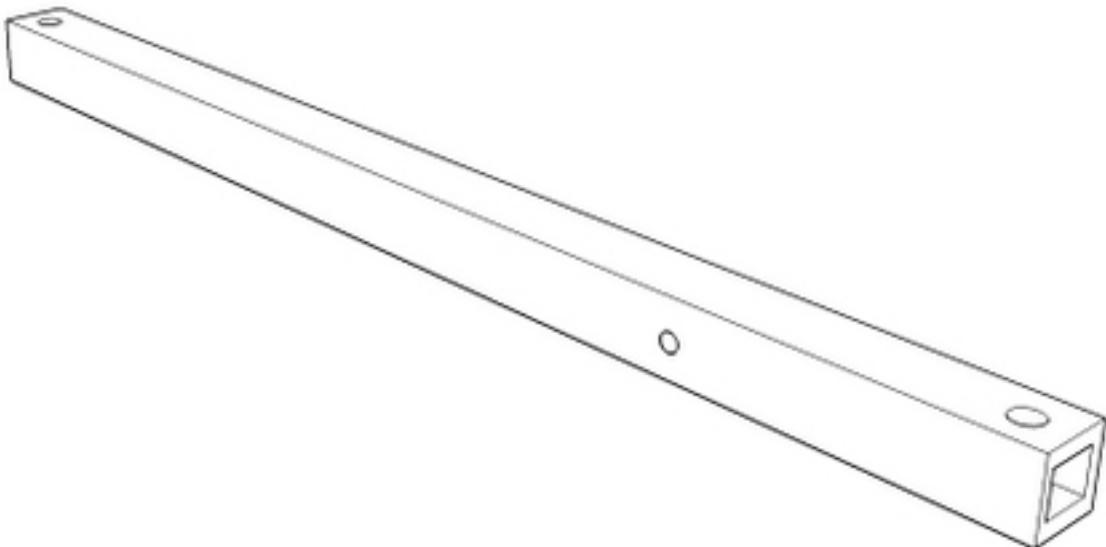
TIP: A drill press is particularly useful for this process to ensure that the holes are perpendicular to the rails and are perfectly aligned. If using a hand drill, take great care to drill at right angles to the rails.



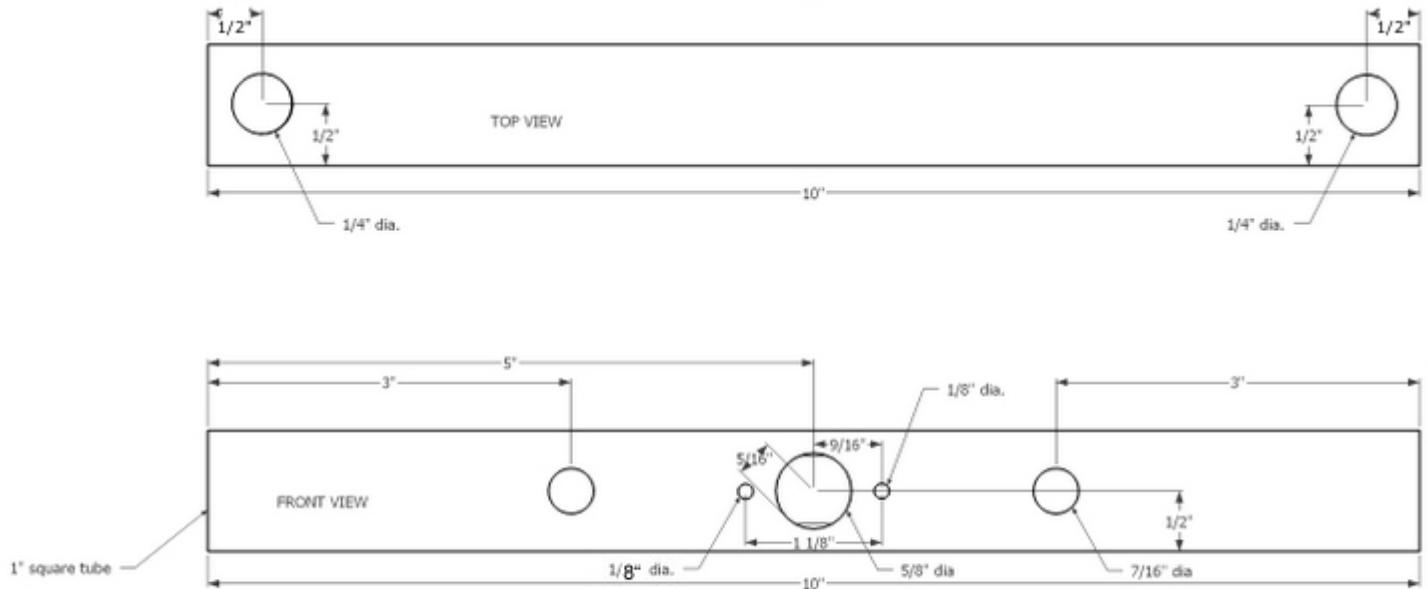


Chassis Side Rails (4 off)

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

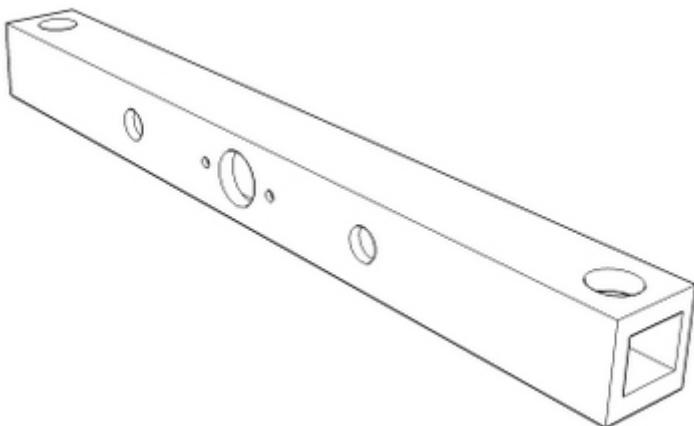


Chassis Side Rail, perspective view

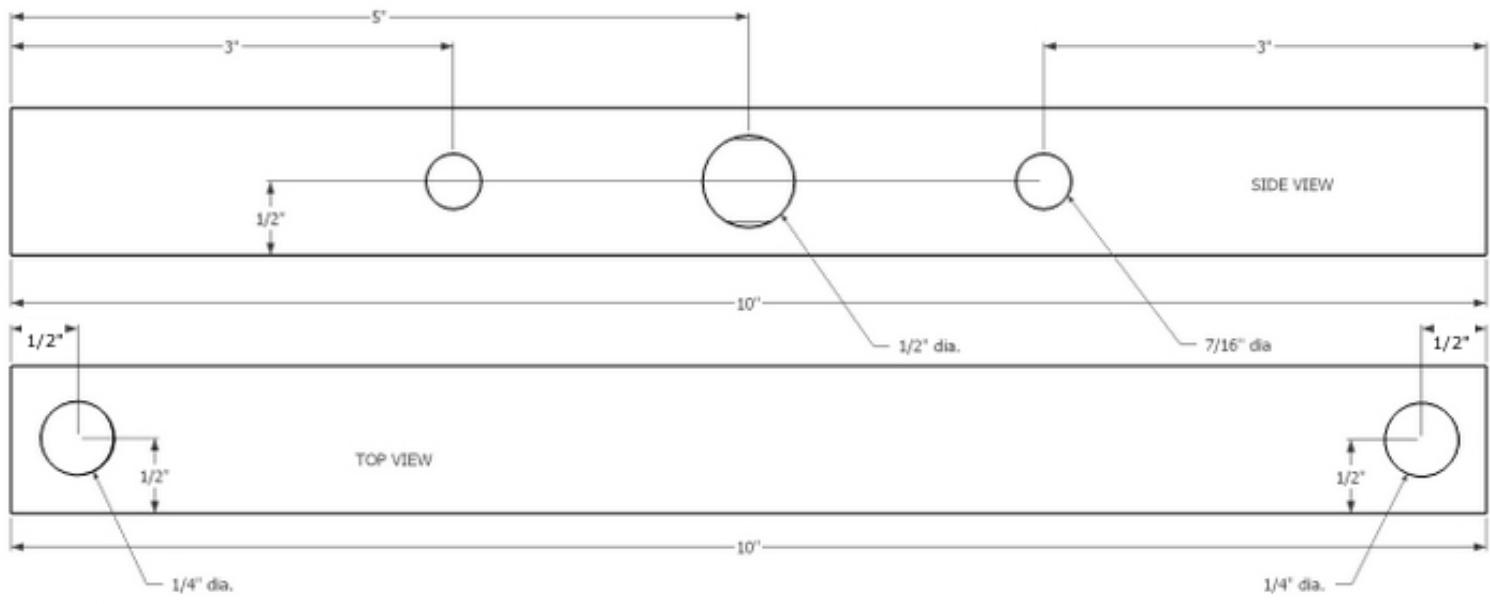


FRONT CHASSIS CROSS MEMBER (1 off)

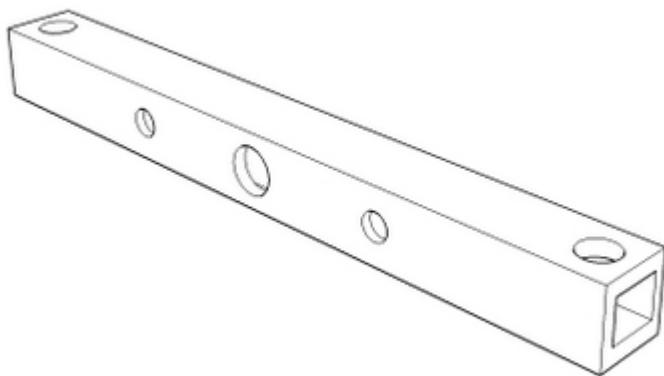
See page 129 for NEMA 17 motor mounting hole pattern and dimensions



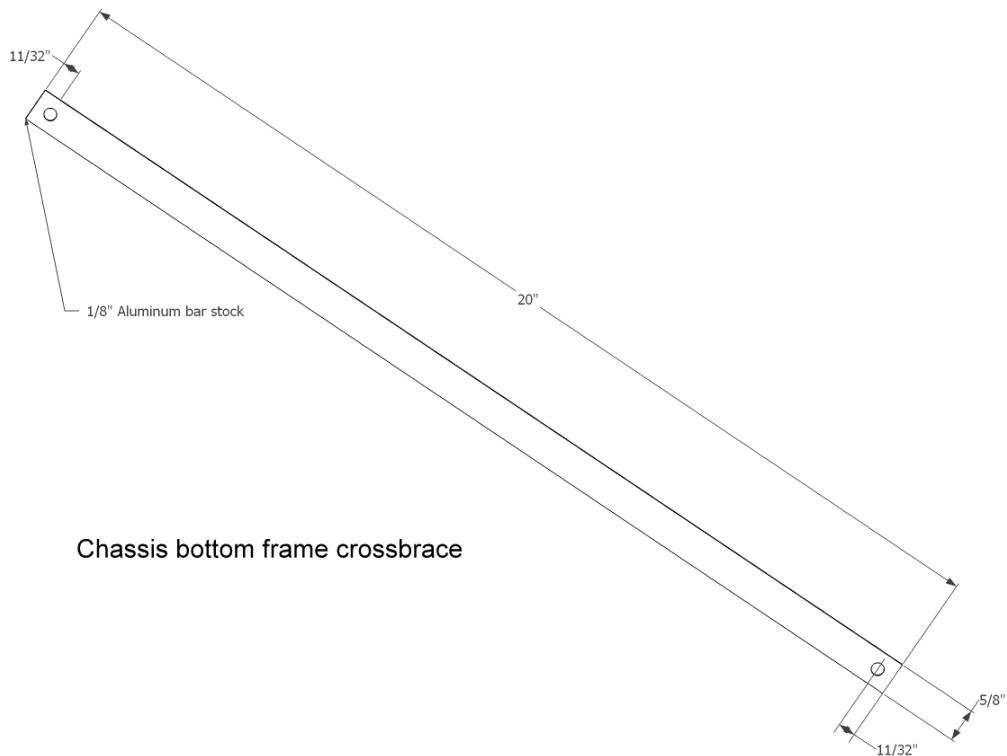
Front Chassis Cross Member, perspective view



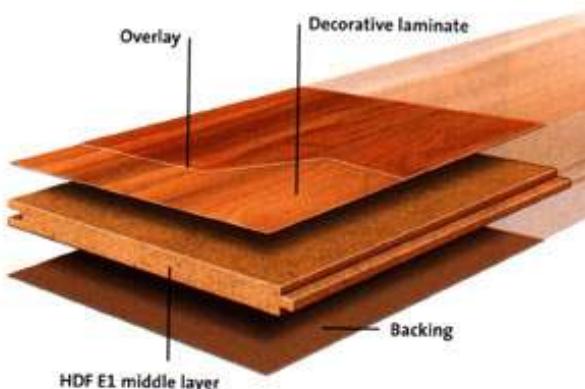
REAR CHASSIS CROSS MEMBER (1 off)



Rear Chassis Cross Member, perspective view



Wood



Downloads section of your MyDIYcnc account.

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. Drawings for the wooden base are found online in the



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 boards and are perfectly aligned. If using a hand drill, take great care to drill at right angles to the boards.



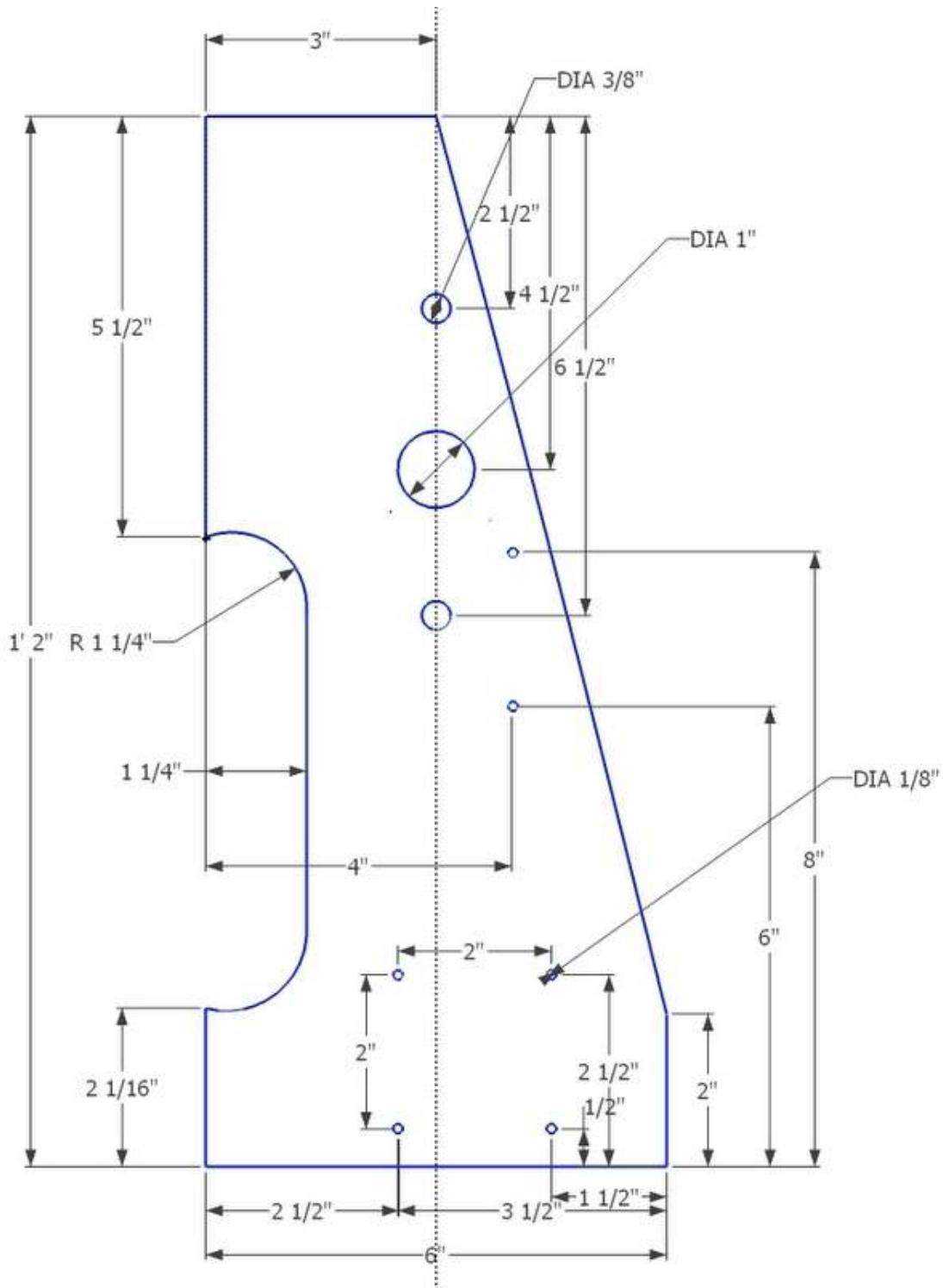
Uprights and Gantry Brace

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.

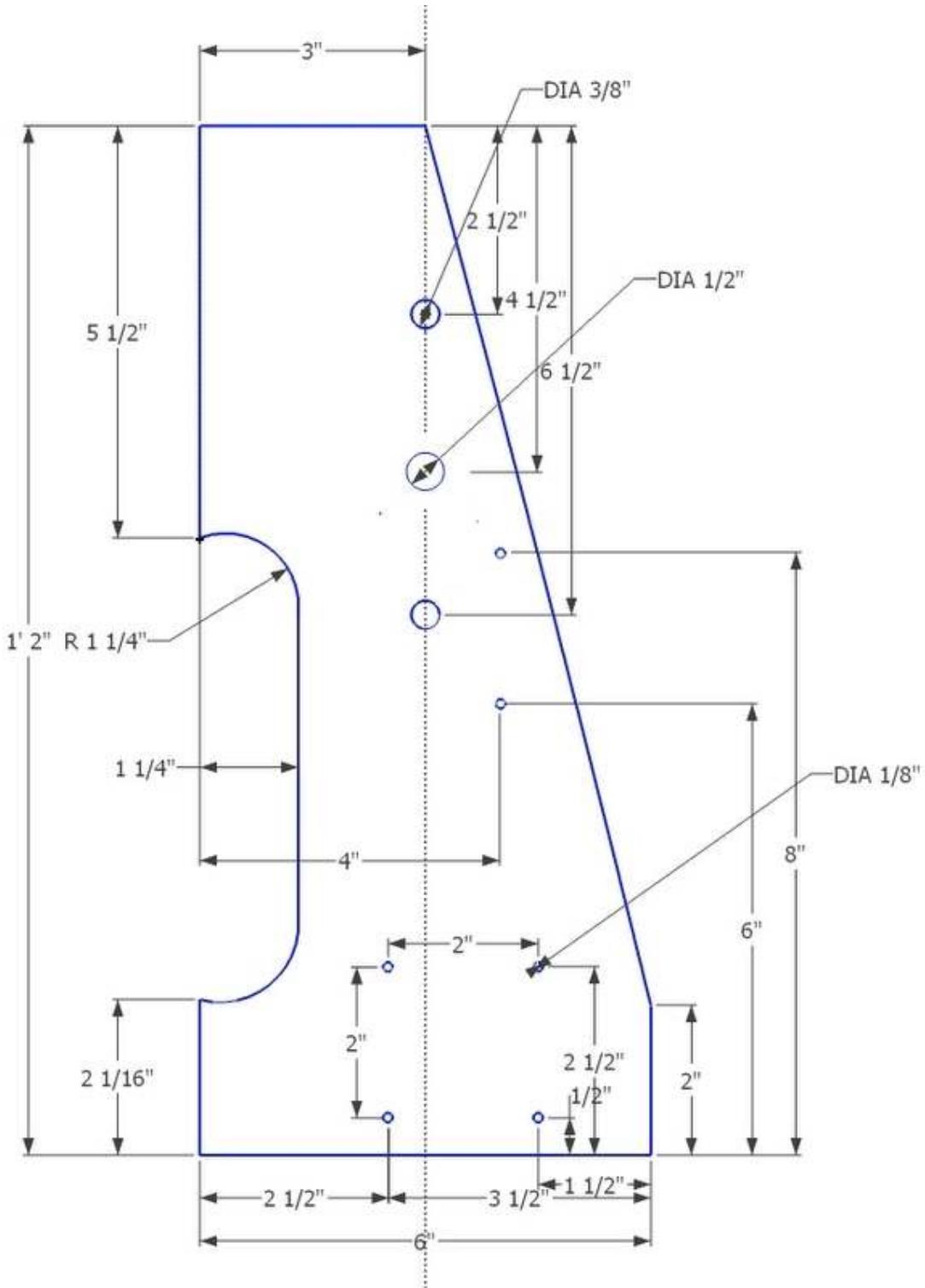
The following drawings provide dimensions for the creation of a left- and right-hand gantry support upright. See the appendices for the NEMA 17 motor mount hole dimensions. Note that with the exception of the motor mount holes, the uprights are exact mirror duplicates of each other.

TIP: It is best to cut and drill these parts simultaneously while clamped together. This is especially beneficial when aligning the holes for the Y axis rods and the base mounting holes. By drilling through both pieces simultaneously 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.

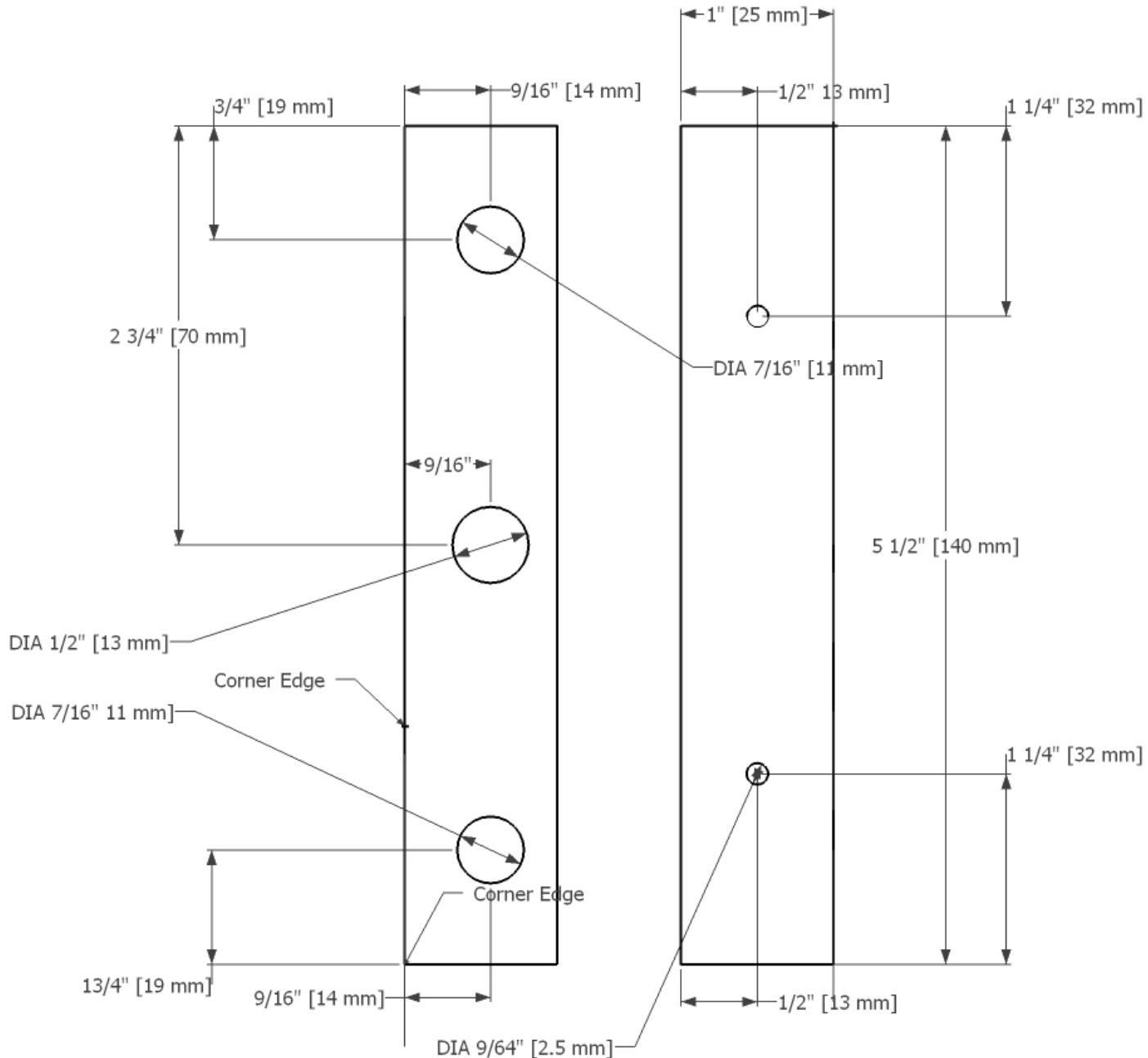
The bearings are a specialized product from Igus called, iglide clip bearings with a part number of MCI-06-02. They can be obtained directly from Igus (www.igus.com) and from suppliers such as Grainger (www.grainger.com), DrillSpot (www.drillspot.com) and Global (www.mscdirect.com).

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.

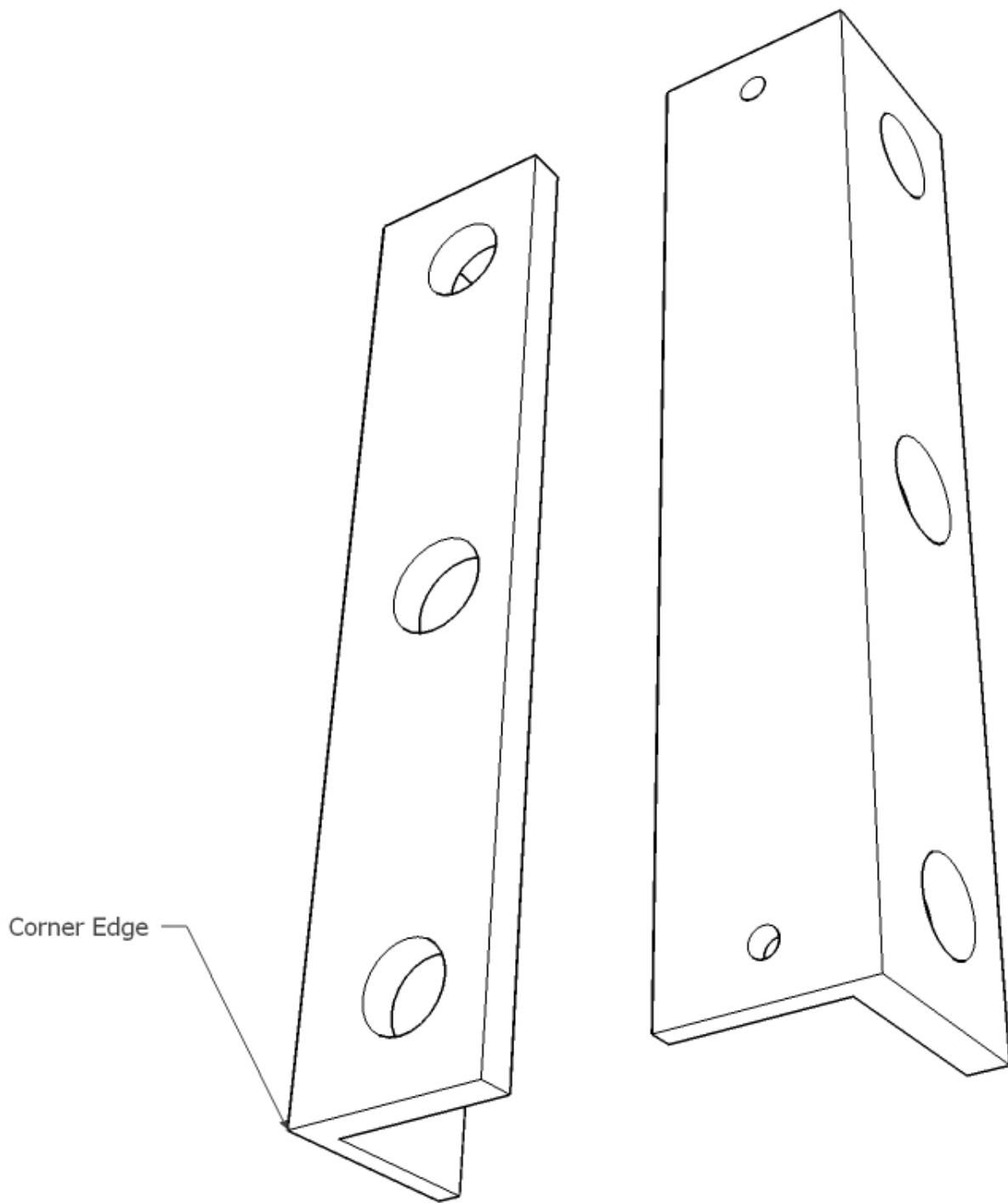


WARNING: Take care when cutting or drilling in metal to avoid getting cut on the sharp edges created. Use a file to de-burr sharp edges.

