MY SECOND ROBOT

This is a book written by
Michael D. Hobgood
about the experience of designing, and building a homemade robot.

I decided that the heading above should be changed from “My First Robot” to “My Second Robot” since there have been so many changes made to the machine. The first build was using a 3/4 HP Porter Cable Router as the tool being controlled by the robot. While the machine design is not quite robust enough to handle precision machining, it does do wood routing with satisfactory results!

This is a work in progress, and will be updated as improvements to my knowledge and experience grows. So will this book, in an effort to ultimately become an “Owner’s Manual” of sorts. There are no patents being applied for here. As most of the design of this machine (with a few exceptions) are based on parts which are readily available at local hardware suppliers.

Design Details of My CNC Router Table

I began this project around the middle of October, 2008 after being “bitten by the CNC bug”. I had seen several home made routers, mills, etc. on YouTube videos and became inspired to build my own.

I started by researching the subject on the Internet, and learned quite a bit about the subject. Then I started shopping on E-bay for the controller/driver board, stepper motors, lead screws, bearings, aluminum, and cable tracks.

I began with NO specific plans on paper, but just a general desire to construct a table 24”x48” which I thought would be a good general size to allow the tool to be used for most small signs, etc.

I went shopping for my steel angle, and flat stock at places like Home Depot and Lowe’s. I also bought most of the nuts, bolts, and washers there as well.

I have in my home garage the following tools which I used to construct this project: metal lathe, drill press (with an X-Y mill table), drill press vises, bench vise, C-clamps, metal band saw, bench grinder, belt sander, metal chop saw, portable drill, and various end mills, drill bits, and cutters. Also, taps and dies and their holders.

Dial calipers are also an essential tool for precision measurements. Working with Hot-Roll Steel requires one to pay CLOSE attention to details, measuring EACH piece as you go. I was amazed at how much this type of material varies in size from one plane to another, or even one piece to another!

The base frame I started with, I happened to already have a stand constructed of 1”x1” tubular steel. These were from a store display given to me by a friend several years ago. I mounted the two 1.5”x1.5”x3/16”x48” steel angles to this stand, by drilling a single hole into the vertical plane of each end of the angles, and into the 1” frame. I bolted them all together, and naturally since there was no support along the bottom, the whole thing could tilt end to end until it fell over! (Think hinge assembly)

So, I next added two more pieces of angle steel to each side. One about 4” below the top piece of angle, and the other about 12” up from the floor. This made the whole structure very stable, but I still later added X-braces made of 1”x1”x1/8” angle, and 1”x1/5” flat stock for an absolutely RIGID base.

As the saying goes “A picture is worth a thousand words” I will dispense with all this writing, and present you with drawings of My CNC Router in the pages which follow. To answer the main question I am sure many of you will have, my cost (to date) has been about $1900.00 for everything I have purchased in building this machine.

Update: the total cost to date has now grown to about $2200.00 (I upgraded the driver electronics to a Gecko G540 4-axis driver board). The original Mechatronics driver board I was using became unstable, and could not be relied upon for precision machine control. After researching the various suppliers, I learned that Gecko makes a quality product with a 1 year warranty which includes free return shipping, and free repair/replacement of their products.

Design Details of My CNC Router Table

Now that the machine has been built, and (for the most part) is completed, I have now turned my attention to the software side of things. The software I am using to drive the machine is Artsoft's Mach 3 CNC Mill, with the Mill add-ons package, and LazyCAM Pro. The package also included Lazy Turn (to drive a CNC Lathe), and can also be used to drive a CNC Torch, Laser, Plotter, Foam cutter, or whatever tool one can imagine. It is probably the best value available today, with support from many other software vendors in terms of Post-processing the Gcode files needed to machine a given part.
Some of the websites I have found informative for researching and learning about CNC are:
www.cncinformation.com
www.youtube.com
www.machsupport.com
www.cnczone.com
www.buildyourcnc.com
www.google.com
www.vectric.com
www.kelingtechnologies.com
www.grzsoftware.com
www.cncwrapper.com
And the suppliers found on ebay are (sometimes) a good place to start for finding the various components needed to build your own CNC system. I have downloaded the trial version of V Carve Pro from Vectric, and plan to purchase this software as soon as I am able to afford it. The ease of use, is simple. And the quality results of the machined part from the gcode produced by their software is absolutely amazing!

During my research about CNC, I have learned that this process has been around for many years. But the price of the technology and machines have left it in the exclusive realm of multi-million dollar companies. Until software companies such as Artsoft began to write programs which will run on a home computer to control machines through the printer port of the computer. This has resulted in a grass-roots style of change to the entire industry.

Now, most anyone can buy, (or as in my case) even build their own machine affordably. Which can be used to do precision machining, or carving, or engraving, or molding, or lathe turning, or (insert your use here____________).

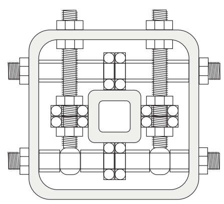
Essentially, software such as the Mach 3 driver program, is an interface which one uses to control the movements of a Robot! The language which the Robot understands, is called Gcode. Which is simply a text file containing the instructions for basic (or sometimes very complex) geometry movements. Everything is based on a co-ordinate system, with X being Left to Right or Right to Left movements, Y being Forward or Reverse, and Z being Up and Down movements. It is also possible to control Indexing movements as well with a 4th axis being the A axis. Further movement can be achieved with a 5th, or even 6th axis.

B being the 5th axis, and C being the 6th axis. These axes are for controlling the X movement in an arc, and the Y movement in an arc (B and C respectively). The complexity of these types of movements requires design software which is still out of reach for most home users because of the expense.

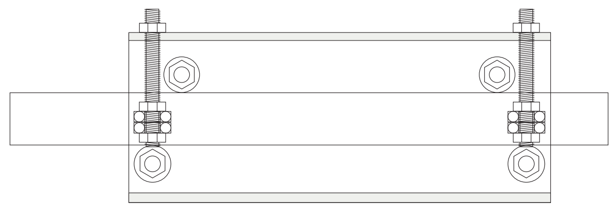
However, the Mach 3 software appears to be able to accommodate even these complex levels of movement! The more I learn about the capabilities of Mach 3, the more I am amazed. I have begun to realize that this is a project which will be a life-long one, which will be under a state of constant refinement. In terms of learning how to use the various design software, as well as the design/feature/capabilty improvements to the machine itself.

Design Details of My CNC Router Table

END VIEW