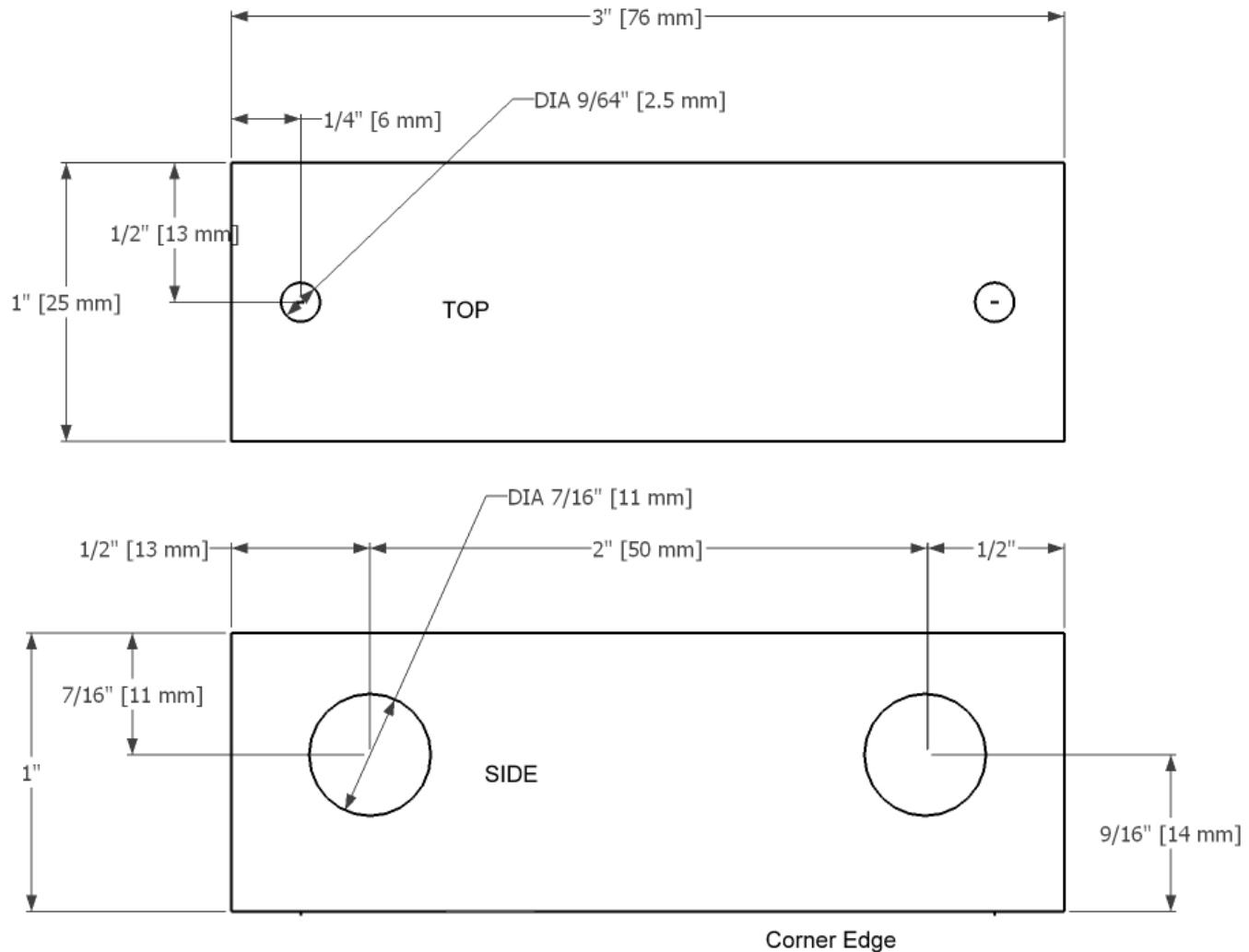


4 Required, 2 each for X and Y axis. Note for X axis small mounting holes change to $7/64''$ [2.8 mm]

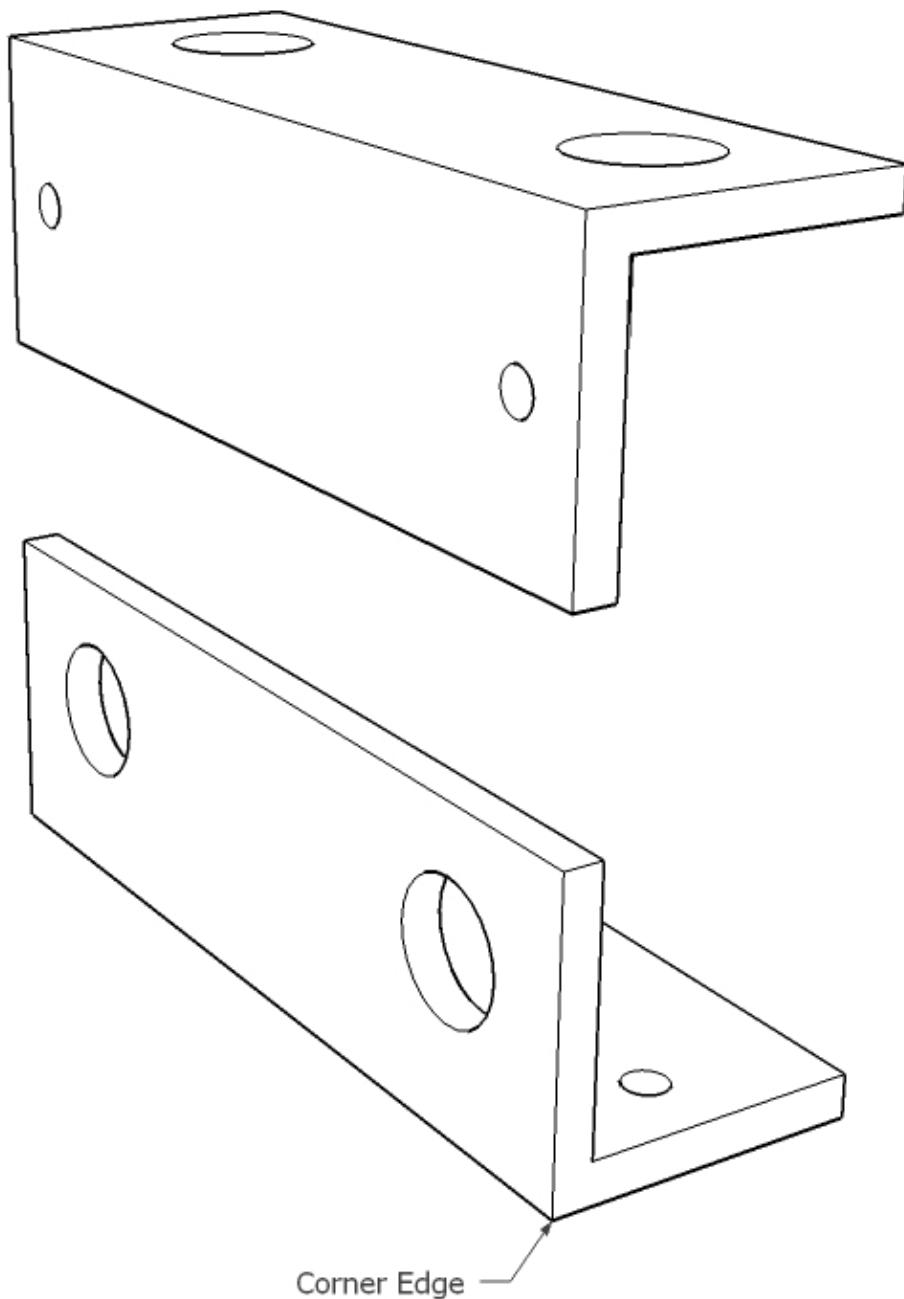
X and Y Axes Bearings Support Sub-Frame



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 Desktop CNC Machine is designed to use a 1/4"-20 threaded rod to provide the gearing necessary to produce the 0.001"-per-step resolution required. The threaded rods and their respective lengths are listed in the **Bill of Materials** in the **Appendices** at the end of this manual. 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 Desktop CNC Machine 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 to "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 (McMaster-Carr, www.mcmaster.com, part 9579K63).



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 Desktop CNC Machine section below.



The DIY Desktop CNC Machine is designed to use NEMA 17 bipolar Stepper Motors. See the section on ***Expanding Your DIY Desktop CNC Machine*** for details about using different 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 MyDIYcnc 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.

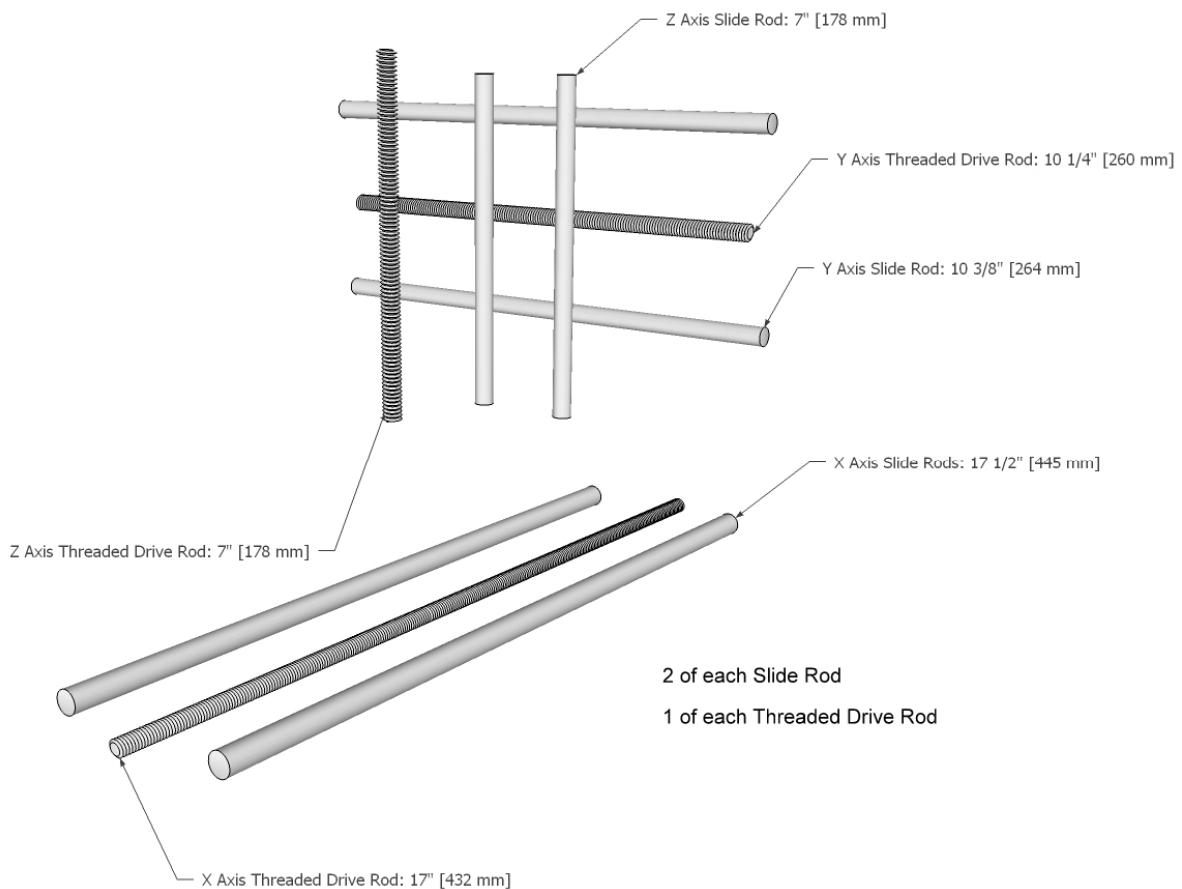
The drawings provided show the mounting holes arrangement for NEMA 17 stepper motors. You will also require a set of four machine screws to mount each motor. They must match the threaded holes in your motors (for instance, the MyDIYcnc motors use a metric thread, and therefore M3 machine screws are used) 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 emery 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 Igus 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. You can also purchase online from a vendor such as MSC (www.mscdirect.com) who usually takes great care in packaging their products for shipping. Cut each pair of rods to length as indicated in the drawings



Cut Slide Rods and Threaded Drive Rods to Dimensions Shown

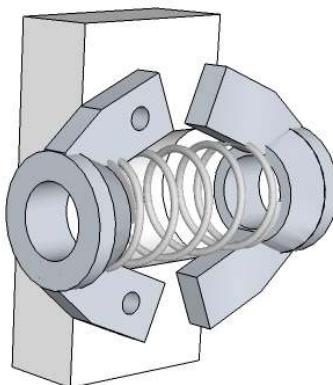
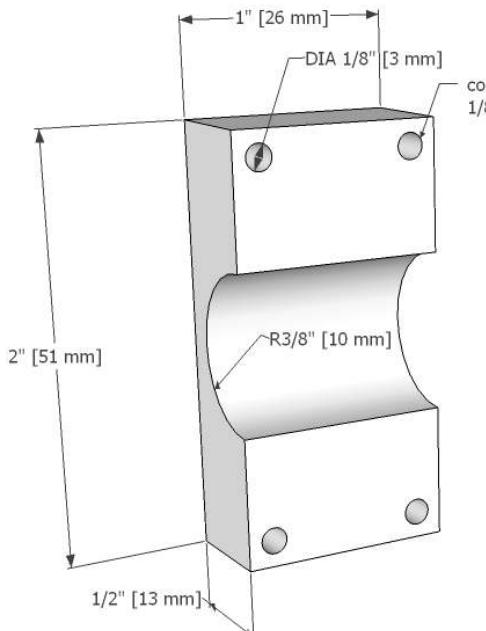
Anti-backlash Lead Nuts

"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 Desktop CNC Machine 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 spring-loaded 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.





3 Anti-Backlash Assemblies Required

Only 2 (X & Y Axes) have corner holes

Holes for Mounted Wingnut Drilled Through Wingnut In Position

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.

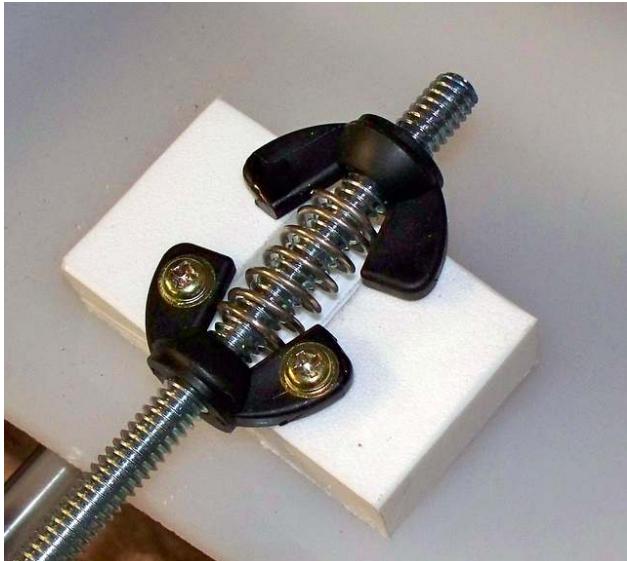
Drill the four 1/8" [3 mm] mounting holes through the blocks in the corners of each block as shown in the drawing.

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.



TIP: Take a moment here to feel the lone wing nut on the threaded 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 mechanism will remove from your DIY Desktop CNC Machine.

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.



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.

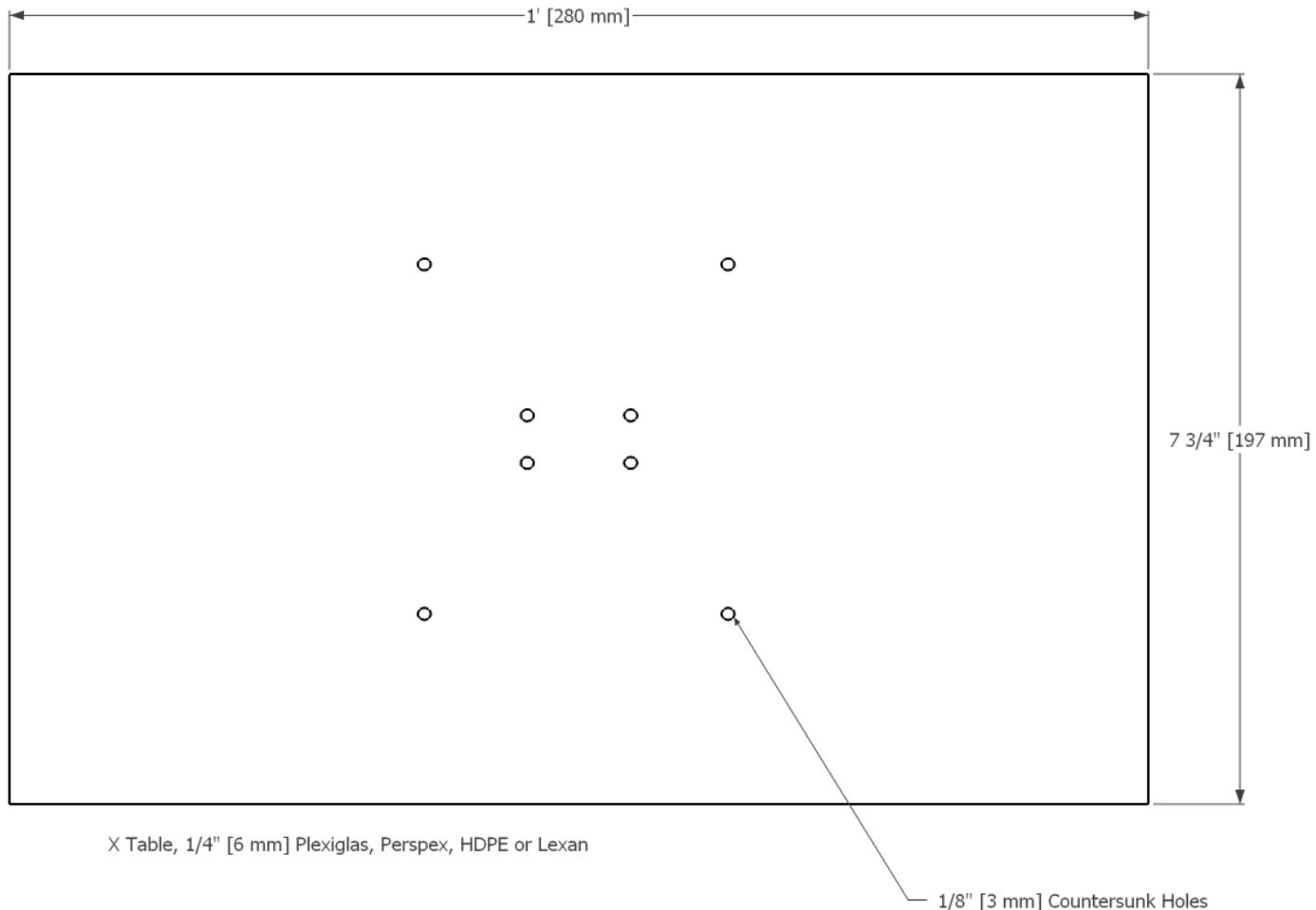
The completed anti-backlash lead nut assembly should allow the threaded rod to rotate freely, but without any slack or play when doing so.

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 misalignment 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 Desktop CNC Machine* below.



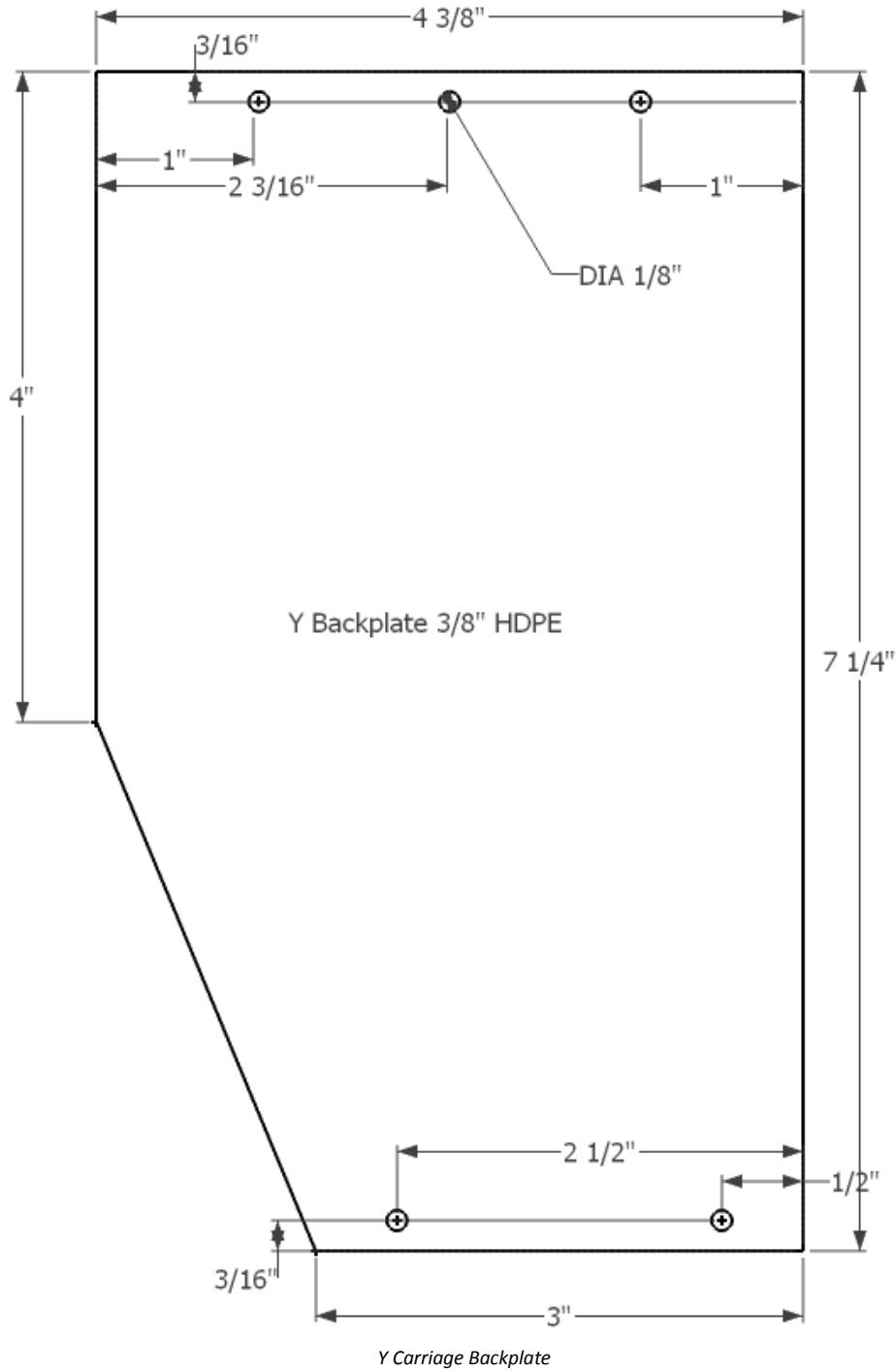
X Table, 1/4" [6 mm] Plexiglas, Perspex, HDPE or Lexan

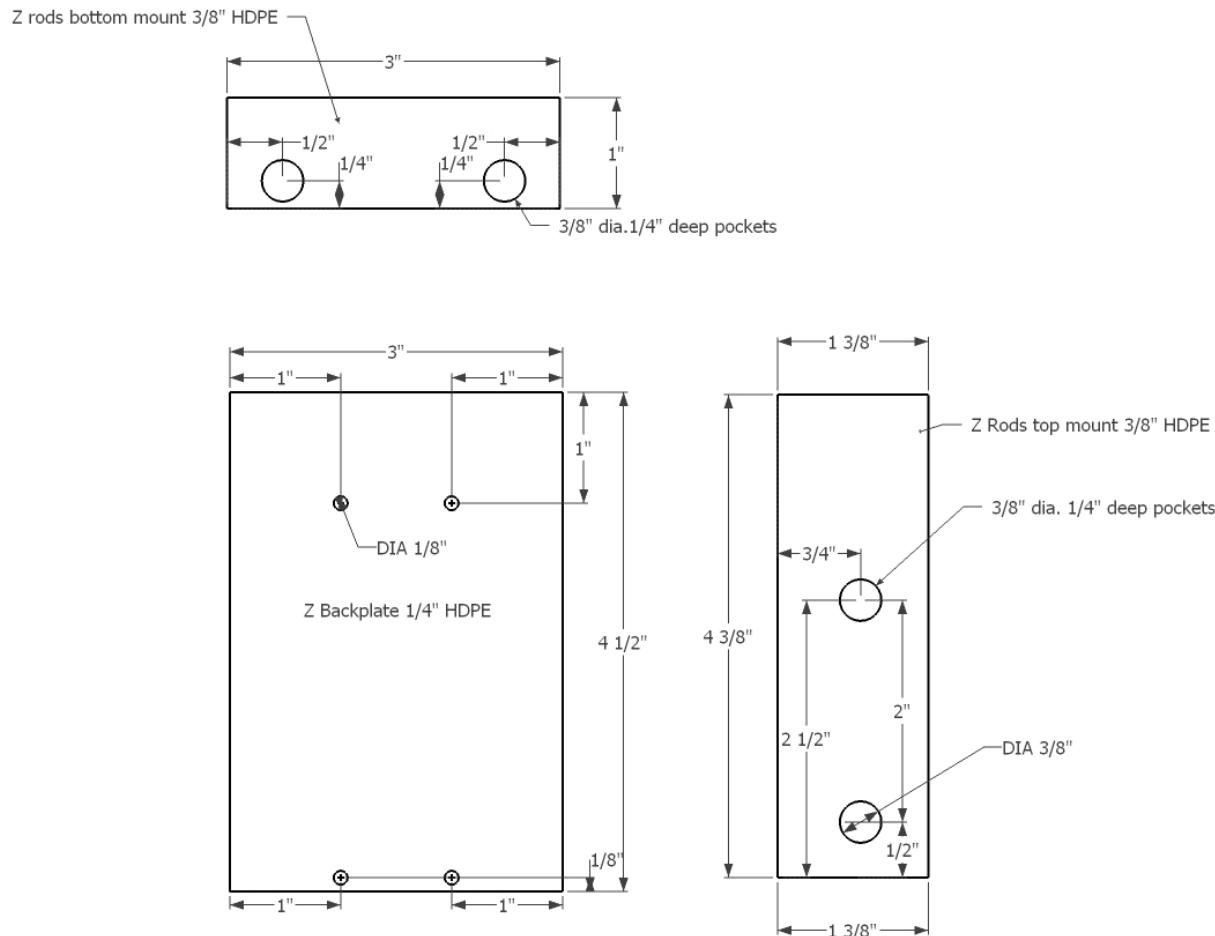
1/8" [3 mm] Countersunk Holes

Y Carriage

The Y carriage consists of a $\frac{1}{4}$ " 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 Z Carriage Assembly

Z Carriage

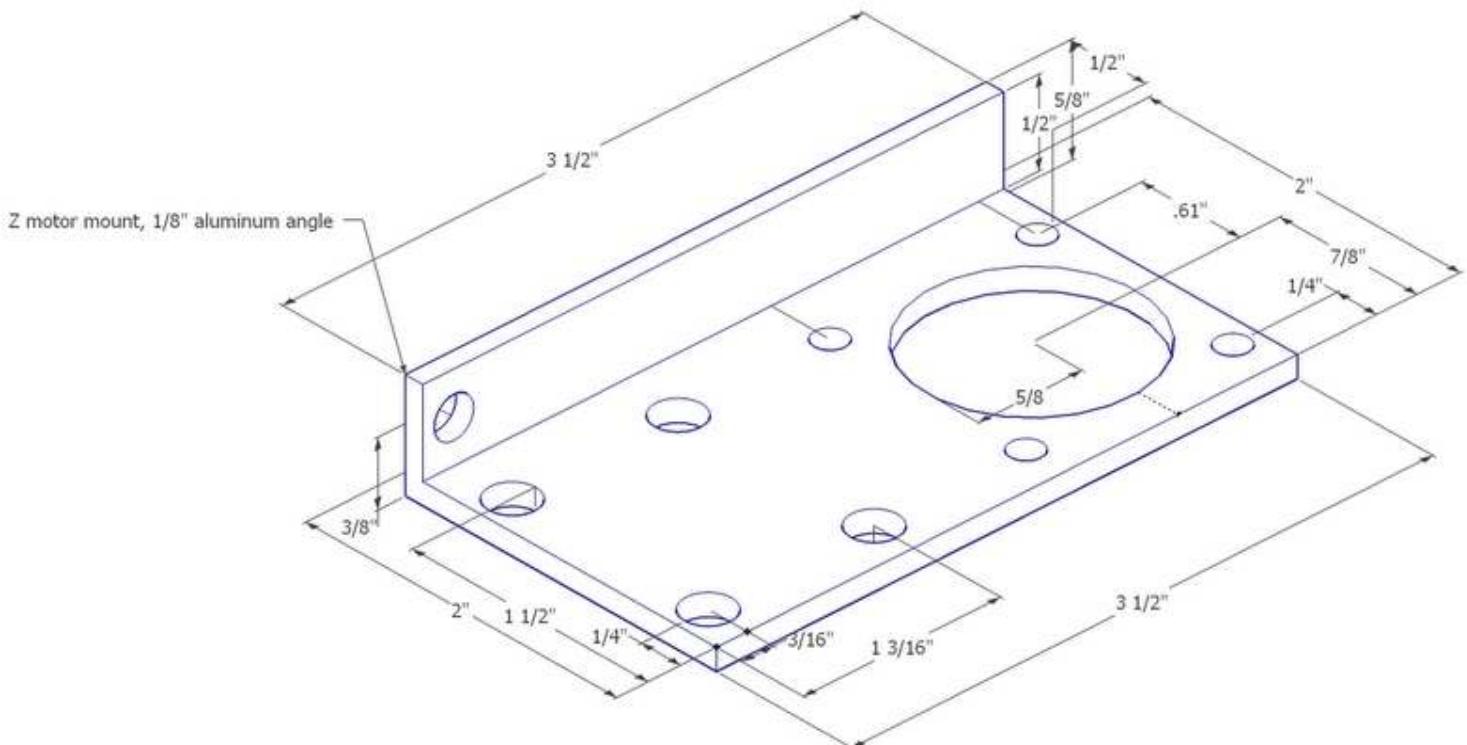
The Z carriage has several components designed to smoothly lower and raise the spindle to and from the X table surface – the working area. The Z carriage consists of a back plate, to which are connected the spindle cradle/mounts, the Z bearings sub frame and the Z axis anti-backlash lead nut assembly.

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.

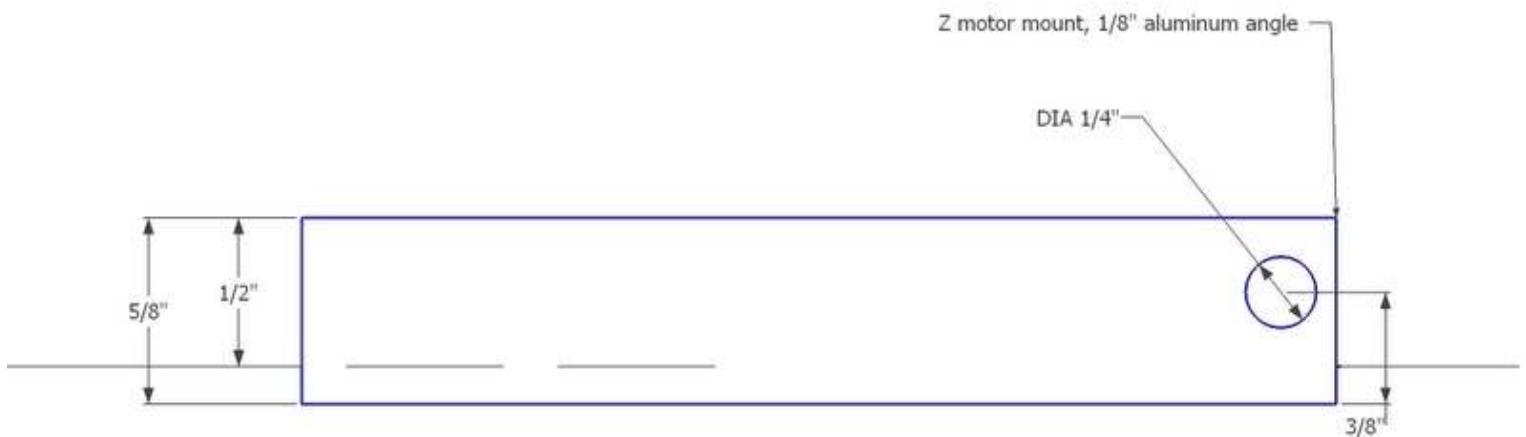
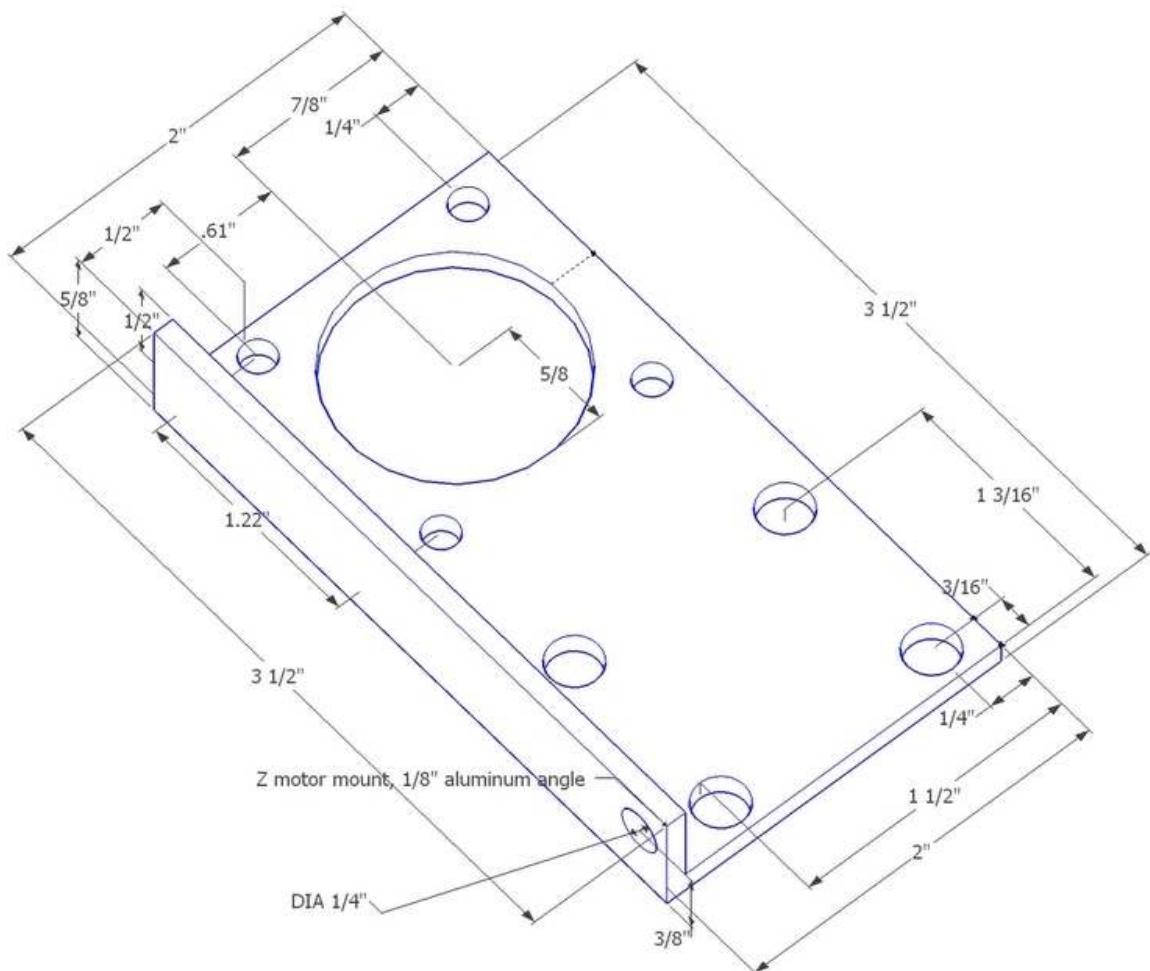
Z Motor Mount

The Z motor mount is made from a section of $1/8"$ thickness $2"$ aluminum angle, cut down to provide a $2" \times 1/2"$ 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.

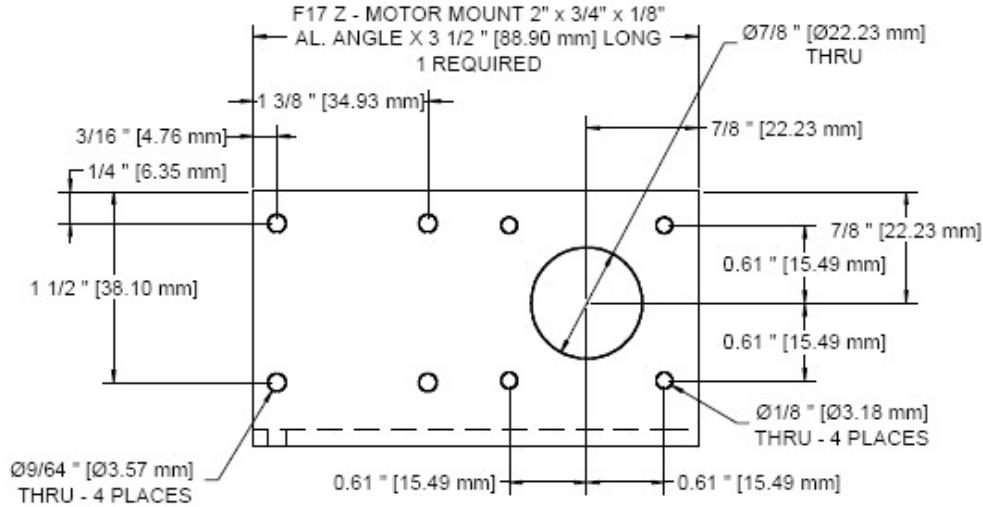
NOTE: If you use a motor coupling clamp you will need the $1\frac{1}{4}"$ motor shaft clearance hole. If not, a $7/8"$ shaft clearance hole is recommended to match the raised flange on the motor face (see drawing on page 41).



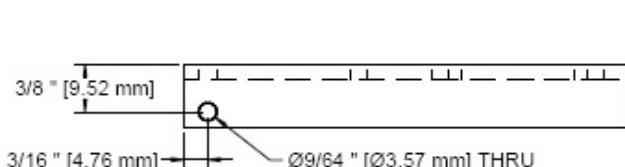
Z Motor Mount, 3D views



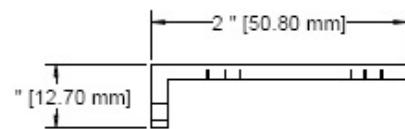
Z Motor Mount, edge view



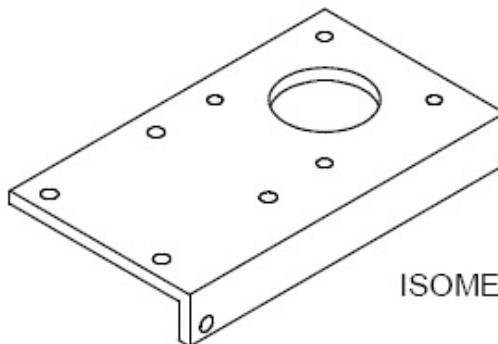
PLAN



SIDE ELEVATION



END ELEVATION

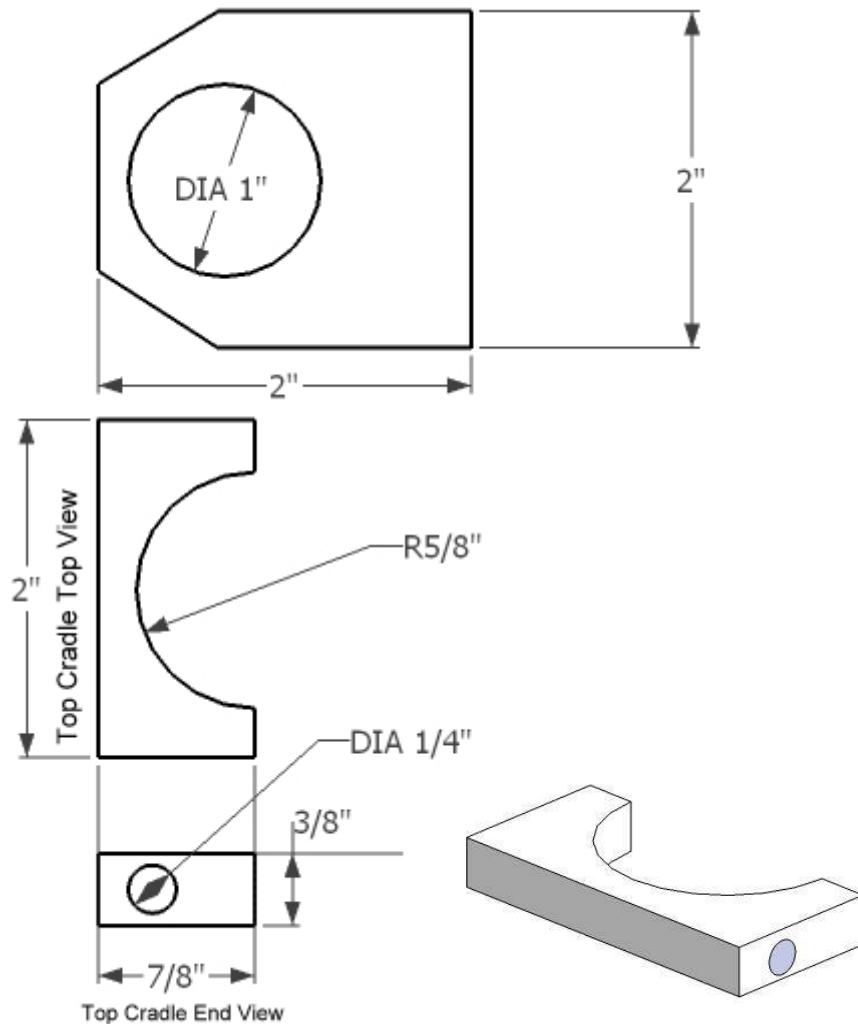


ISOMETRIC VIEW

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CONTAINED HERE
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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 MyDIYcnc spindle as supplied with the DIY Desktop CNC Machine full kits and systems, 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 semi-circular 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 MyDIYcnc 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 Desktop CNC Machine modified to mount an etching laser head. In this instance the upper spindle cradle is unused.

Wiring Diagrams

Wiring of the DIY Desktop CNC Machine 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 Desktop CNC Machine is designed to use a standard PC power supply. They are easily 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.

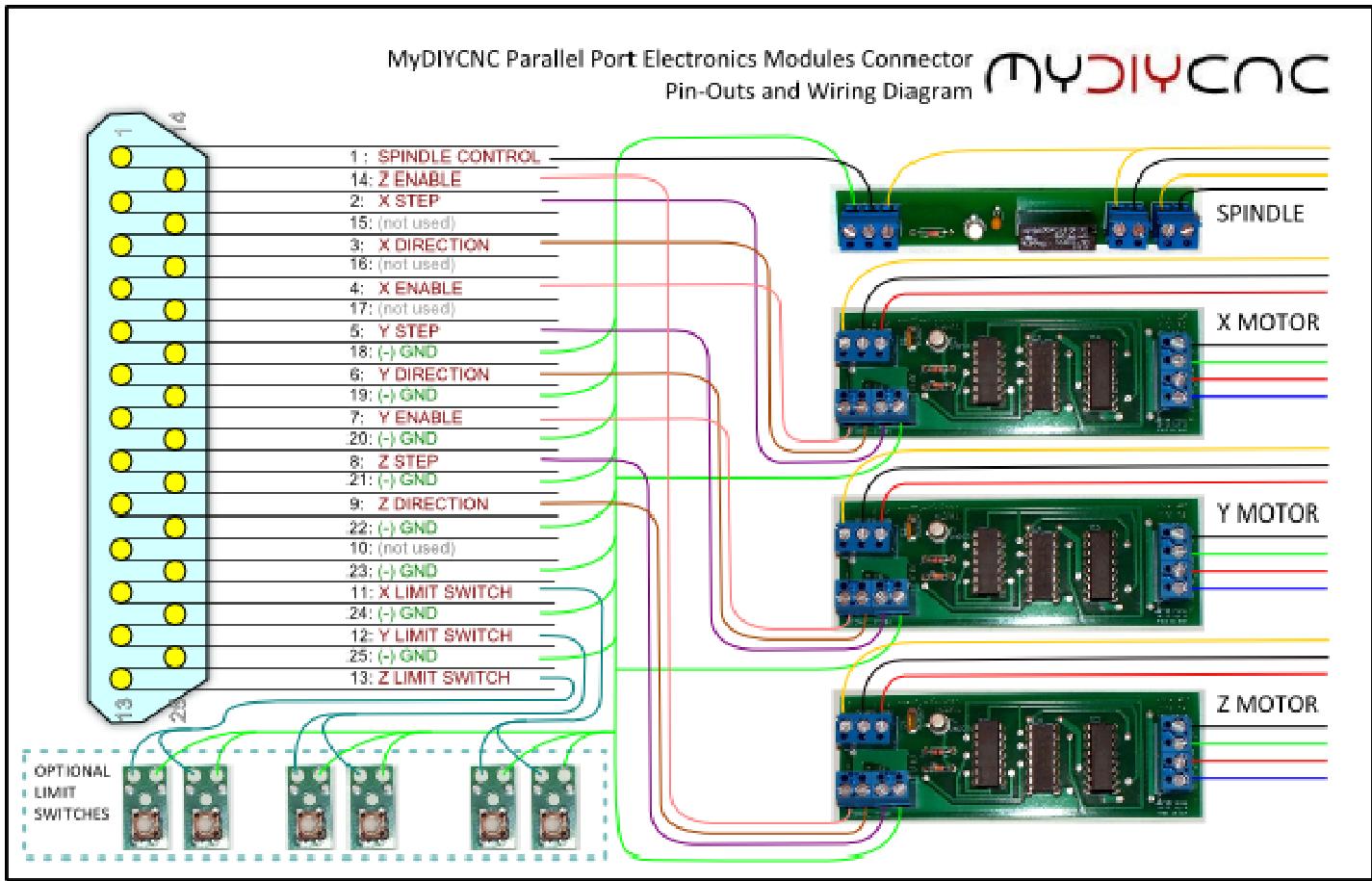
Instructions on how to modify a PC power supply for use with a DIY Desktop CNC Machine are provided in the section *Creating Your Parts* below.

There are five main wiring tasks involved in setting up your DIY Desktop CNC Machine electronics.

1. Wiring the DB-25 connector to the three MyDIYcnc Universal bipolar Stepper Control Modules
2. Wiring the power supply to the three MyDIYcnc Universal bipolar Stepper Control Modules
3. Wiring the three stepper motors to their respective MyDIYcnc 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.





Hardware



The DIY Desktop CNC Machine 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.

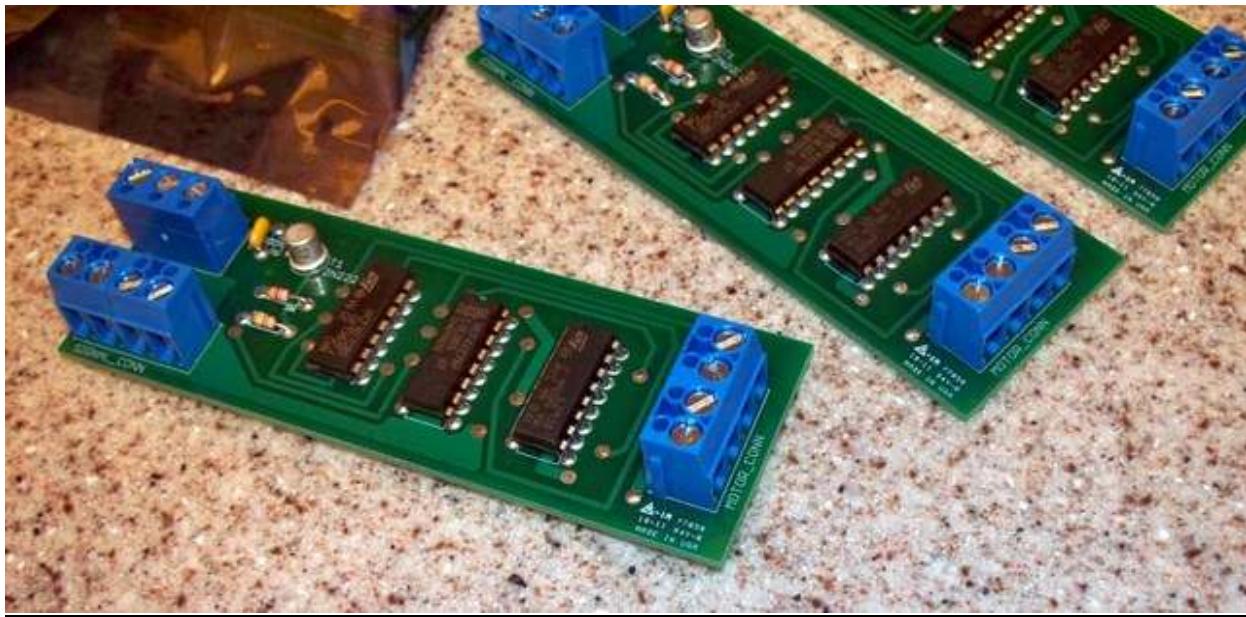
Electronics

The DIY Desktop CNC Machine'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. The *Master Bill of Materials* in the Appendices provides a complete list of components with part numbers and online sources.



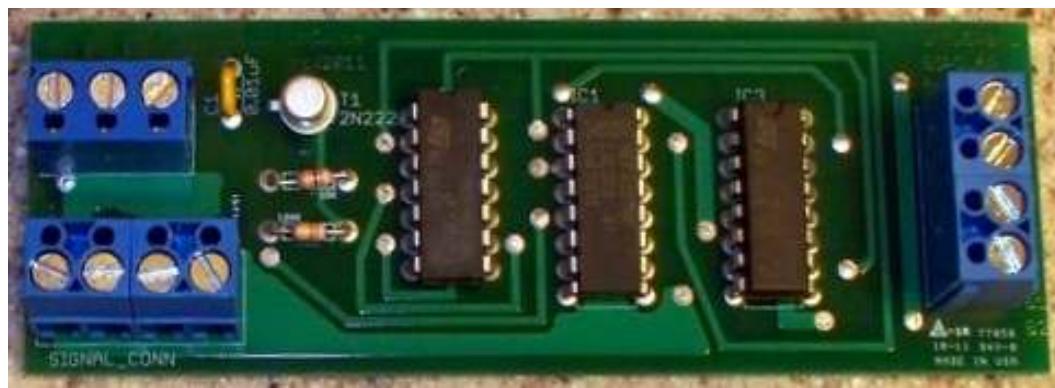
Bare printed circuit boards, electronics board kits and fully assembled boards are available from our online store at www.MyDIYcnc.com

Stepper Controller Module

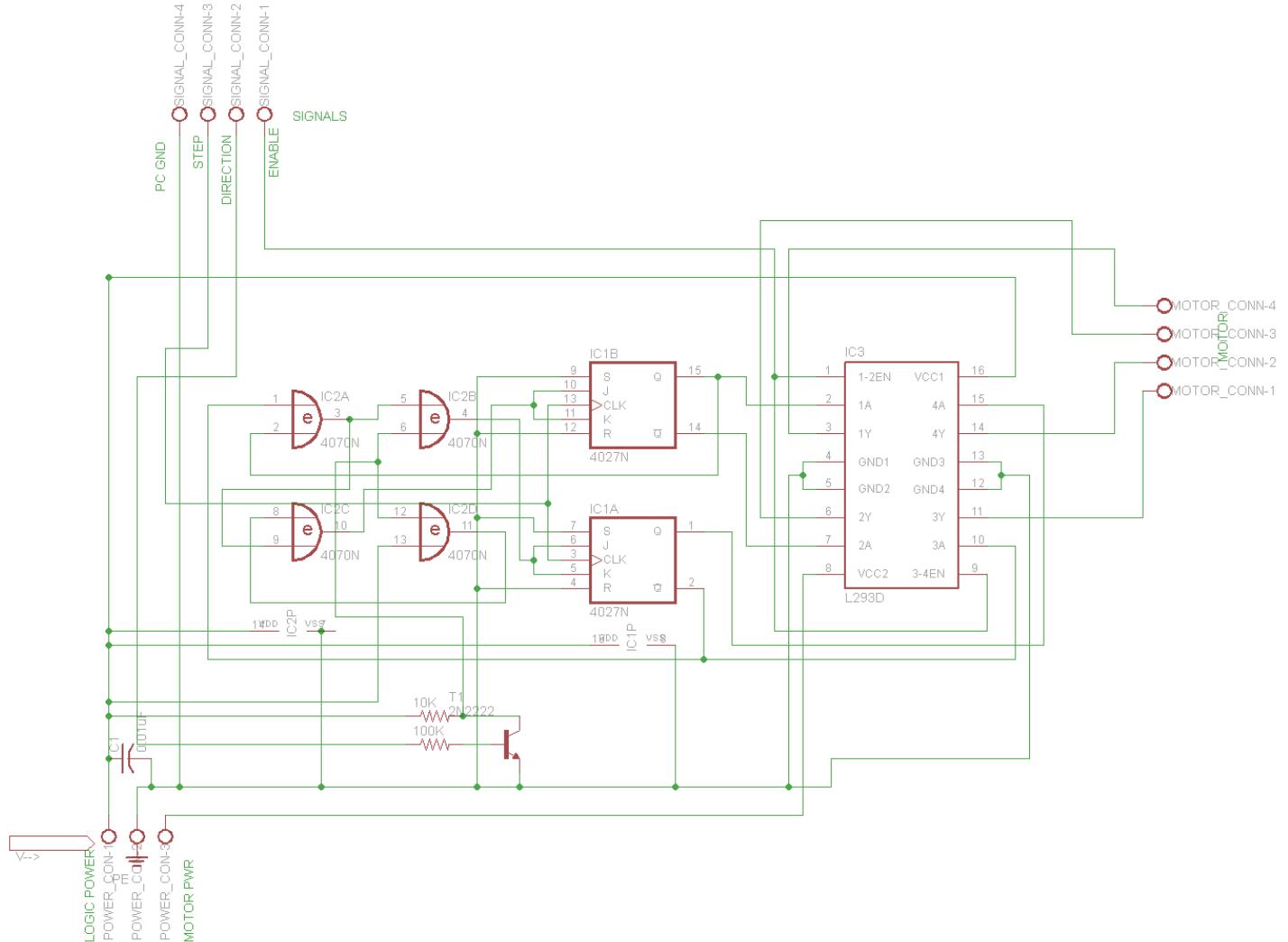


Specifications

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 Current	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" [35 mm] x 4" [102 mm]



Circuit Diagram



See appendix *Electronics Schematics* for a full-size PCB layout. Your online account at www.MyDIYcnc.com will provide you access to a full-size PCB layout in PDF format for laser printer toner transfer processing.

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. See the www.MyDIYcnc.com website resources for instructions on making your own printed circuit boards.

Bill of Materials

Component	Quantity Per Board
10K Resistor	1
100K Resistor	1
0.01uF Capacitor	1
4027N CMOS Logic, DIP	1
4070N CMOS Logic, DIP	1
L293D 4 Channel Motor Driver, DIP	1
2N2222 Transistor	1
W237-04P Screw Clamp Connector (or equiv.)	1
W237-3E Screw Clamp Connector (or equiv.)	2

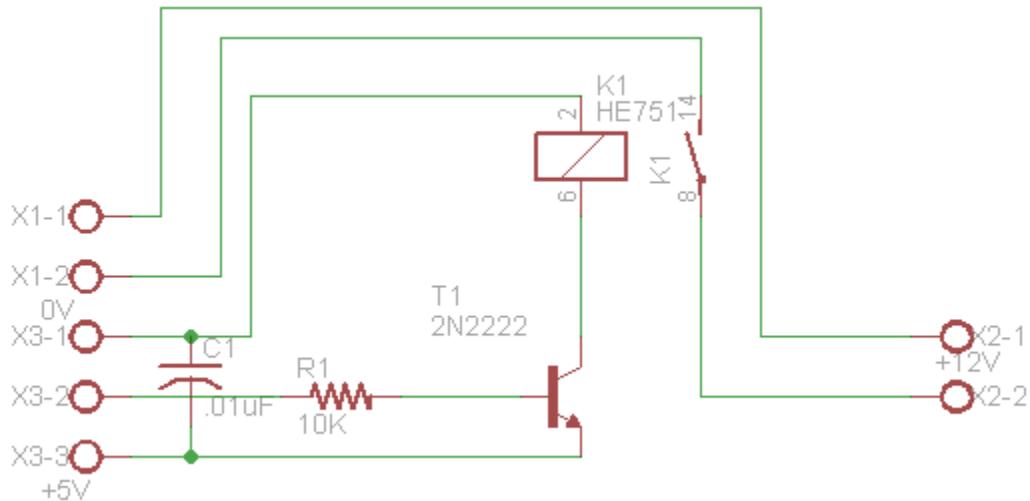
Spindle Controller Module



Specifications

Operating Voltage	12 VDC
Logic Voltage	5 VDC
Spindle Voltage	3 – 24 VDC 110 VAC 220 VAC
Connection Type	PCB-mount Screw Clamps
Dimensions	.5" x 4"

Circuit Diagram



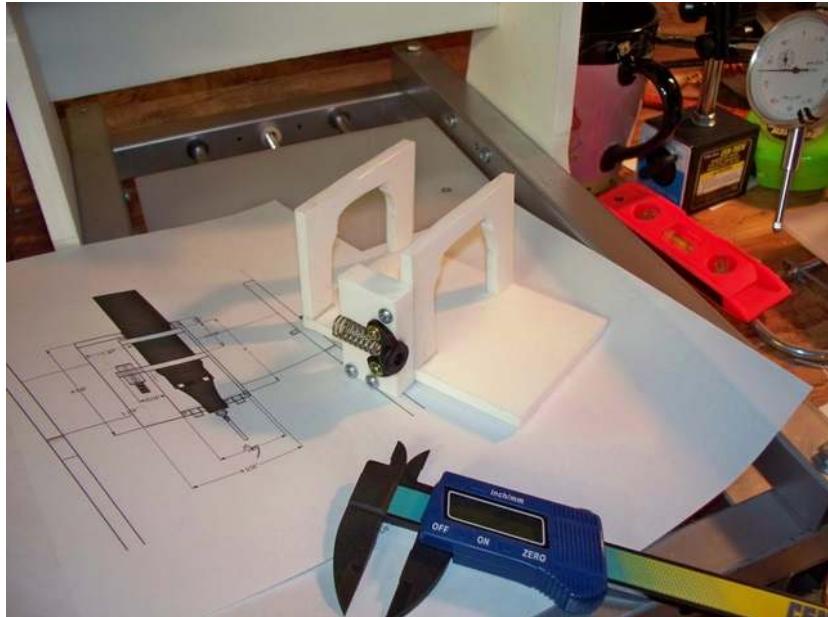
Bill of Materials

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

Creating your Parts

Following the set of drawings provided for the DIY Desktop CNC Machine 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 Desktop CNC Machine.



Notes on Precision Cutting and Drilling

The DIY Desktop CNC Machine 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**

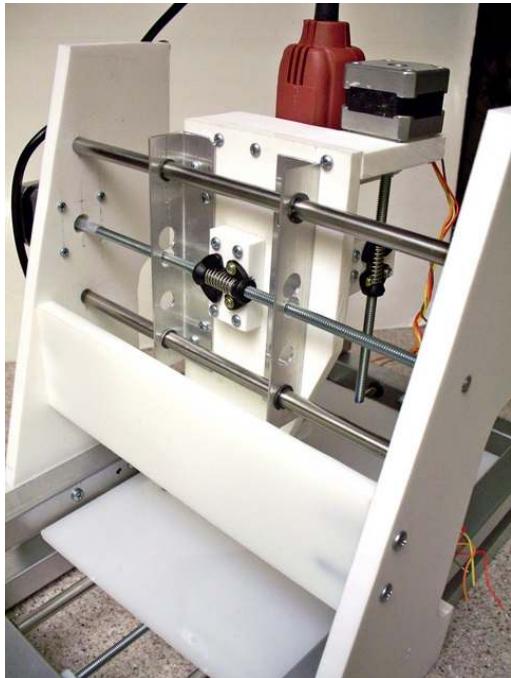
Rods and Bearings.

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.

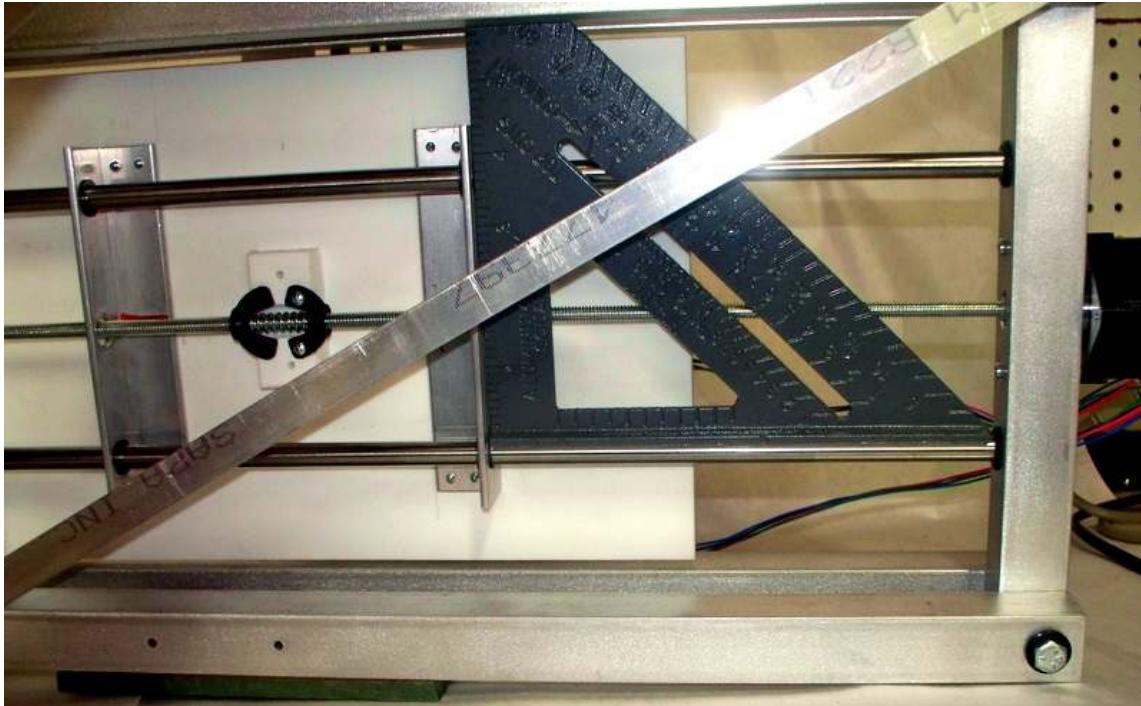


As mentioned above, drilling matching parts in pairs is a simple and effective way to ensure alignment of holes between pieces. However, since the smooth operation of each carriage requires that rods must be parallel, and aligned accurately to the bearings, it is critical that care is taken to drill 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 section *Troubleshooting* towards the end of this manual for possible remedies and corrective measures.





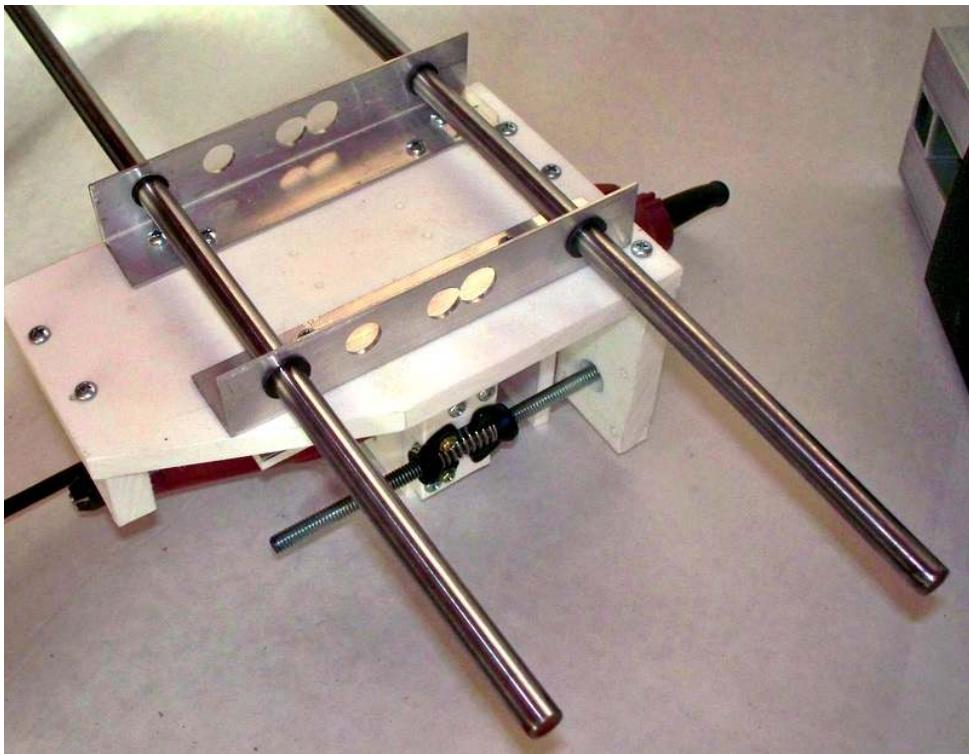
Use a carpenter's or machinist's square to ensure squareness of bearing support subframes to axis rods

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 Desktop CNC Machine 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° 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

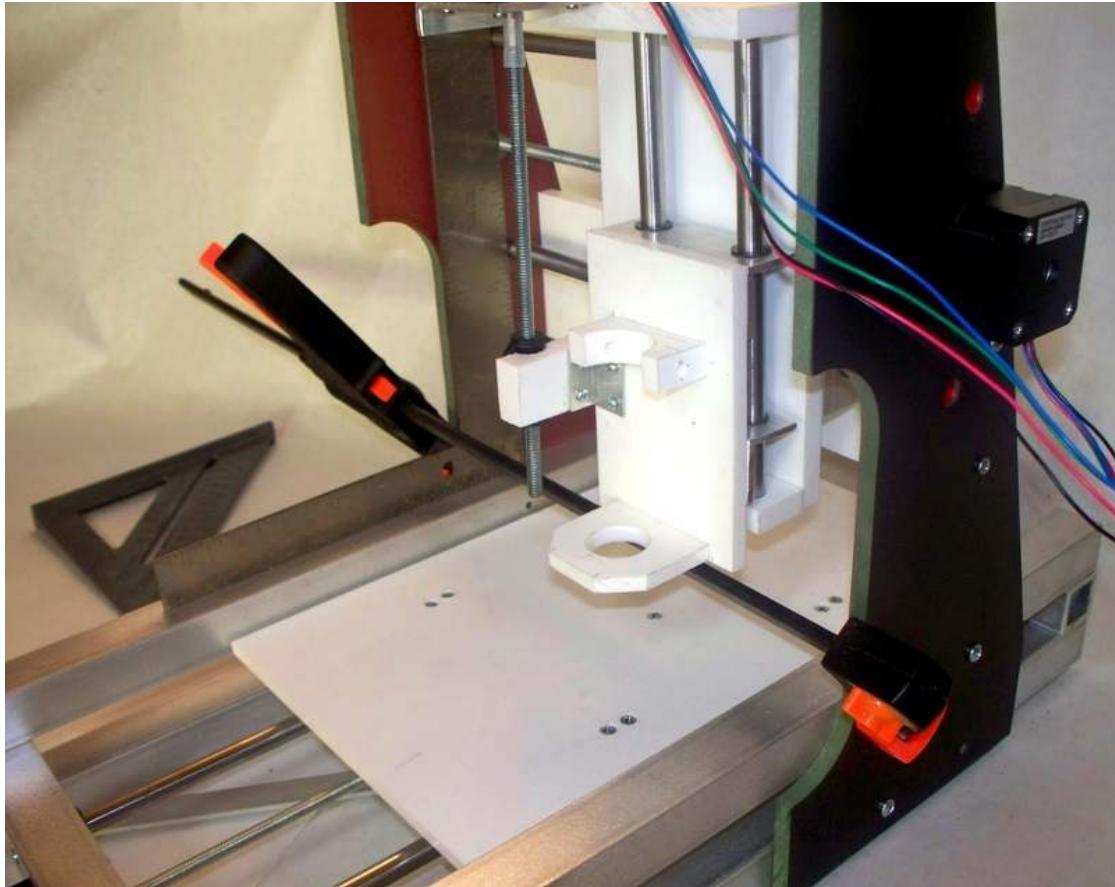


in the bottom of the upright gantry supports as guides for drilling through into the metal frame, taking great care to drill perpendicularly into the metal.

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

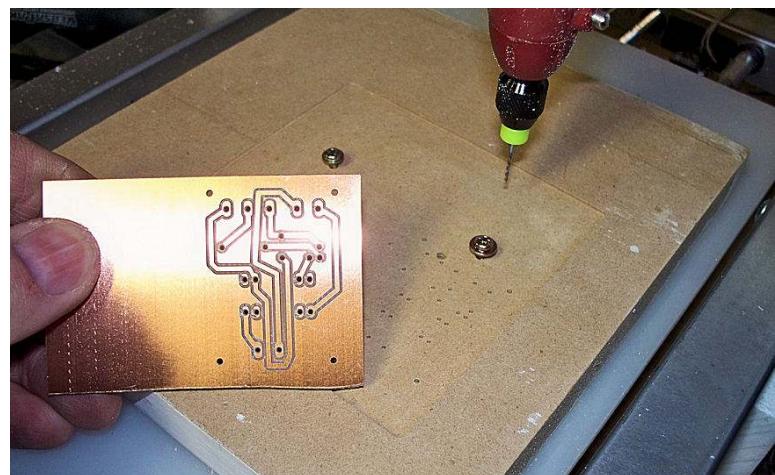
the way down just yet. Measure again for squareness between the Y carriage gantry and the X table, adjust if necessary, and tighten down the screws.

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.



As mentioned earlier, see the section on *Troubleshooting* should you encounter any alignment issues.



See the Tutorials section of the www.MyDIYCNC.com website for instructions on how to mill PCBs on your DIY Desktop CNC Machine. The PCB Isolation Track Milling tutorial explains how to set up your table, prep your g-code from your PCB design application, and what end mills to choose to suit your board.

Building your DIY Desktop CNC Machine

You will be building your DIY Desktop CNC Machine either from scratch or from kit parts supplied by MyDIYCNC.

While the following instructions will be the same for both build processes, many of the kit parts will come with pilot holes pre-drilled in the correct location. However, not all kit parts' holes are pre-drilled. Many assemblies rely on the accurate and exact square alignment of the parts, and in several cases this requires that the parts be aligned, tested for squareness and then clamped/secured in the precise location before drilling a pilot hole and screwing them together.



Therefore, when building from your own parts, or using parts that do not have the holes discussed in this manual, you will need to drill a pilot hole to suit.

NOTE: if you're building from a MyDIYCNC kit, download and follow the pictorial step-by-step assembly guide provided with your online account.

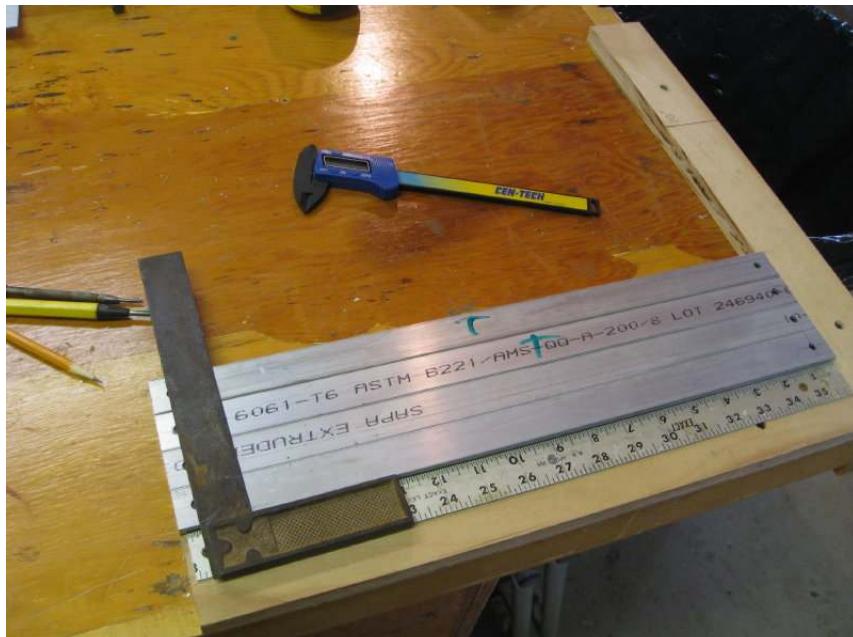
Chassis Frame

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.

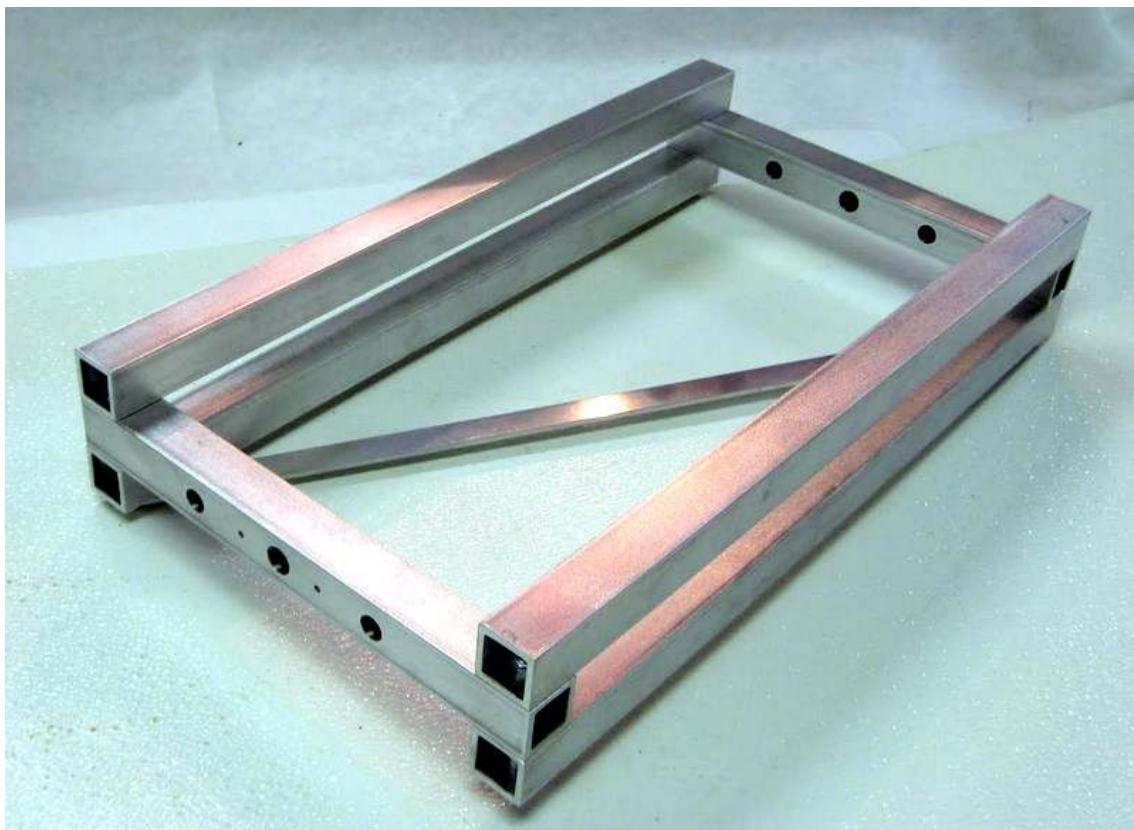




Clamp or tape together rail pairs for drilling to ensure alignment of holes

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 Lead Screws

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 Desktop CNC Machine's 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.

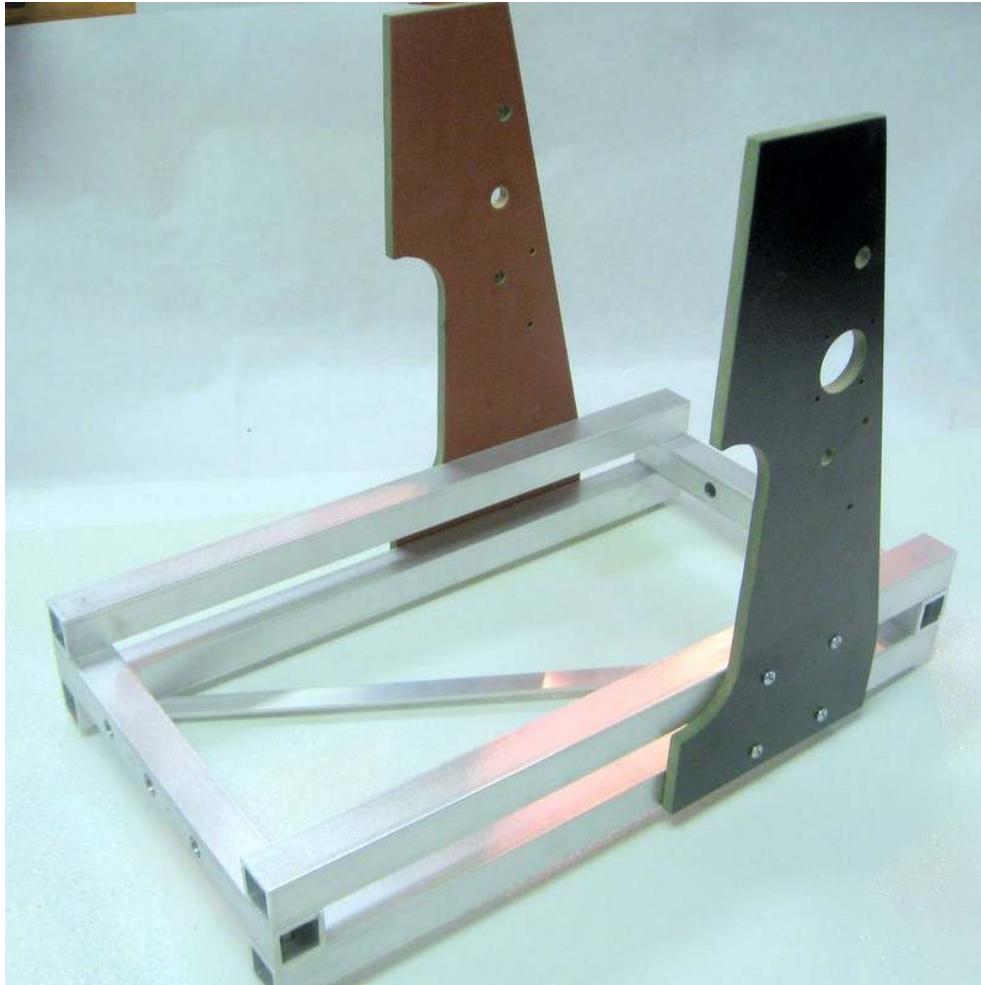
The uprights are best clamped and drilled together. In the absence of a suitable clamp they may be bound together tightly with strong masking or duct tape. Great care must be given to preparation for this step to ensure that both pieces are perfectly aligned before drilling. Without this critical first 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 edge 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.

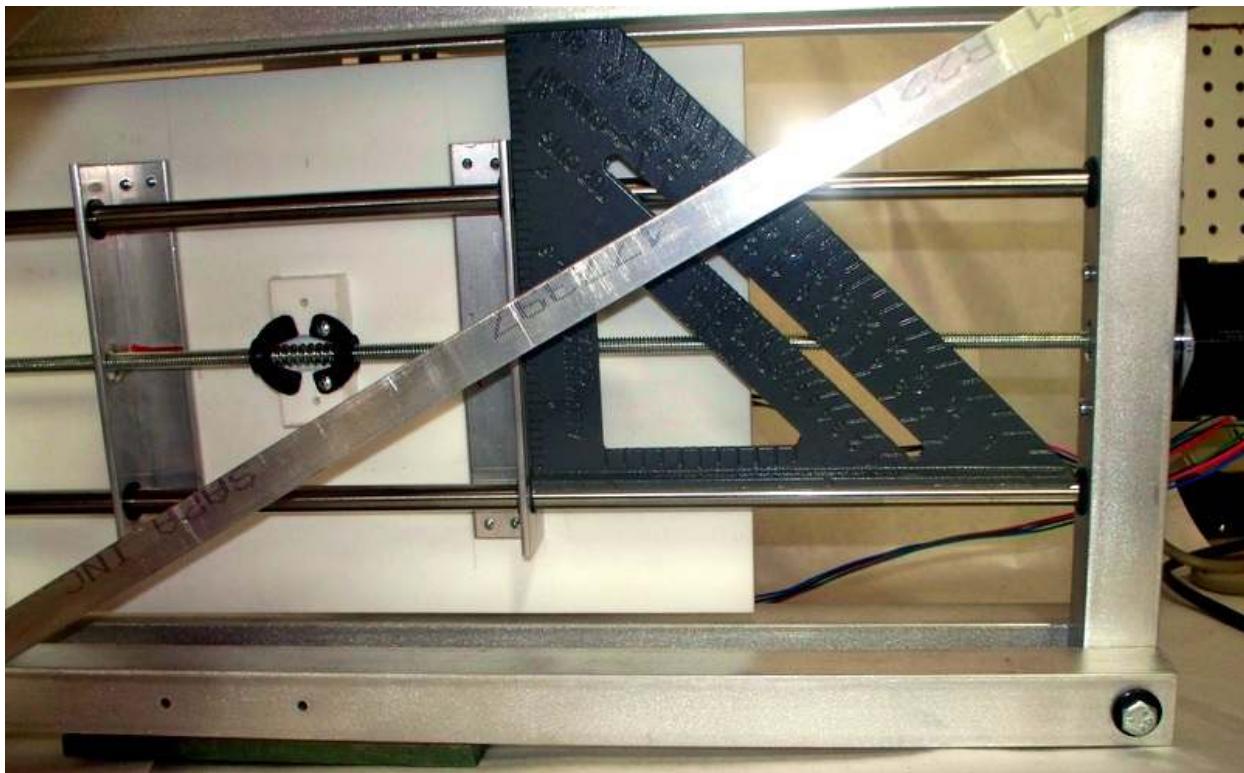
Take the two X axis rods you prepared earlier and slide them through the front rail into the rubber grommets in the rod mounting holes. They should be a tight fit, but if they resist to the point that the rubber grommet is getting pulled out of the hole, apply a small amount of soap and water to the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



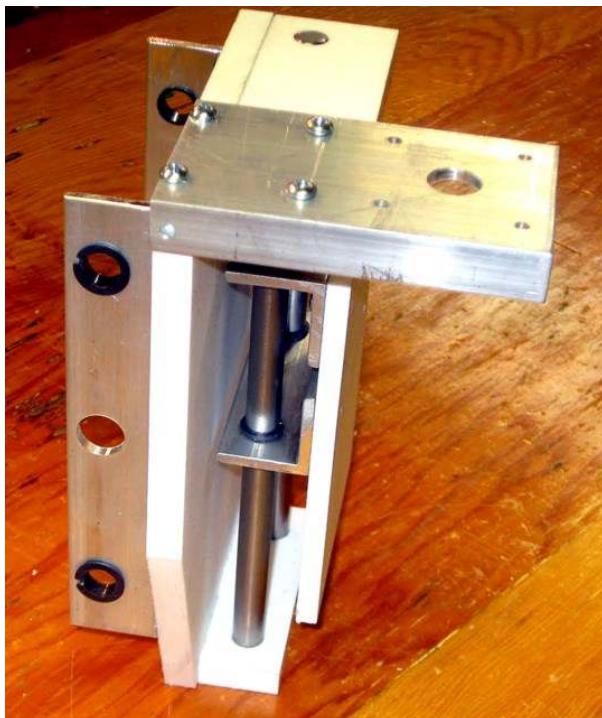
Use a machinist's or carpenter's square to ensure squareness between the rods and bearing support sub-frames

Flip the DIY Desktop CNC Machine 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 Desktop CNC Machine 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.



Gantry and Carriages

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

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 Desktop CNC Machine. 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

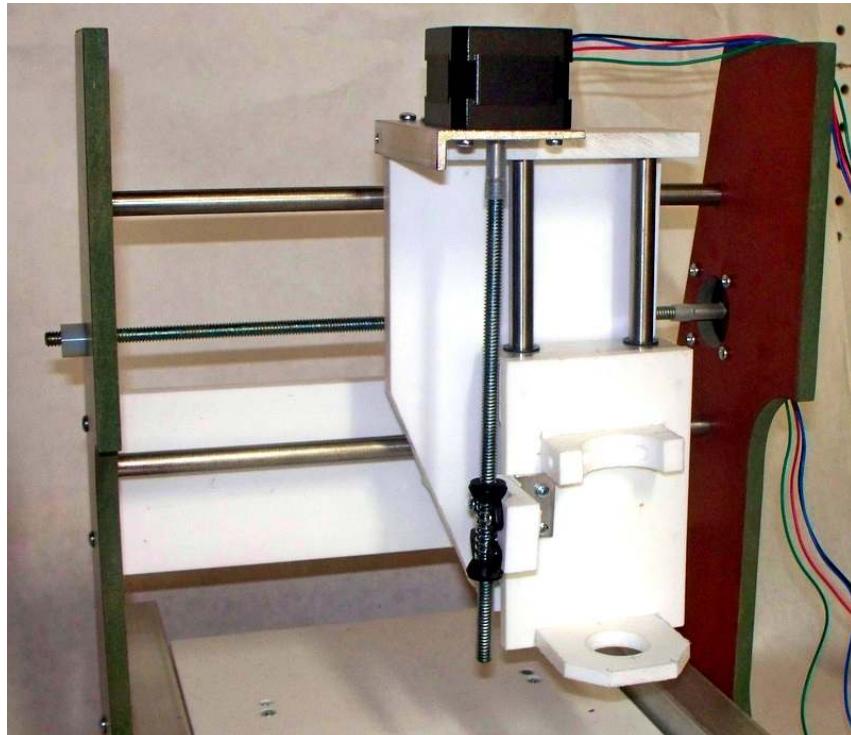
Z axis backplate, as shown in the diagram, and attach the bearing sub frame with #4 x 3/8" screws. Measure down from the top of the Z carriage backplate and make a mark at the location of the second bearing subframe. Do the same for the other side. Align the second bearing subframe to the marks and using 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 Desktop CNC Machine.

Axes Drivetrains

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

CAUTION: The DIY Desktop CNC Machine 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 clutch 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 Desktop CNC Machine.



The MyDIYcnc kits are supplied with optional clamps for this coupling but should only be used if the coupling is too loose to operate under normal operational loads. Be aware that the clamps effectively diminish the ability to slip when necessary to do so.

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. 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.



Heat the coupling in boiling water to make it more pliable

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.

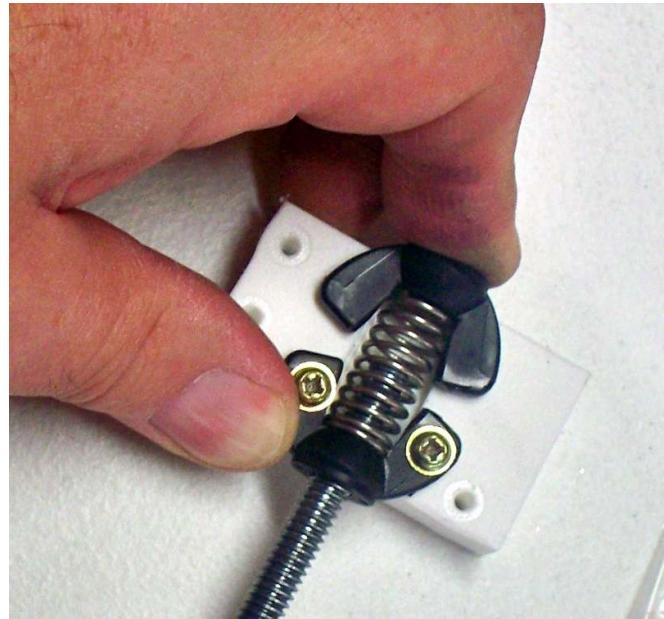
Repeat this process for all three drivetrains/motors.



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.

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.

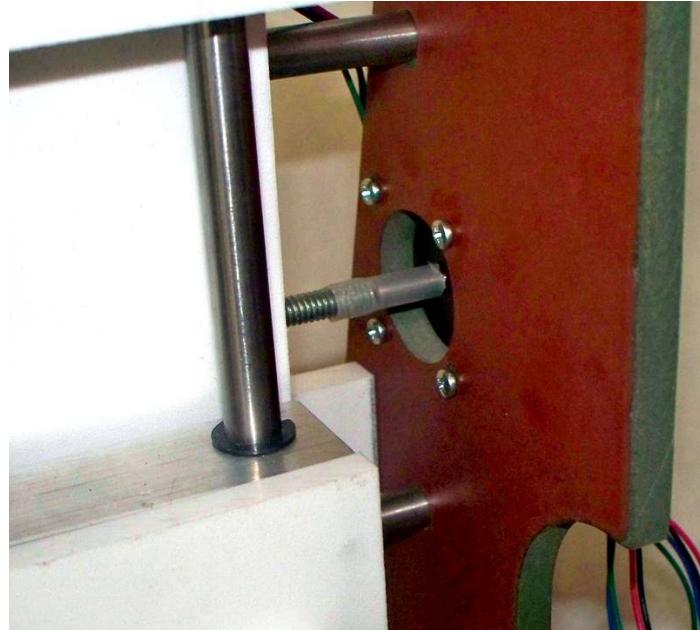
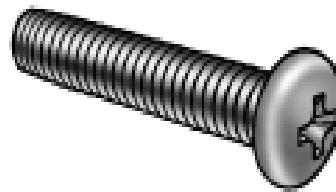


Thread the rod about halfway along the mounting block and slip the spring over the protruding end of the threaded rod. With one hand hold the second floating wingnut against the end of the mounting block, keeping the spring compressed. Continue to thread the rod until it enters the second floating wingnut and protrudes out the end of the anti-backlash assembly by an inch or so.

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 sub-frames but the same assembly process applies.



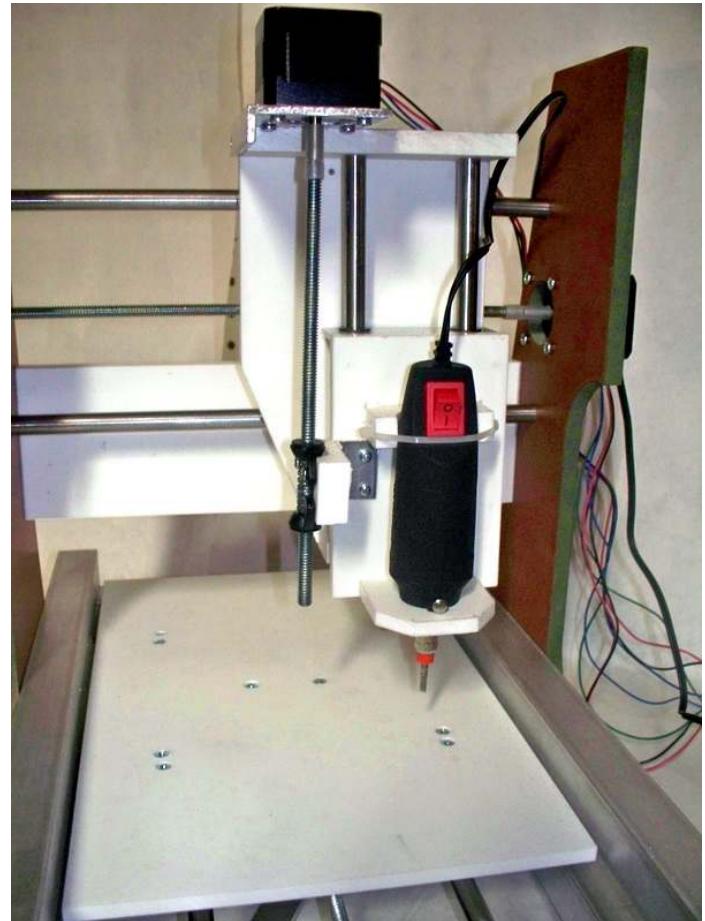
Stepper Motor Mounting

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 over-tightened. 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:

A completed Y axis assembly →



Test Your Axes

Test your axes by rotating the drivetrain (manually or with the Stepper Signal Exerciser) to move the carriages along their rods. If you experience any binding or excessive resistance at any point along the travel of the axis, refer to the section on Troubleshooting for diagnosis and remedies.

At this stage your DIY Desktop CNC Machine should be fully assembled. Now on to 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.

Modifying and Preparing your Power Supply

The DIY Desktop CNC Machine 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 Desktop CNC Machine 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 so 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.

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.



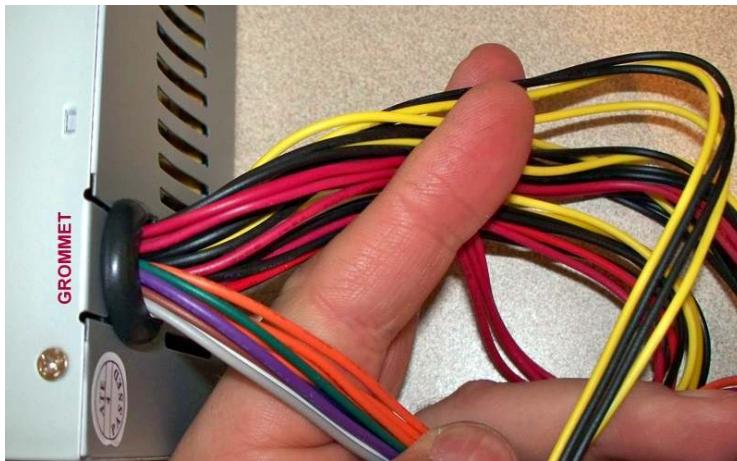
To achieve this find the green wire that goes to the largest connector and cut it and an adjacent black wire close to the connector. Strip back the insulation on both wires and twist them together. Using a wire nut or electrical tape, insulate this splice well as it will be pushed back into the power 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.

Selecting the Required Power Feeds

For the DIY Desktop CNC Machine, 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 (non black, 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.





power supply case.

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

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

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.

Attaching the Electronics Enclosure (optional)

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



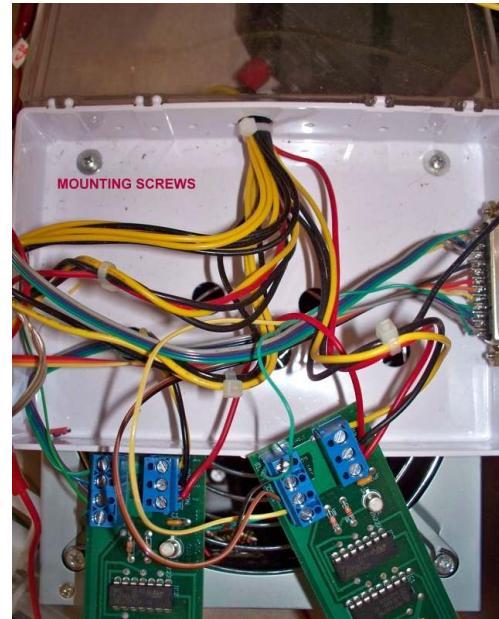
Note: Having the enclosure attached to your power supply will remove the possibility of movement in the wiring between the power supply and your electronics causing wires to come undone. It also keeps the distance between the power supply and your electronics as short as possible, and you can move this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

Unless you purchased a MyDIYcnc 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.

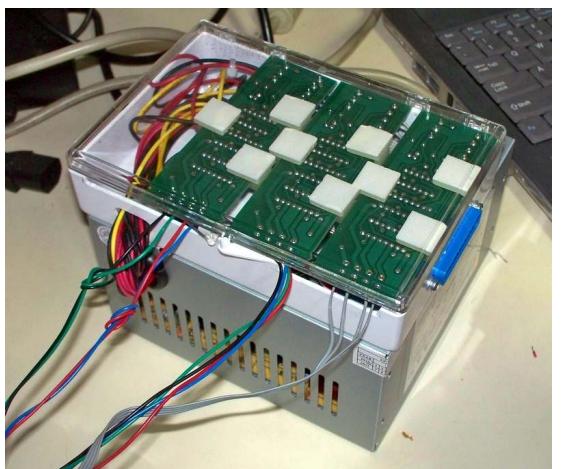
Using the power supply lid as a template, mark and drill two holes through the bottom of your enclosure to align with the power supply lid screws. Replace the lid. Use the power supply lid screws to attach the enclosure to the power supply lid and the lid to the supply.

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 MyDIYcnc 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

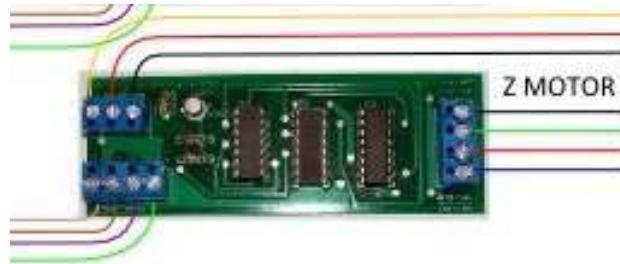
use with your DIY Desktop CNC Machine.

Wiring Motors and Limit Switches

There are two major wiring stages to setting up your DIY Desktop CNC Machine; wiring the stepper motors and axes limit switches, and wiring of the electronics to the Power Supply and PC.

Stepper Motor Wiring

Refer to the DIY Desktop CNC Machine master wiring diagram in the Appendices at the end of this manual.



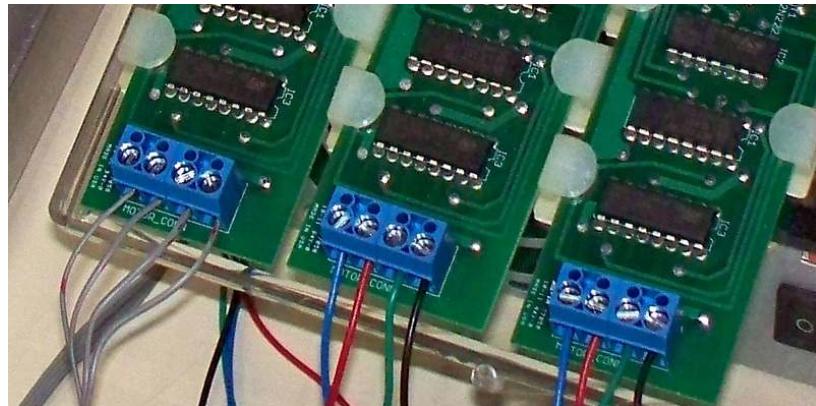
be **blue, red, green and black**, in that order.

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.

MyDIYcnc Stepper Motors

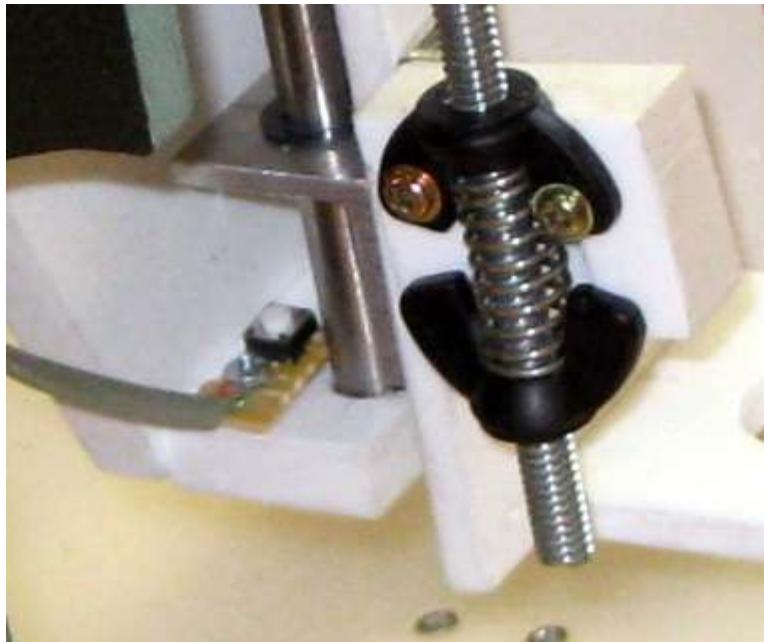
If you are using MyDIYcnc-provided stepper motors, then the motors are simply connected in the color order shown in the following diagram.

Reading from left to right, the colors should



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 Desktop CNC Machine could be damaged. The drivetrain couplings should prevent serious damage, but at the very least they will be

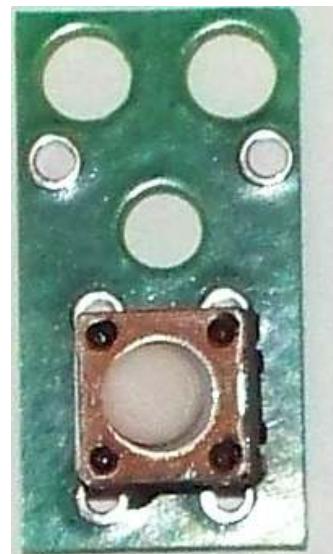
destroyed in the process.

To prevent this from happening, your DIY Desktop CNC Machine 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 Desktop CNC Machine would be shut down by the CAM application before any damage could occur.

MyDIYcnc Kits come with the mounting hole for each axis' limit switches pre-drilled in the correct location.

MyDIYcnc Limit Switches

The MyDIYcnc limit switches are provided in kit form. The switch provided is simply soldered to the small PCB, and a suitable length of two core cable (such as telephone or speaker wire) is soldered to the terminals on the PCB. The large hole in the center is for the mounting screw and plastic insulating washer. The remaining two large holes are for a cable tie which is used to secure the cable and provide strain relief for the contacts.





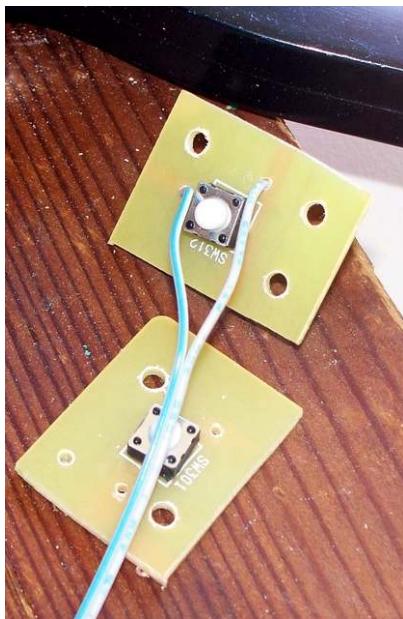
DIY Limit Switches

Any normally-open momentary switch can be located at the end of your axis' travel to become a limit switch.

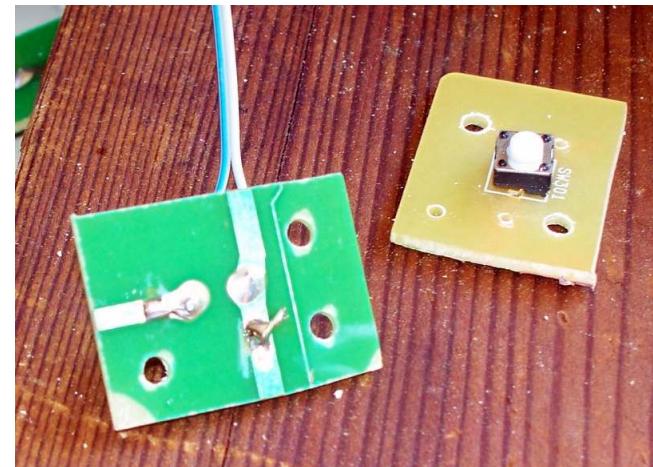
Probably the simplest way to make a set of limit switches is to use the button panel from a recycled piece of electronic equipment (as shown), such as a fax machine or a multifunction printer that uses a button panel.

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

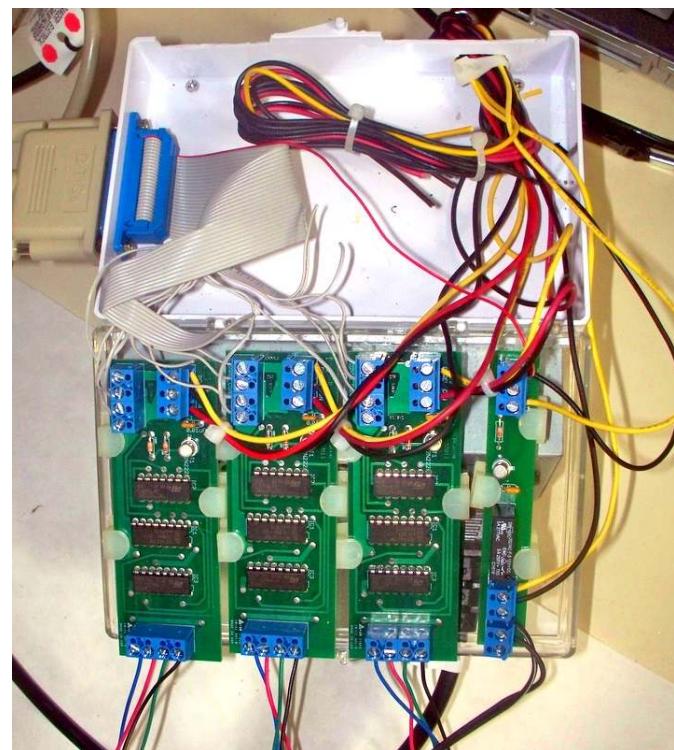
The limit switches for each axis are wired in parallel between ground and the input line for that axis on the parallel port. In this way, should either of the switches for an axis be pressed, the circuit will be closed and the limit emergency stop triggered. See the Wiring Diagrams Appendix for details.

Electronics Wiring

This is probably the most complex of the wiring tasks for your DIY Desktop CNC Machine. However, this task can be accomplished correctly by carefully following the diagram provided in the Wiring Diagrams Appendix.

Connecting a DB-25 male Connector

For connecting to a PC parallel port, the DIY Desktop CNC Machine 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. The MyDIYcnc kits come with the ribbon cable version of this connector.



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.



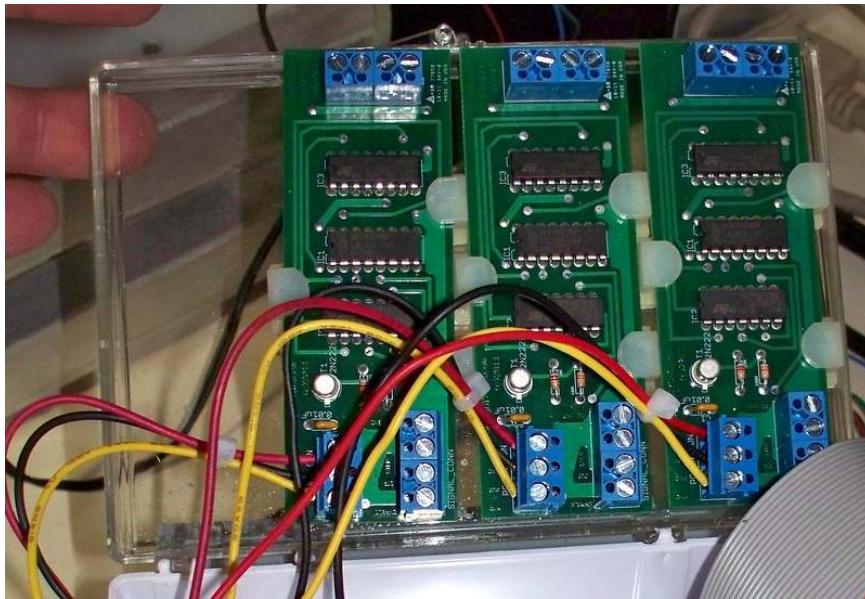
TIP: Tinning is very important as the ribbon cable cores are thin stranded wires and will not make good contact in the screw clamp connectors without the thickness of the additional solder.

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 MyDIYcnc enclosure or to the hole you made for it in your own enclosure.



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



MyDIYcnc Stepper Driver Modules have labels on the board, as shown in the illustration, indicating the purpose of each connection.

The MyDIYcnc stepper motors use 12 VDC and therefore the 12 VDC (yellow) wires are connected to the motor power connector (MTR) on the MyDIYcnc 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 MyDIYcnc Stepper Driver Module. Details about connecting other stepper motors are provided in the section *Expanding Your DIY Desktop CNC Machine* below.

Configuring your PC and CNC app

Your DIY Desktop CNC Machine 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 Desktop CNC Machine. 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	Interface 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\$95
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 Desktop CNC Machine. There are many step-by-step setup tutorials and guides for each of these third-party software applications. Registered users will find a list of such guides in the resources section of the www.MyDIYCNC.com website. With those guides and the following information, you will be able to configure your host PC and CNC application to drive your DIY Desktop CNC Machine.

DIY Desktop CNC Machine Software Configuration Parameters:

Table Dimensions	7 $\frac{3}{4}$ " [197 mm] x 11" [280 mm]
Table Travel	9 $\frac{1}{2}$ " [241 mm] Modifiable to max 15" [381 mm]
Working Height Clearance	3" [76 mm]
Max Spindle Height	5" [127 mm]
Y axis travel	6" [152 mm]
Z axis travel	4" [102 mm]
Step Resolution	0.001" [0.0254 mm]
Steps Per Revolution	50
Step Degrees	7.2
Distance per Step	0.001" [0.0254 mm]
Step System	Full Step
Enable Required per Motor	Yes

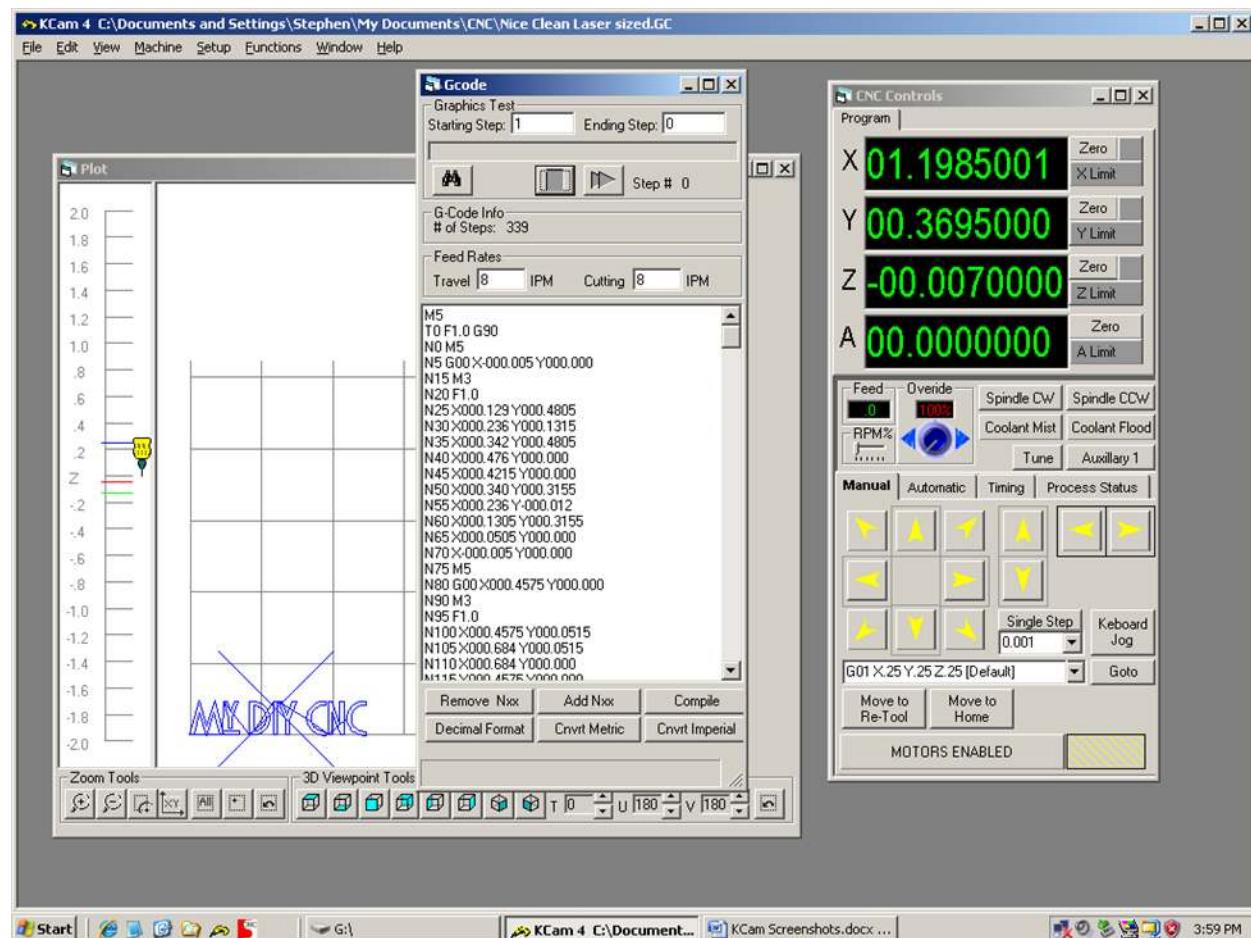
The following sections provide specific settings for particular applications. Use the above general settings, along with the application's own tutorial and the software-specific information provided below, to configure your DIY Desktop CNC Machine.

KCam (Windows XP/98)

KCam is an excellent CNC application, and it performs very well with the DIY Desktop CNC Machine. In fact, a significant amount of the development of the DIY Desktop CNC Machine and the demonstration videos provided on the MyDIYcnc website was done with KCam as the CNC control application.

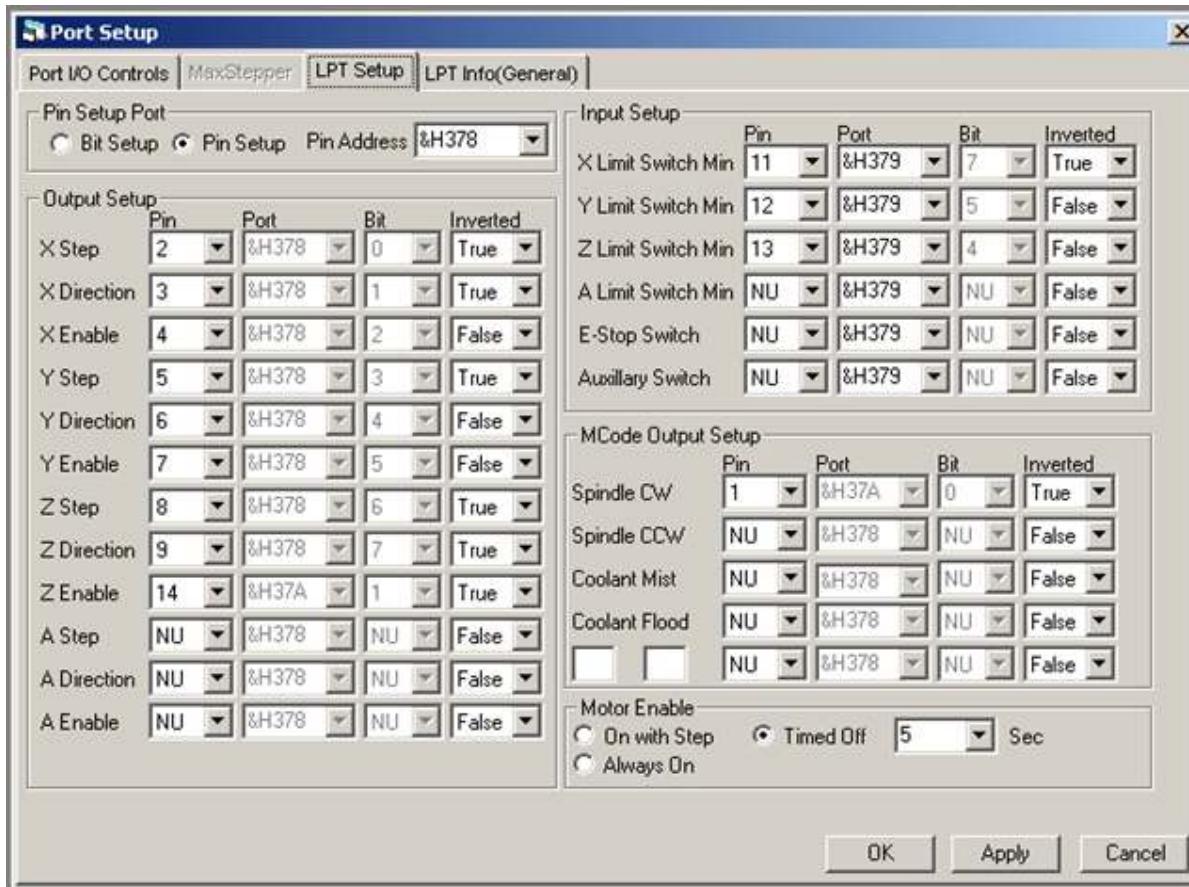


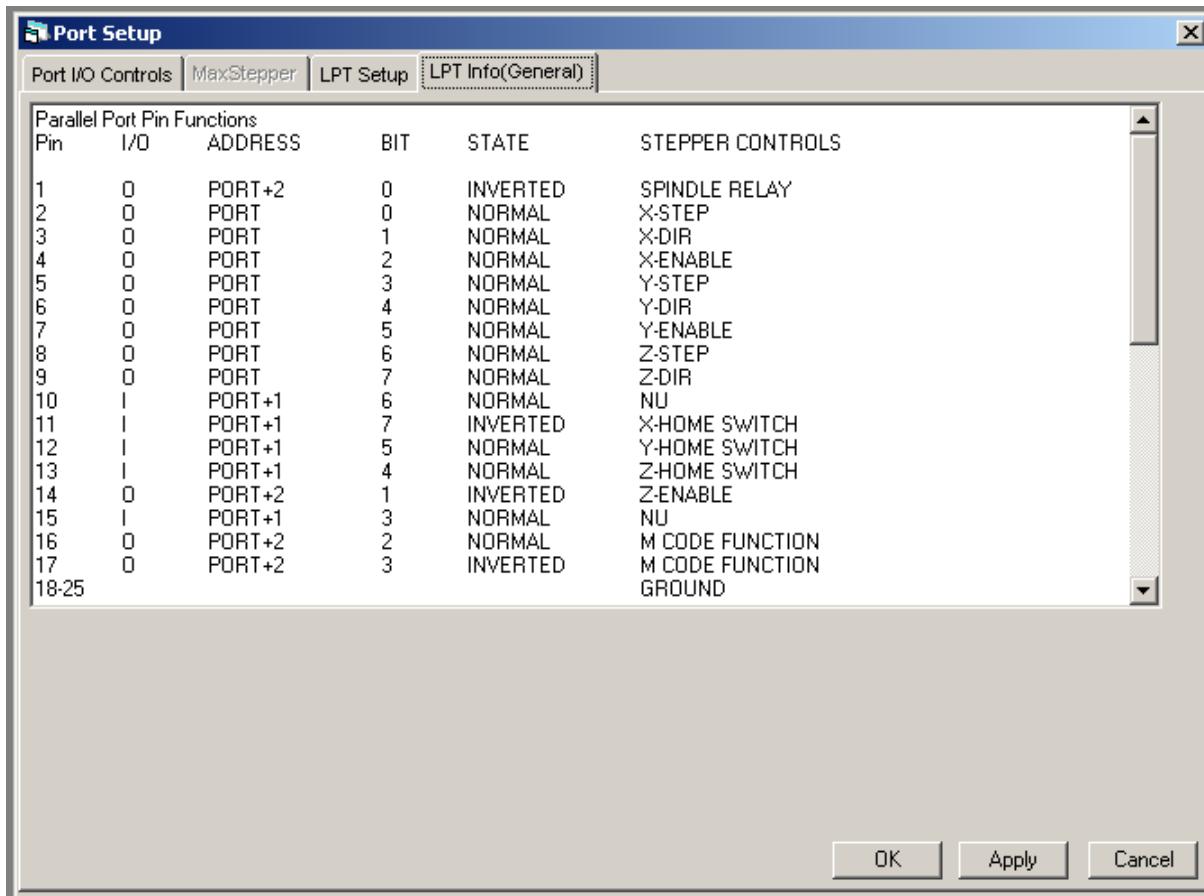
Use the following screenshots and notes to configure KCam to drive your DIY Desktop CNC Machine.



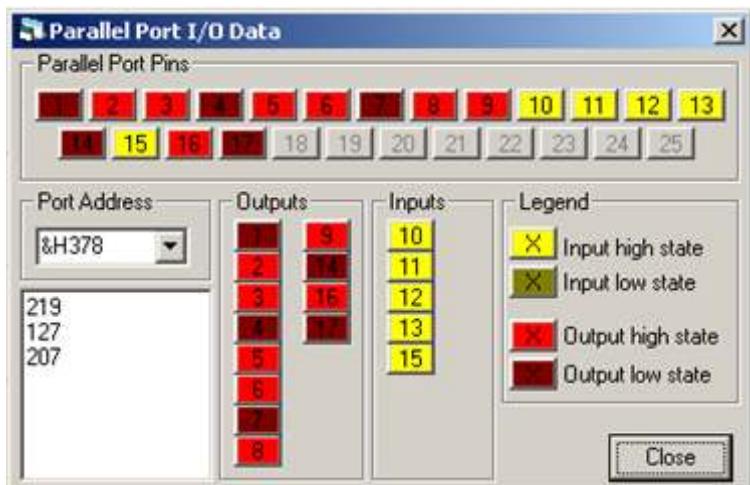
KCam interface screen, showing the Plot table, G-code and CNC Controls windows.

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 Desktop CNC Machine wiring diagrams and instructions. Use this screenshot and the DIY Desktop CNC Machine wiring diagrams to troubleshoot connection problems with KCam.

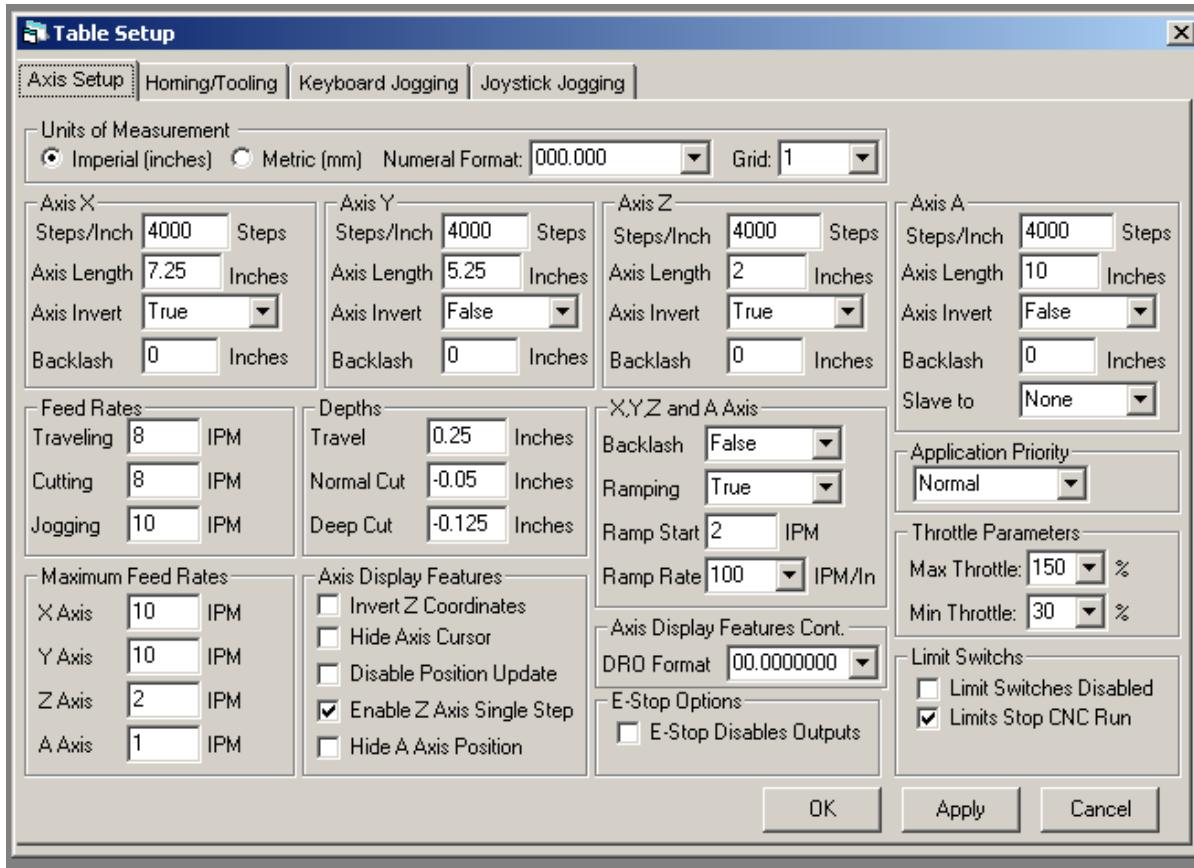




Once this configuration is set up correctly, use the Parallel Port I/O Data screen to monitor the parallel port channels. See that they correspond to your use of the CNC manual controls.

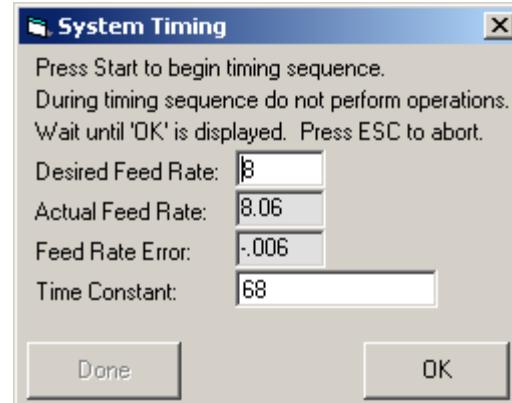


Probably the most important setup screen in KCam is the Table Setup screen. Use the parameters shown to configure your installation of KCam to your DIY Desktop CNC Machine.



Note: Even though your DIY Desktop CNC Machine is a 1000-step-per-inch machine, KCam requires a value of **4000 steps/inch** to apply the correct scale to your DIY Desktop CNC Machine.

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 Desktop CNC Machine.



Now that you have configured your DIY Desktop CNC Machine parameters in KCam, it's time to test its operation.

Use the CNC Controls window to jog the DIY Desktop CNC Machine's axes back and forth.

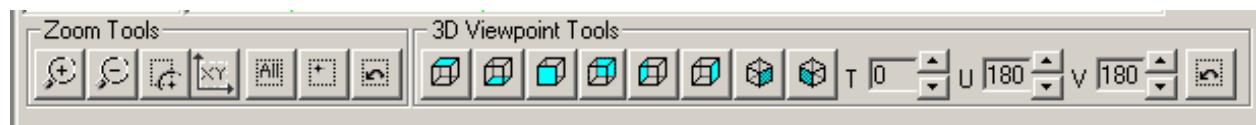
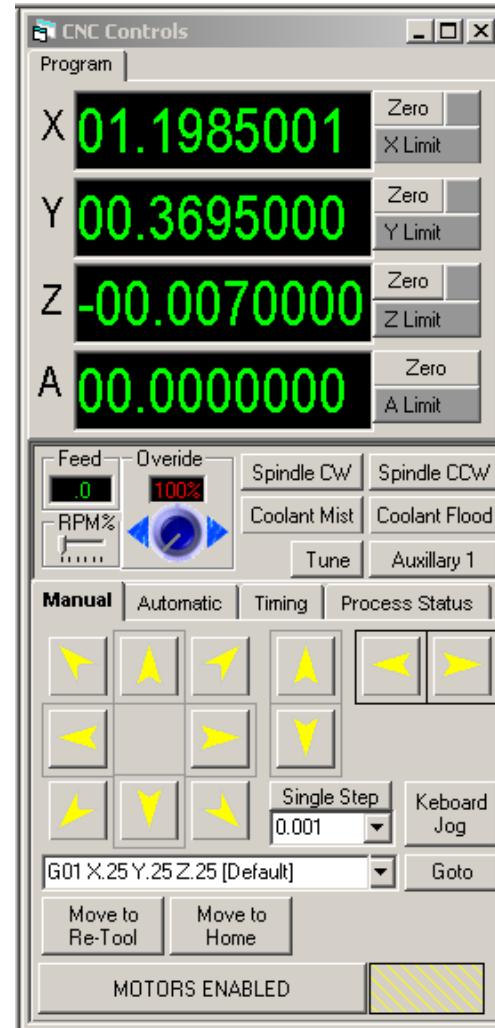
If you have limit switches installed, they should halt all operations when clicked and the button at the bottom of the CNC Controls screen will display MOTORS DISABLED against a red background.

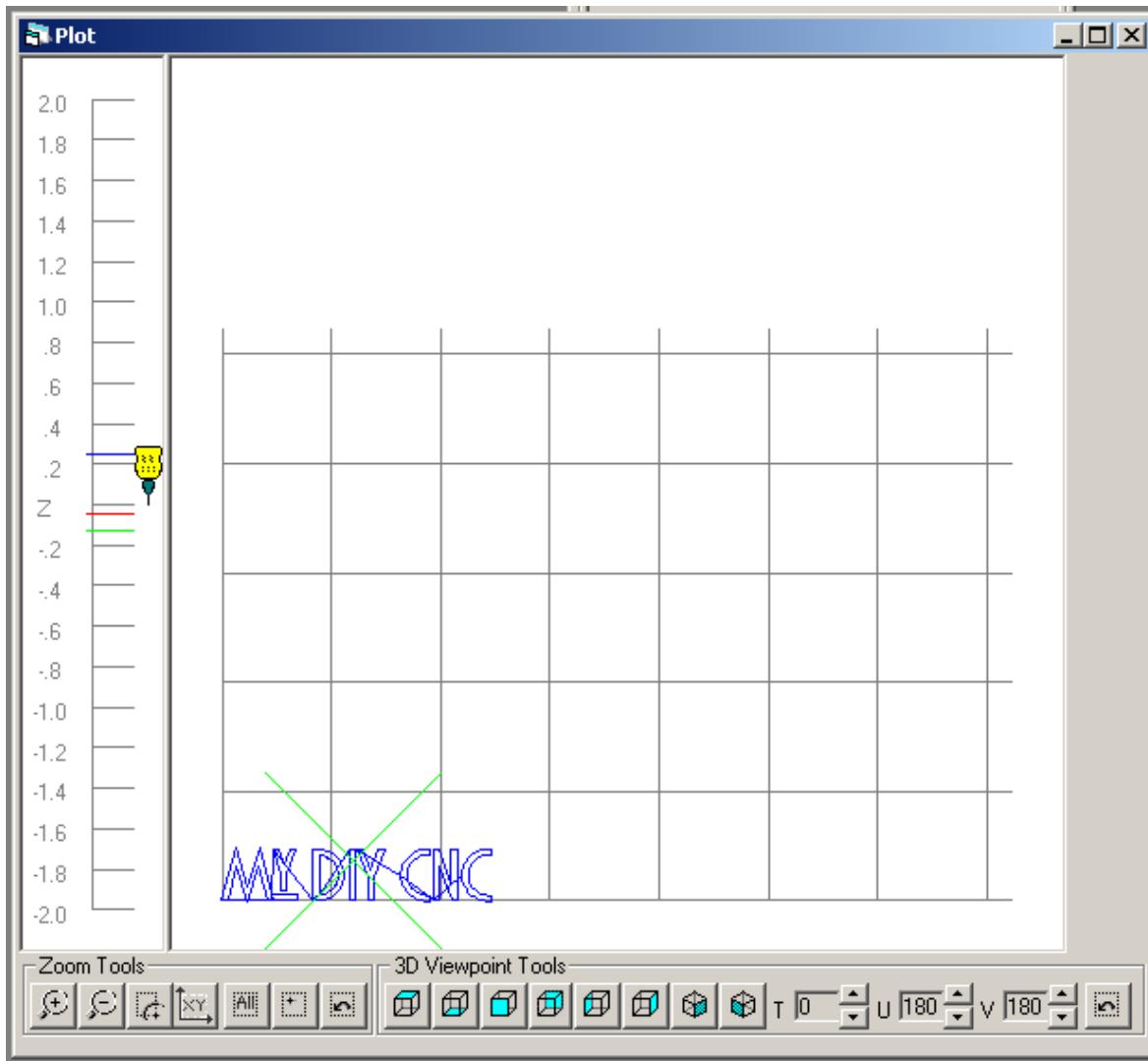


Check what caused the issue. The limit button to the right of the axes coordinates display will be highlighted to indicate which axis triggered the limit switch. You should jog the offending carriage away from the limit switch and click the red MOTORS DISABLED button to re-enable the motors.

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 Desktop CNC Machine's table. The plot should display on the table diagram and give a good indication as to where it will be located on the DIY Desktop CNC Machine.

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.

Check out the resources section of the www.MyDIYcnc.com website for more guides and tutorials for KCam.

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 CD-ROM, 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 Desktop CNC Machine.



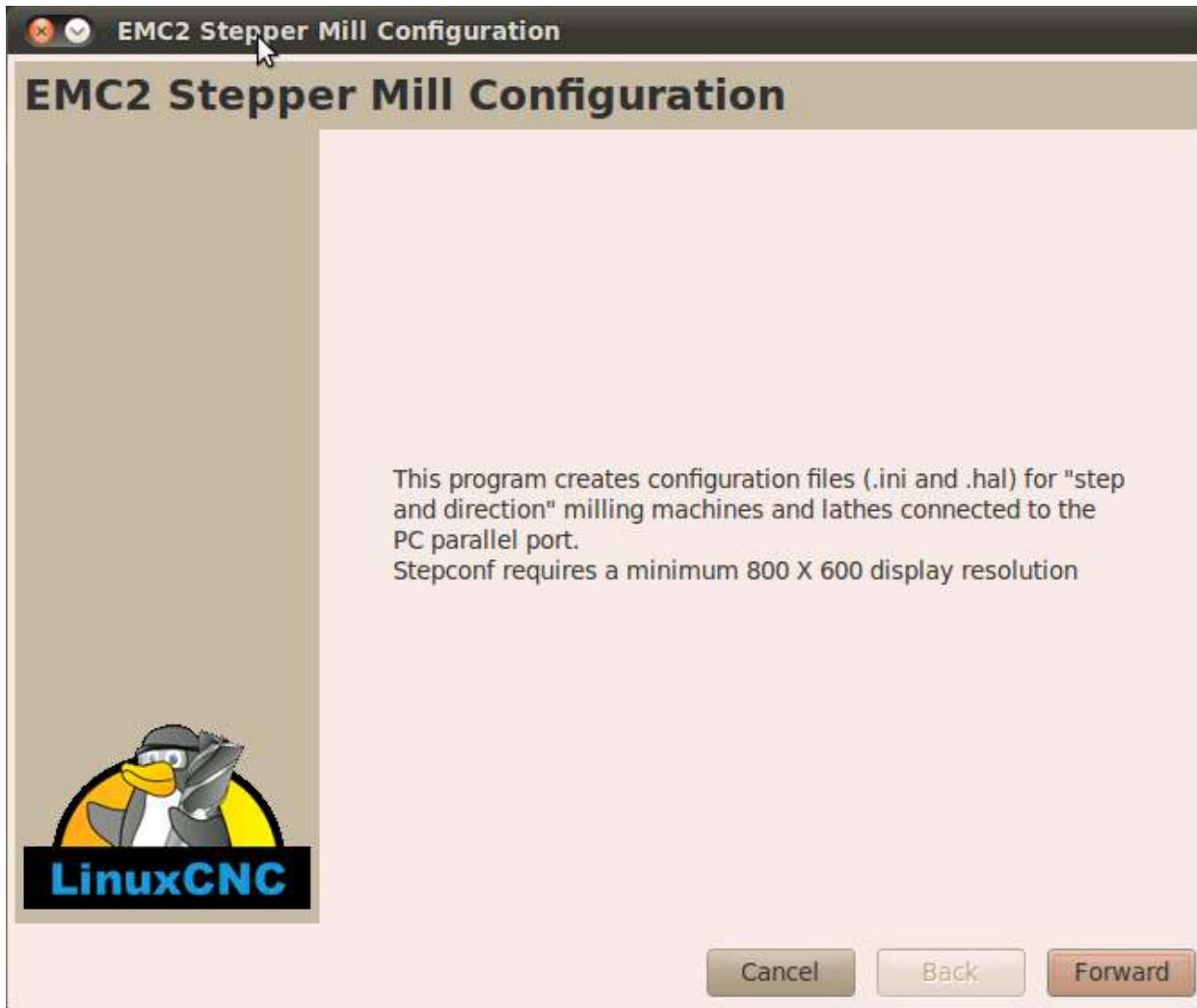
As a registered user at www.MyDIYCNC.com you will be able to download an EMC2 configuration file **MyDIYCNC.stepconf** for your DIY Desktop CNC Machine. The instructions below show you how to create your own configuration file from scratch.

Use the following screenshots and notes to configure EMC2 to drive your DIY Desktop CNC Machine.



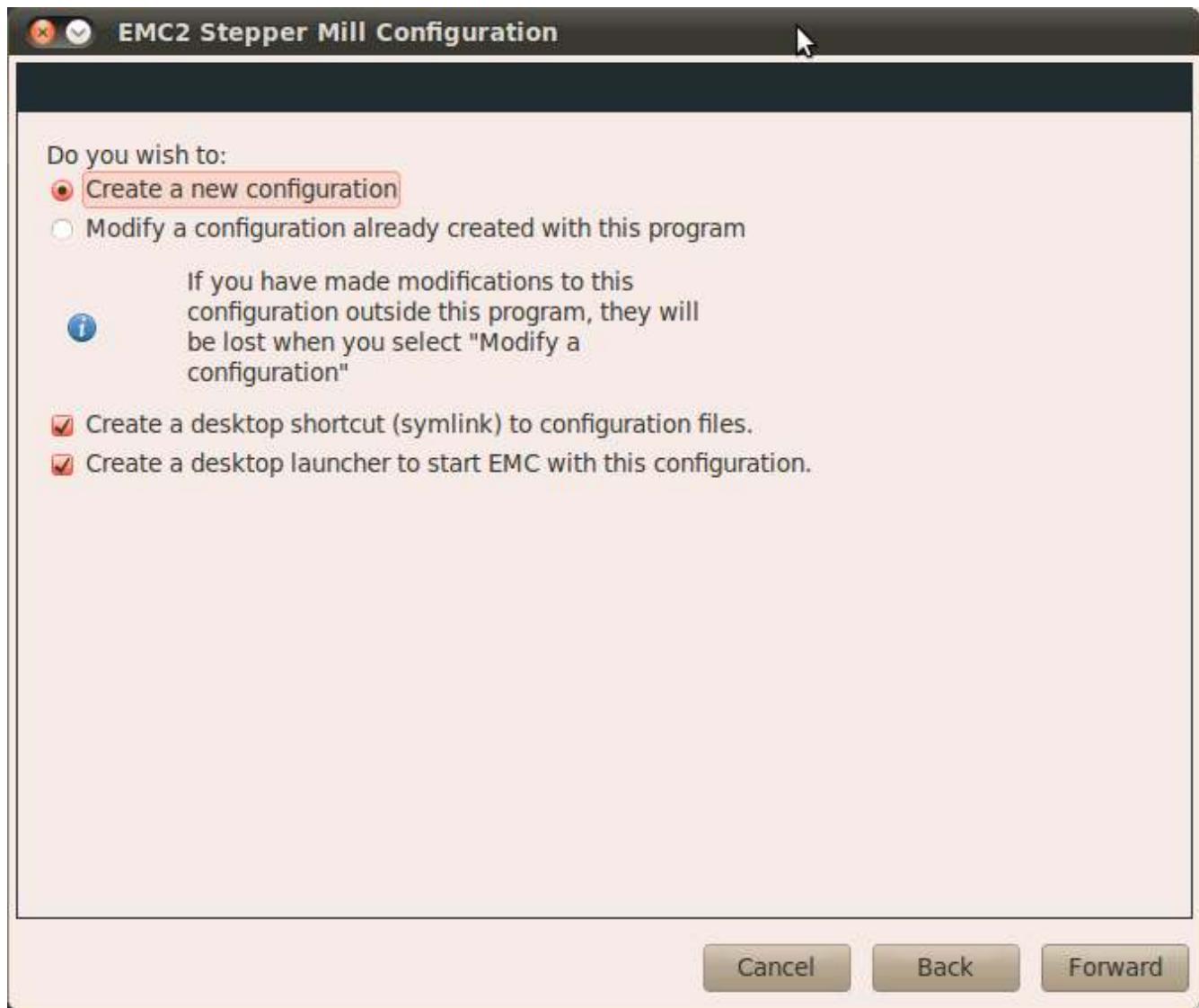
Be sure to read the EMC2 Getting Started manual at www.linuxcnc.org/docs/EMC2_Getting_Start.pdf. It's a good idea to print it out and refer to it as you set up your DIY Desktop CNC Machine. It will provide a wealth of additional information regarding the setup of EMC2 on your PC.

Check the resources section of the www.MyDIYCNC.com website for additional valuable information about EMC2 and your DIY Desktop CNC Machine.

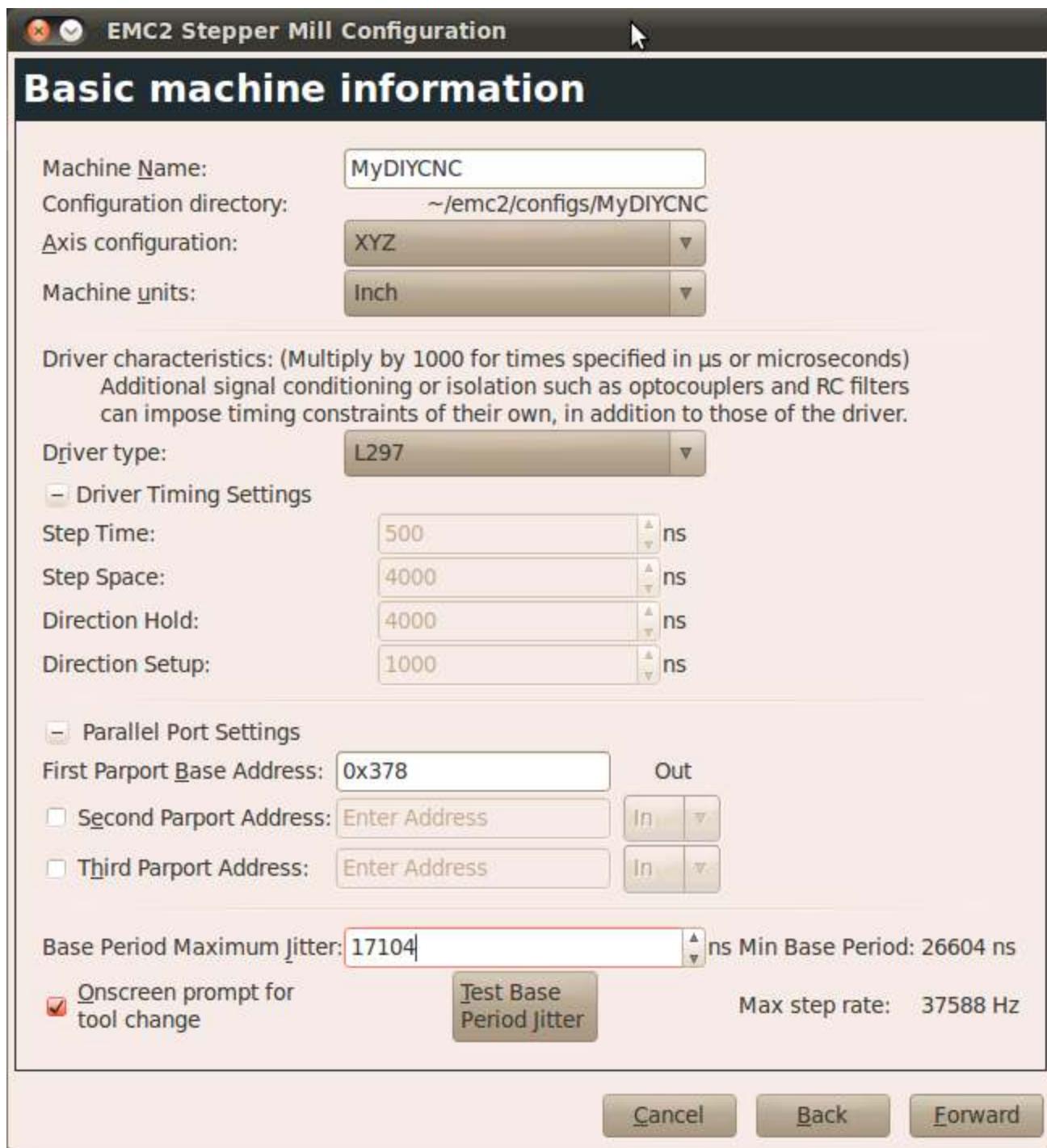


The EMC2 StepConf Wizard

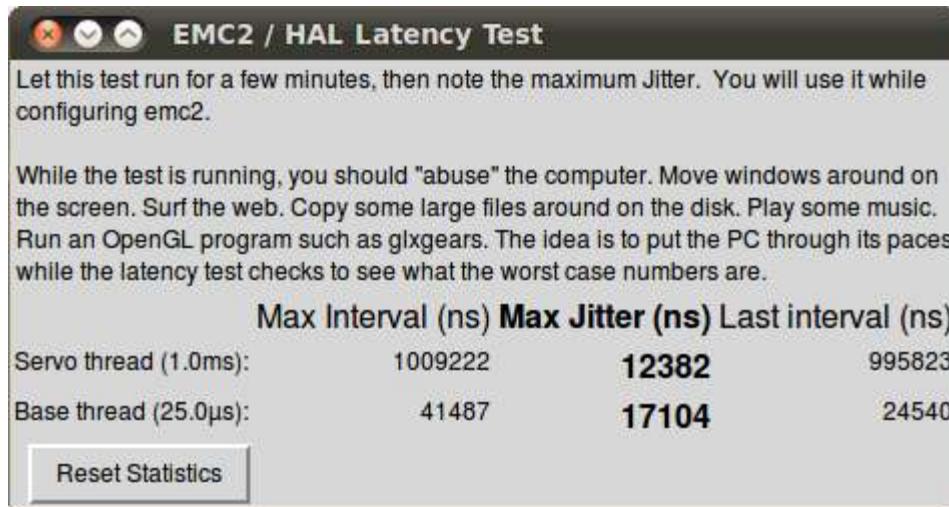
Launch the StepConf Wizard. You'll find it under the CNC applications group. Take note of the information given in each screen as you progress from screen to screen. Click the Forward button.



You are creating a new configuration file for your DIY Desktop CNC Machine. 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.

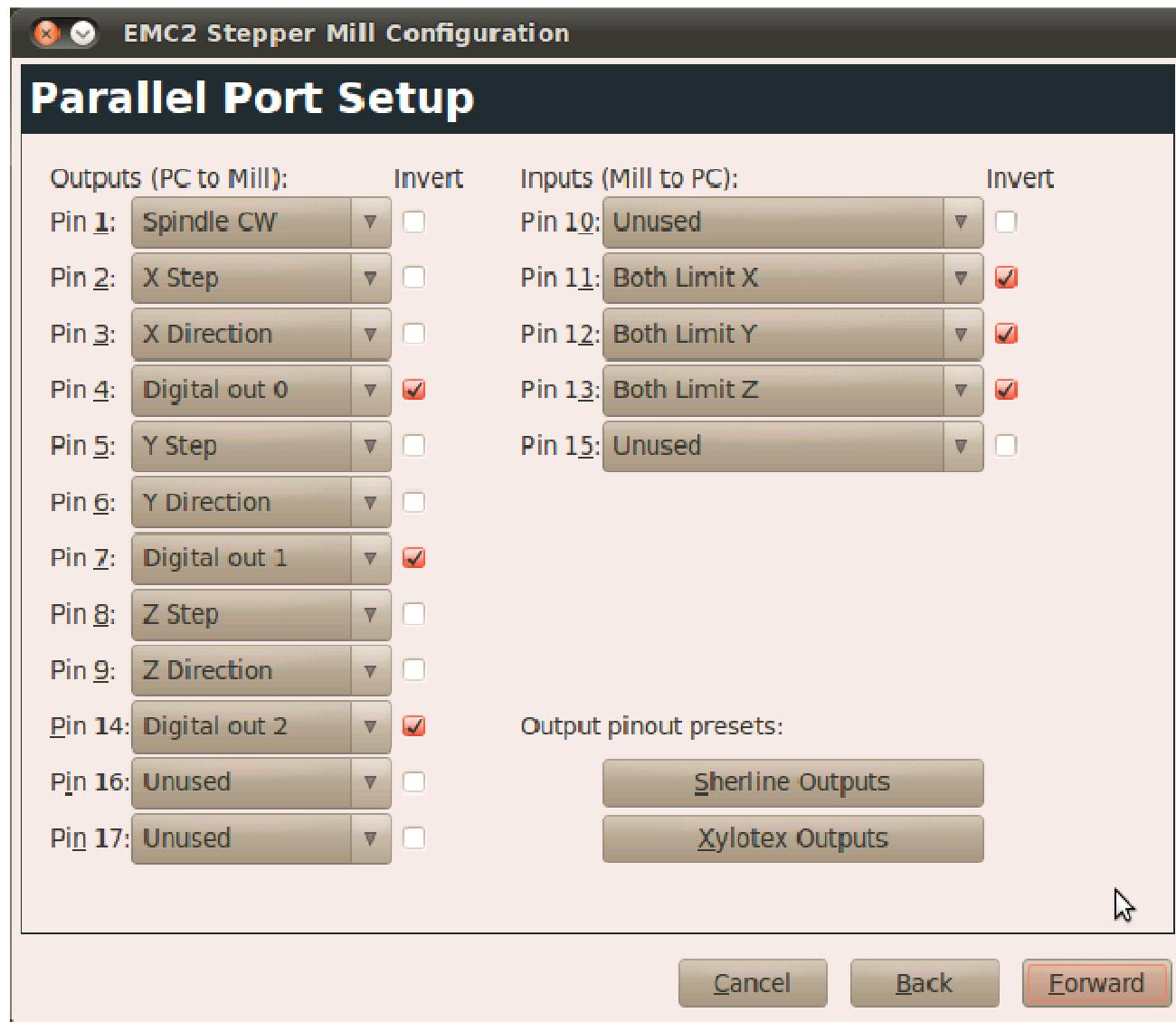


The Latency Test application at work

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 Desktop CNC Machine. Enter the same values into your Parallel Port Setup window as seen below in this illustration.

WARNING: Your MyDIYCNC Stepper Driver Modules use step, direction and enable signals to control your DIY Desktop CNC Machine's 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 appropriate port for each axis, but it can only do so all the time rather than on demand. The net result 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 should still stay within operating temperatures, when using EMC2 it will be necessary to run the DIY Desktop CNC Machine with the electronics' enclosure open to prevent heat buildup.

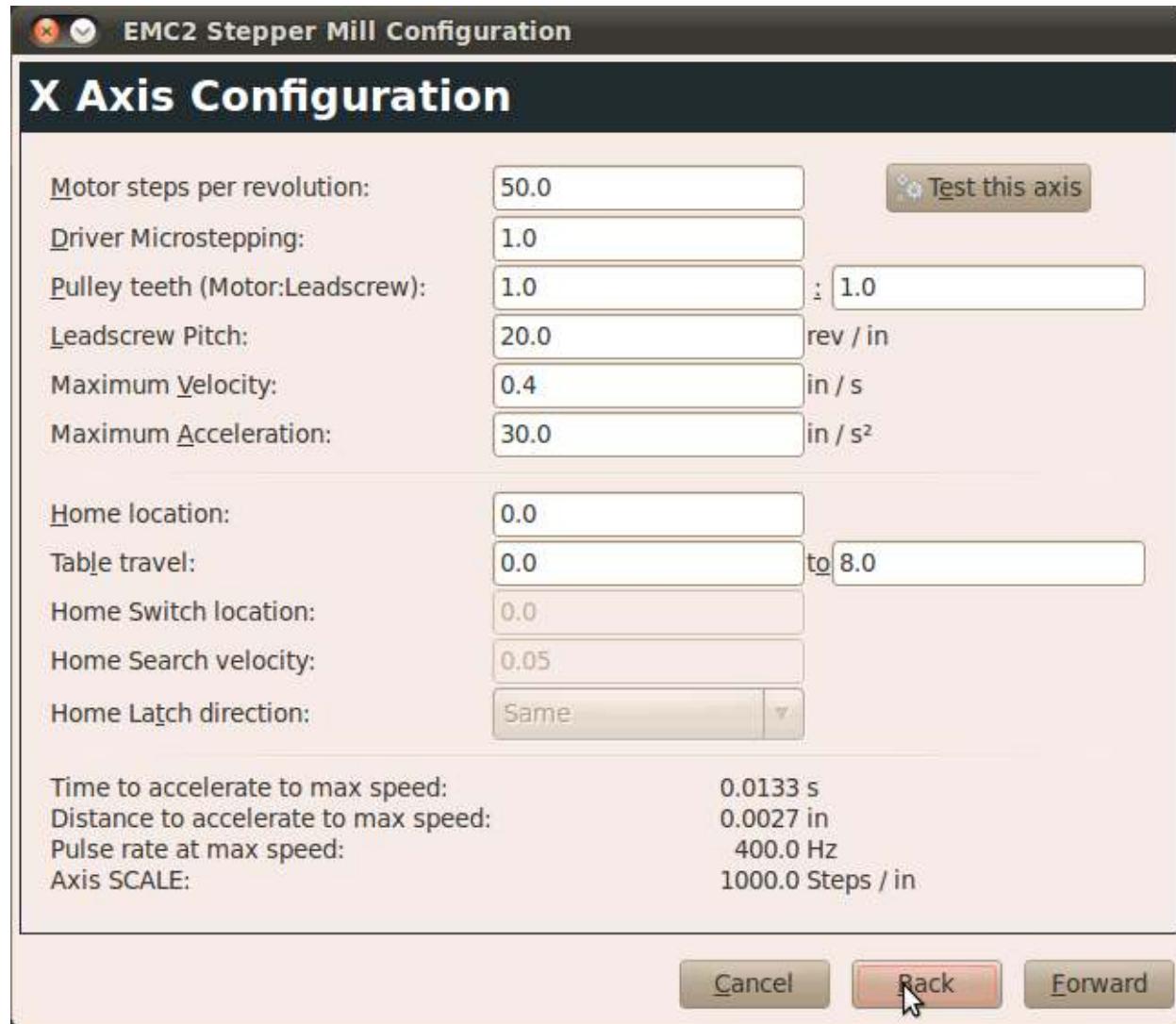




Note the pseudo-enable signals set for pins 4, 7 and 14

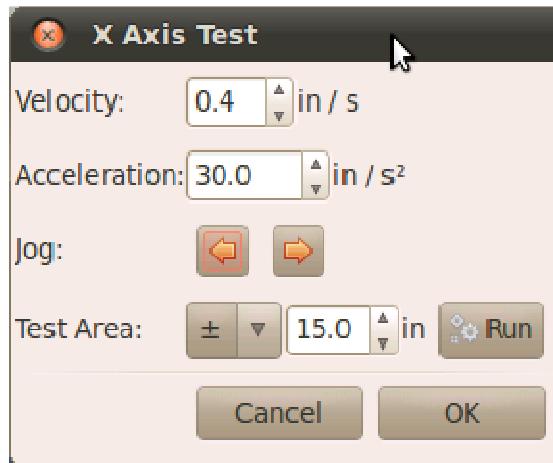
If you are using the optional limit switches, be sure to invert the signals on channels 11, 12 and 13 to accommodate the normally-open switches used in the MyDIYcnc Limit Switch Modules. If you are not using limit switches, then make sure that pins 11, 12 and 13 are set as "Unused".

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 Desktop CNC Machine, that EMC2 can control your axis and your step and direction connections are correct.



X Axis settings

The axes settings shown should work fine for your DIY Desktop CNC Machine 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 →

EMC2 Stepper Mill Configuration

Y Axis Configuration

<u>Motor steps per revolution:</u>	50.0	
<u>Driver Microstepping:</u>	1.0	
<u>Pulley teeth (Motor:Leadscrew):</u>	1.0	: 1.0
<u>Leadscrew Pitch:</u>	20.0	rev / in
<u>Maximum Velocity:</u>	0.4	in / s
<u>Maximum Acceleration:</u>	30.0	in / s ²
<u>Home location:</u>	0.0	
<u>Table travel:</u>	0.0	to 5.5
<u>Home Switch location:</u>	0.0	
<u>Home Search velocity:</u>	0.05	
<u>Home Latch direction:</u>	Same	
<u>Time to accelerate to max speed:</u>	0.0133 s	
<u>Distance to accelerate to max speed:</u>	0.0027 in	
<u>Pulse rate at max speed:</u>	400.0 Hz	
<u>Axis SCALE:</u>	1000.0 Steps / in	

Cancel Back Forward

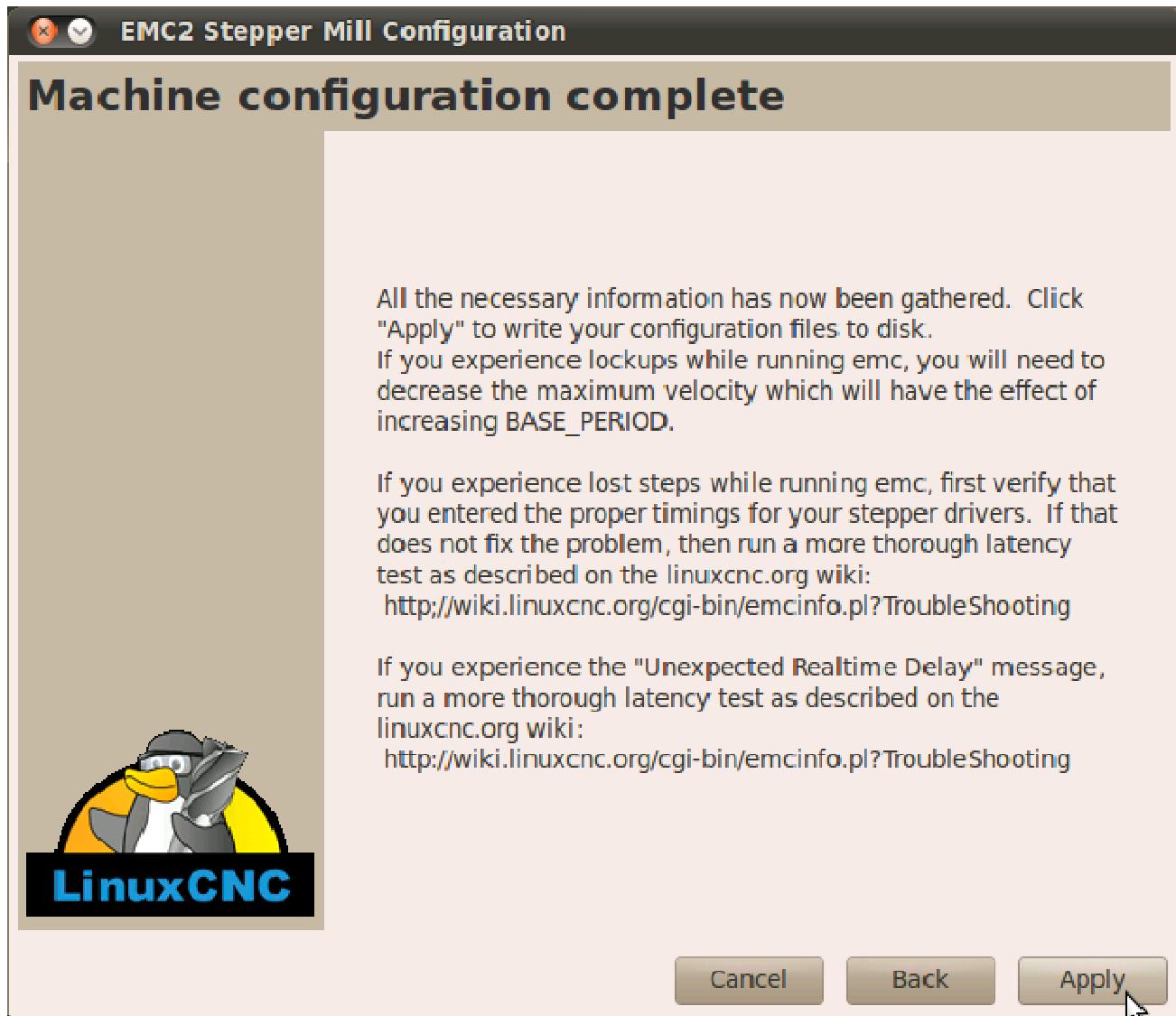
EMC2 Stepper Mill Configuration

Z Axis Configuration

<u>Motor steps per revolution:</u>	<input type="text" value="50.0"/>	<input type="button" value="Test this axis"/>
<u>Driver Microstepping:</u>	<input type="text" value="1.0"/>	
<u>Pulley teeth (Motor:Leadscrew):</u>	<input type="text" value="1.0"/>	: <input type="text" value="1.0"/>
<u>Leadscrew Pitch:</u>	<input type="text" value="20.0"/>	rev / in
<u>Maximum Velocity:</u>	<input type="text" value="0.4"/>	in / s
<u>Maximum Acceleration:</u>	<input type="text" value="30.0"/>	in / s ²
<u>Home location:</u>	<input type="text" value="0.0"/>	
<u>Table travel:</u>	<input type="text" value="-4.0"/>	to <input type="text" value="0.0"/>
<u>Home Switch location:</u>	<input type="text" value="0.0"/>	
<u>Home Search velocity:</u>	<input type="text" value="0.05"/>	
<u>Home Latch direction:</u>	<input type="text" value="Same"/>	<input type="button" value="▼"/>
<u>Time to accelerate to max speed:</u>	0.0133 s	
<u>Distance to accelerate to max speed:</u>	0.0027 in	
<u>Pulse rate at max speed:</u>	400.0 Hz	
<u>Axis SCALE:</u>	1000.0 Steps / in	

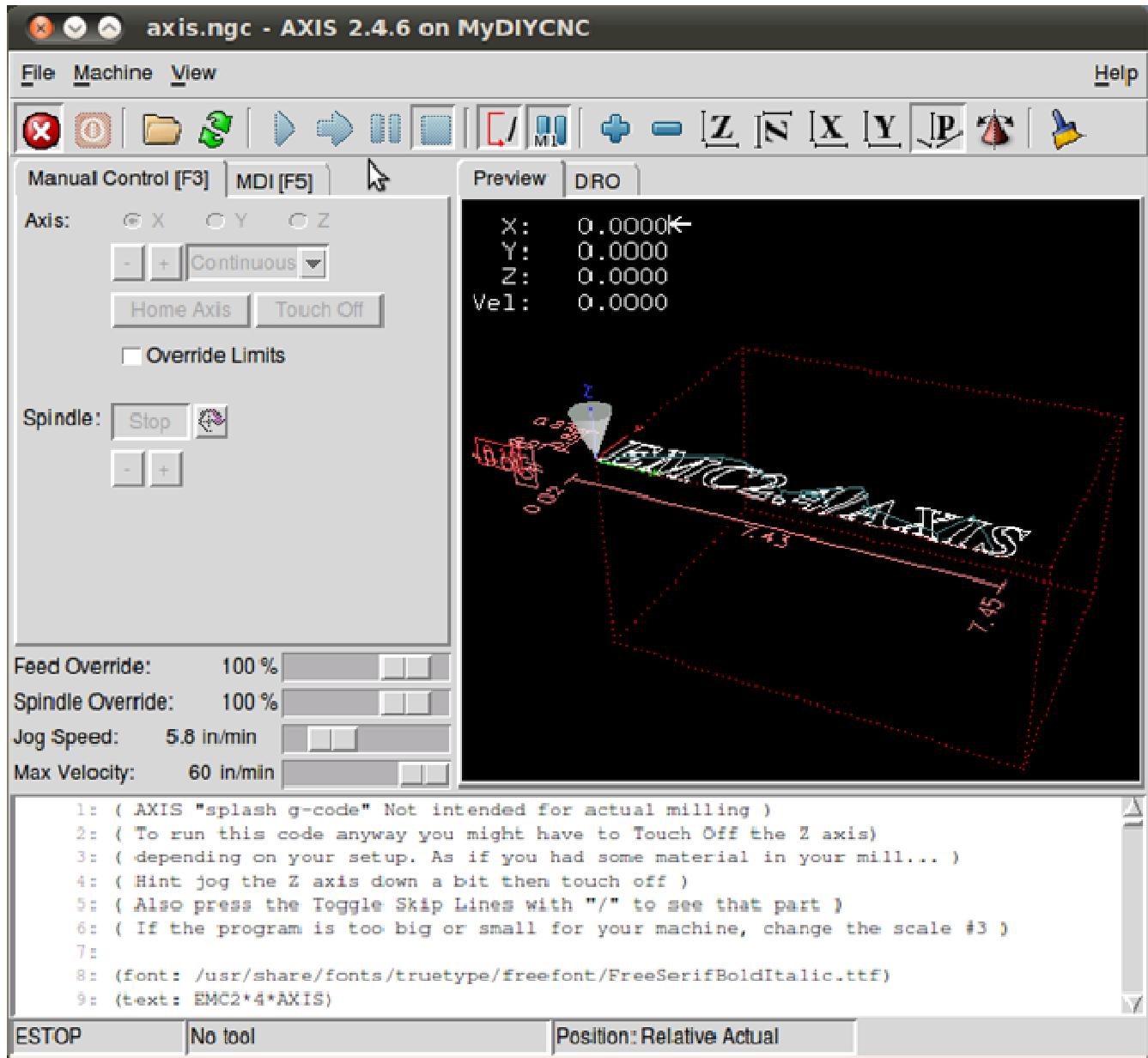
Z Axis Configuration. Note the table travel values are negative as the Z axis travels away from the table.

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 Desktop CNC Machine

You should now be good to go with EMC2 and your DIY Desktop CNC Machine. 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 Desktop CNC Machine. The www.MyDIYcnc.com website will also provide additional information and resources for using EMC2.

Other CNC Applications (Mach3, TurboCNC, etc.)

Your DIY Desktop CNC Machine will work with any of the other CNC applications that use a discreet enable/step/direction signal set to control the CNC axes steppers. You will find more details about how to configure these applications for your DIY Desktop CNC Machine in the resources section of the www.MyDIYCNC.com website.

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/

Expanding Your DIY Desktop CNC Machine

Workspace Dimensions

To expand the physical workspace of your DIY Desktop CNC Machine 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 Desktop CNC Machine's 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 Desktop CNC Machine to extend the travel of the X axis. The X axis stepper motor obstructs the table travel. Cut a $1\frac{1}{4}$ " [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.

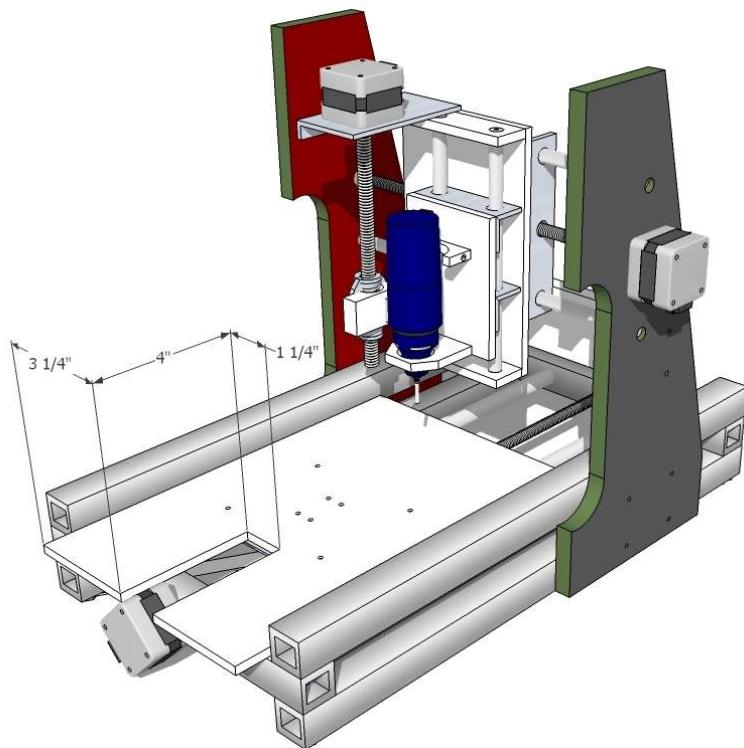


Table modification to allow more X axis travel

Spindle Upgrades

Your DIY Desktop CNC Machine, 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.

You will find several spindle upgrade options at the MyDIYcnc website.

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

WARNING: Never use a cordless rotary tool as a spindle on your DIY Desktop CNC Machine. 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 Desktop CNC Machine may damage itself severely in trying to continue with the operation when the spindle is stuck in the work piece.



The MyDIYcnc Spindle Control Module has the ability to switch on and off the power to any cabled rotary tool correctly wired to its power terminals.

Stepper Motor Upgrades

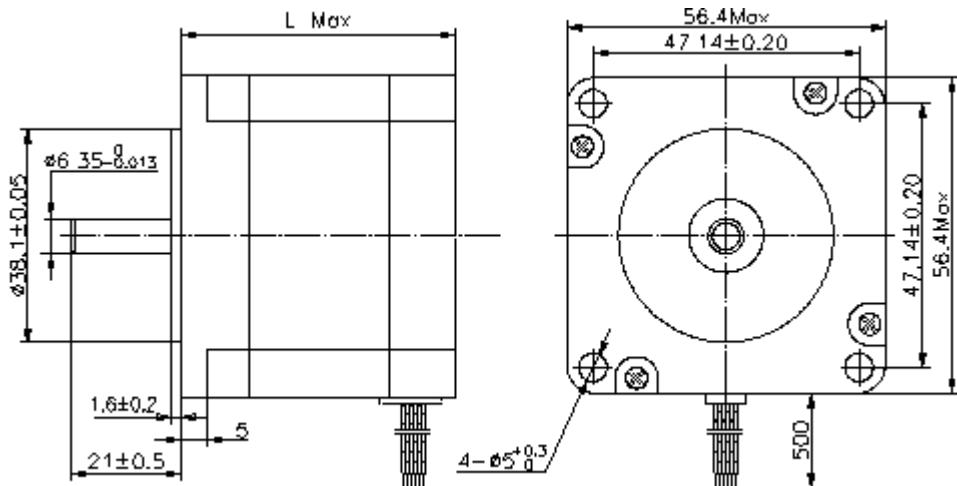
Larger Stepper Motors

The DIY Desktop CNC Machine 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 tap of the motor coils and wiring across the coils as if it were a bipolar stepper motor. You’ll find instructions on how to do this in the resources section of the MyDIYcnc website.

However, you should be able to easily accommodate a wide range of different stepper motors to meet your specific needs. The MyDIYcnc 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 Desktop CNC Machine 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.

Salvaged and Recycled Stepper 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 Desktop CNC Machine 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). You'll find more details about configuring stepper motors in the resources section of the MyDIYcnc website.

Wire Connection Diagrams

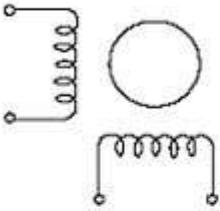
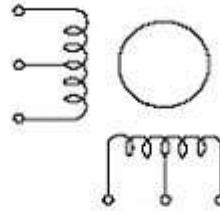
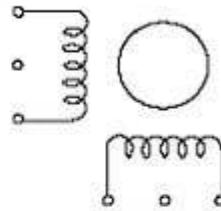
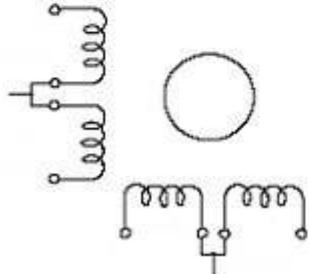
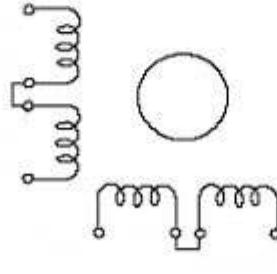
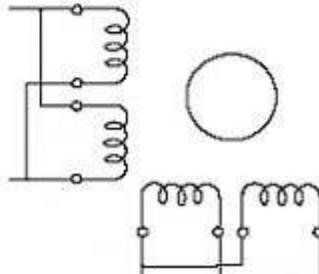
4 Lead Bipolar Connection	6 Lead Unipolar Connection	6 Lead Bipolar (Series) Connection
		
8 Lead Unipolar Connection	8 Lead Bipolar (Series) Connection	8 Lead Bipolar (Parallel) Connection
		

Image source: www.probotix.com

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 MyDIYcnc 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 MyDIYcnc 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

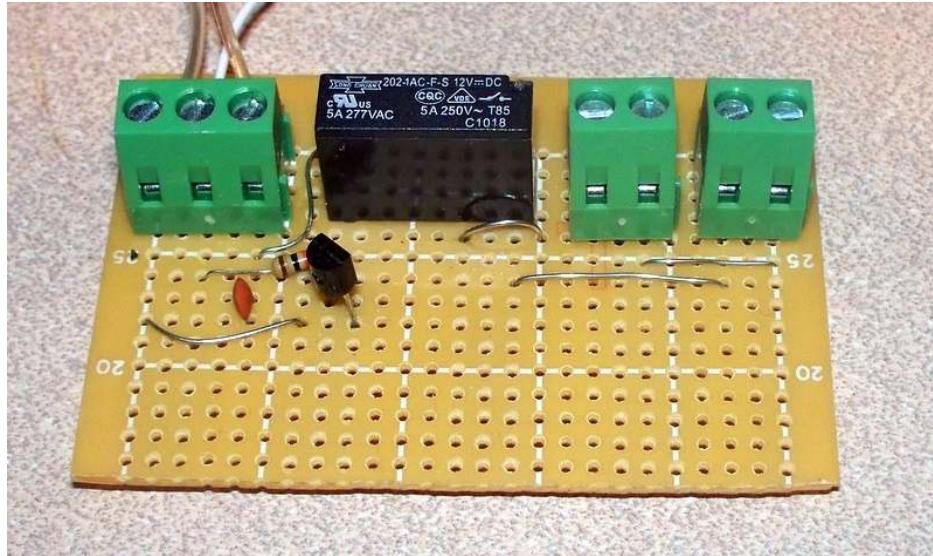
Once you have determined the settings of your stepper motors, be sure to enter these values into your CNC application's configuration settings.

Electronics Upgrades

In addition to the MyDIYCNC electronics to drive the DIY Desktop CNC Machine's stepper motors you may wish to upgrade to a Spindle Control Module and Limit Switch Modules to round out your machine.

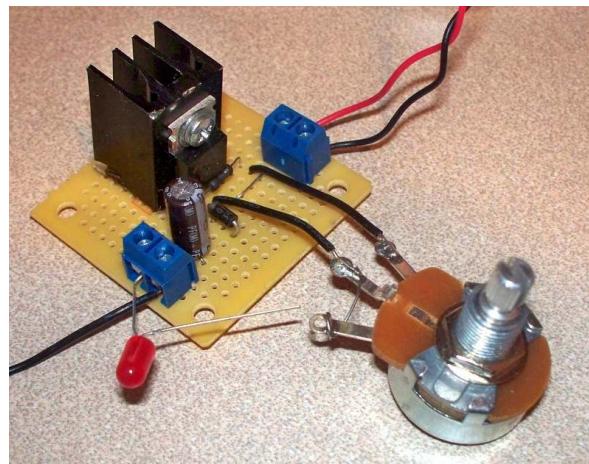
The Spindle Control Module

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

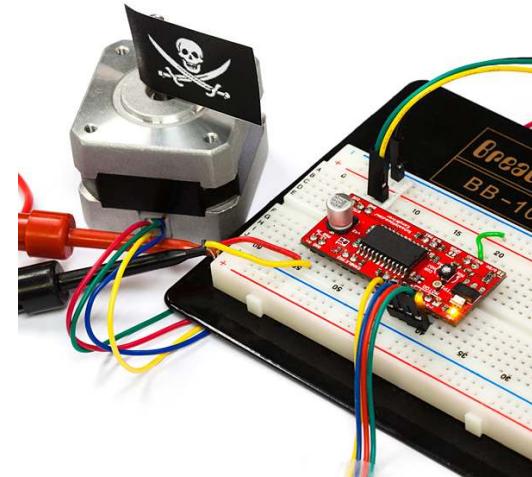
The Spindle Control Module can be used to turn on and off any power source/object with a signal from your PC. If you decide, for instance, to mill hard metals and require irrigation to cool your end mill, then the Spindle Control Module is used to **turn the coolant pump on and off** on command from 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, made from instructions provided on the MyDIYcnc website

Alternate Stepper Motor Drivers

The MyDIYCNC 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 Desktop CNC Machine. 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 Desktop CNC Machine.



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.

Future MyDIYCNC Developments

At the time of writing this manual, MyDIYCNC has several exciting development projects on the drawing board for the DIY Desktop CNC machine. 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.

Keep an eye on the MyDIYCNC website and subscribe to our newsletter for more details and developments. In addition the resources section of the website will provide you with additional links to other stepper driver board designs that you may wish to build yourself.

Getting Support

There are two primary sources of technical support for your DIY Desktop CNC Machine:

1. Direct support via the MyDIYCNC website for MyDIYCNC customers who purchased products that included technical support services
2. Community support in the MyDIYCNC online forum

Your MyDIYCNC account

As a customer of MyDIYCNC you will receive a private login account at the time of purchase. Thereafter, once logged in, the project updates, online resources, downloads and technical support services become available to you. Technical support is provided via a helpdesk ticketing system on the website with an e-mail response.

The MyDIYCNC Online Forum

The MyDIYCNC website forum is intended to build support and foster innovation among DIY Desktop CNC Machine users and contributors. You may participate in the forum by registering for a forum account. No purchase is necessary to participate in the forum.

In addition to the above technical support options, the MyDIYCNC FAQ contains a wealth of information about commonly-asked questions and issues.

Troubleshooting

Before requesting technical support, please use the following Troubleshooting Matrix to determine an initial solution to your issue. If the Troubleshooting Matrix and the MyDIYCNC online FAQ do not provide you with a solution, registered users may start a helpdesk ticket with the tools provided on the website.

Troubleshooting Matrix

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

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
One axis is unresponsive	Bad connection to stepper motor	<p>Check the stepper motor cables are making good contact in the Stepper Driver Module's terminals.</p> <p>Be sure to solder tin the stepper motor wires to allow good contact in the terminals.</p> <p>Double-check the wiring sequence. Make sure that the stepper wires are connected in the correct order.</p>
	Bad connections to Stepper Driver Module	<p>Check all connections to the Stepper Driver Module.</p> <p>Check for good ground to Stepper Driver module.</p> <p>Check that signal connections from the PC/Db-25 connection to the Stepper Driver Module are correct and solid.</p> <p>Check that the Stepper Driver Module enable signal is connected and getting a high (+5 VDC) signal.</p>

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
	Axis limit switch triggered	<p>Check limit switches to if any are either depressed, faulty or shorted out.</p> <p>Make sure that the screw used to mount the limit switch modules is insulated (with a plastic washer) from the board.</p> <p>Check CNC application to see if it is receiving a triggered limit switch signal.</p> <p>In EMC2 check that the parallel port limit switch channels are inverted.</p>
One Axis is "Jittering"	Stepper Motor not connected correctly	<p>Recheck that all connections are solid between the stepper motor and the Stepper Motor Driver module.</p> <p>Check that the stepper motor wires are connected in the correct order.</p> <p>Check that the correct voltage is connected to the motor power terminal.</p>
	CNC application misconfigured	Check that the speed settings for the axis are correct in the CNC application.

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
	Axis, drivetrain or carriage is binding or obstructed	<p>Check that the axis is not binding up or is being obstructed.</p> <p>Check that the anti-backlash leadscrew is not obstructed or fouled with debris.</p> <p>With power off, check that the drivetrain threaded rod can rotate freely. If not, determine why and remedy.</p> <p>Apply light machine oil to the Igus bearings (air tool oil is a good lubricant for this).</p> <p>Check alignment of axis and correct as necessary.</p>

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
Axis movement is difficult towards one end of travel	Axis rods misaligned	<p>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.</p> <p>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.</p>

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
	Rods damaged	<p>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.</p> <p>If the blemish/damage cannot be removed, replace the rod before any further use.</p>
	Binding is minor	<p>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.</p> <p>If the binding does not improve, check for alignment and/or damage.</p>

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
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 Desktop CNC Machine 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.

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
	One axis is exhibiting backlash	<p>Check the anti-backlash assembly.</p> <p>Check that it is adjusted correctly as described in the manual.</p> <p>Check that the spring is holding tension when adjusted. Replace if necessary.</p> <p>Check for dirt or debris fouling the lead screws.</p>
	Axis is "loose"	<p>Check for excessive wear in the lead screws. Replace with new wing nuts.</p> <p>Check that the mounting block is securely fastened to the carriage.</p> <p>Tighten if necessary.</p> <p>Check for play in the axes mounts, rods, bearings and/or bearing support sub-frames. Correct as necessary.</p>
Travel on one axis stops in mid operation, while other axes continue to move as expected.	Drivetrain coupling failure	<p>Check that the coupling between the motor shaft and the threaded rod is secure.</p> <p>Check for either part spinning inside the coupling. Replace coupling.</p> <p>Check for coupling damage. Replace coupling.</p>

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
	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 <i>troubleshooting a non-responsive axis</i> above.
Depth of cutting increases/decreases across the table	Table not level	<p>Either:</p> <ul style="list-style-type: none"> 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. See the MyDIYcnc website for instructions on how to do this for PCB isolation track milling.
PCB tracks not parallel or “fuzzy”	Incorrect end mill	Use an end mill specifically for PCB milling.

SYMPTOM	POSSIBLE CAUSE	SUGGESTED REMEDY
	Spindle/collet/end mill loose	<p>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.</p> <p>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.</p> <p>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.</p>

Appendices

DIY Desktop CNC Machine Master Bill of Materials

The following is the recommended bill of materials for the DIY Desktop CNC Machine. Bill of materials for the electronics modules are provided separately. Items and suppliers are recommended, equivalents may be substituted.

Description	Qty/Unit	Vendor	Part#
NEMA 17 12V Stepper Motor	3	MyDIYCNC/various	
Stepper Controller Module	3	MyDIYCNC	MyDIYCNC
Optional Limit Switch Module	6	MyDIYCNC	MyDIYCNC
Optional Spindle Control Module	1	MyDIYCNC	MyDIYCNC
200W or greater ATX PC Power Supply	1	Various	
25 pin D-Type, Ribbon	1	Jameco	12335
Ribbon cable, 25-core, 6"	1	Jameco	643911
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	91247A552
Chassis Corner Nut: Nylon-Insert Hex Locknut 1/4"-20	4	McMaster	95615A120
Back Brace Screw Zinc-Plated Steel, NO 6 Size, 3/4"	4	McMaster	90190A151

Description	Qty/Unit	Vendor	Part#
Flat Washer 1/4" Screw Size, 5/8" OD	2	McMaster	98029A029
Uprights Screws Screw Zinc-Plated Steel, NO 8 Size, 3/4"	8	McMaster	90190A197
Table Flat Head Phil Sheet Metal Screw NO 6 Size, 1/2"	12	McMaster	90048A148
Z motor mount, Spindle mount: #6 Size, 1/2" screws	10	McMaster	90190A148
Z Carriage: #6 Size, 3/4" screws	9	McMaster	90190A151
Wingnuts, Z mount: #4, Size, 3/8" screws	26	McMaster	90190A108
Anti Backlash Assembly screws, NO 4 Size, 3/8"	10	McMaster	92005A124
Anti Backlash Assembly Y mount, NO 6 Size, 3/4"	4	McMaster	90190A151
Machine Screws: M3 Size, 30mm	4	McMaster	92005A132
Machine Screws: M3 Size, 14mm Length	4	McMaster	92005A126
Machine Screws: M3 Size, 8mm Length	4	MSC	2631778
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	6050108
1/4"-20 threaded Rod 10" **	1	MSC	6050108
1/4"-20 threaded Rod 7" **	1	MSC	6050108
3/8 precision steel rod 18" **	2	MSC	6010243

Description	Qty/Unit	Vendor	Part#
3/8 precision steel rod 11" **	2	MSC	6010243
3/8 precision steel rod 7" **	2	MSC	6010243
Grommet 3/8" ID, 5/8" OD, 3/32"	4	McMaster	9600K33
Igus linear bearings	12	Igus	MCI-06-02
X table, 7 ¾" [197 mm] x 12" [305 mm] 1/4" HDPE	1	TAP Plastics	
1/4"-20 Nylon wing nuts	6	McMaster	98143A015
Anti backlash spring	3	McMaster	9657K154
1/2" HDPE anti-backlash assembly mounting blocks	6	TAP Plastics	
Two core cable for limit switches, 2' pieces	6	Jameco	100280
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	MyDIYcnc	M97626
1/4" x 2" x 2" HDPE Spindle Bottom Mount	1	TAP Plastics	

Description	Qty/Unit	Vendor	Part#
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	9579K63
Electronics Housing	1	TAP Plastics	
1/2" Nylon Spacer Tube	2	Lowe's (The Hillman Group)	136994
PCB Edge Mounts	12	MyDIYcnc	

** 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

MyDIYCNC Stepper Driver Module Bill of Materials

Description	Qty/Unit	Vendor	Part#
Bare PCB	1	MyDIYCNC	MyDIYCNC
10K Resistor	1	Jameco	various
100K Resistor	1	Jameco	various
0.01uF Capacitor	1	Jameco	various
4027N	1	DigiKey	NXP
4070N	1	DigiKey	ST
L293D	1	DigiKey	ST
16 DIP heatsink (optional)	1	Jameco	2077335
2N2222 Transistor	1	DigiKey	various
W237-04P connector 4 terminal	2	Jameco	2124429
W237-3E connector 3 terminal	1	Jameco	2094493

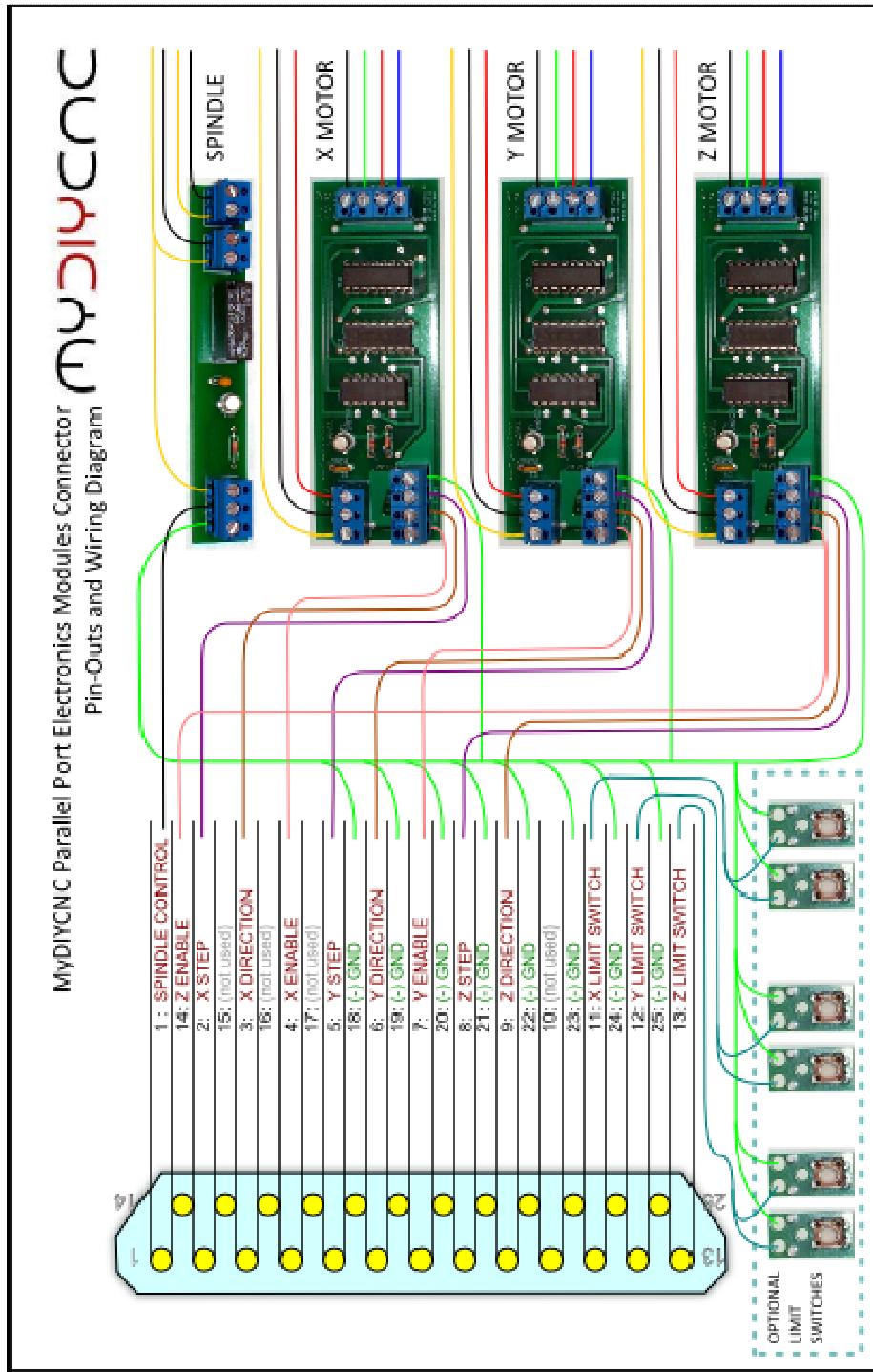
MyDIYcnc Spindle Control Module Bill of Materials

Description	Qty/Unit	Vendor	Part#
Bare PCB	1	MyDIYcnc	MyDIYcnc
Micro Power Relay	1	Mouser	Excel
2N2222 Transistor	1	DigiKey	various
Resistor A	1	Jameco	various
Resistor B	1	Jameco	various
0.01uF Capacitor	1	Jameco	various
W237-2 connector 2 terminal	2	Jameco	2094485
W237-04P connector 4 terminal	1	Jameco	2124429

MyDIYcnc Stepper Motor Signal Exerciser

You can access the circuit diagrams, PCB layouts and bill of materials for the MyDIYcnc Stepper Motor Signal Exerciser in the Downloads section of your online account at the MyDIYcnc website.

Wiring Diagram



DIY Desktop CNC Machine 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

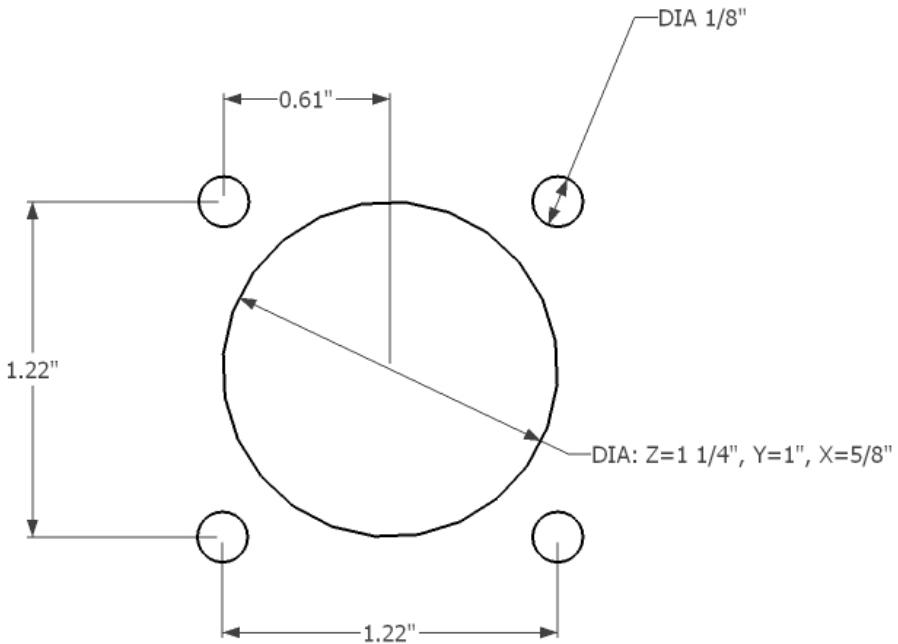
PURPLE: Step Signal

BROWN: Direction Signal

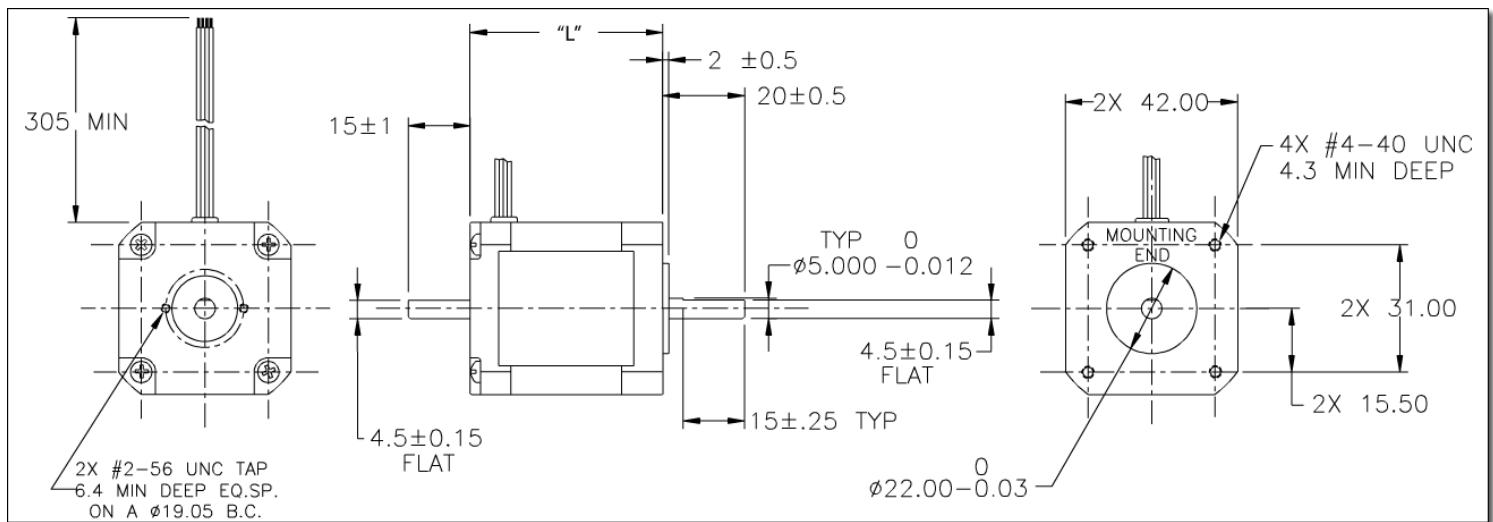
PINK: Enable Signal

TEAL: Limit Switch +

Stepper Motor Mount Holes (NEMA 17)



NEMA 17 Motor Mounts



NEMA 17 Motor Metric Mounting Dimensions

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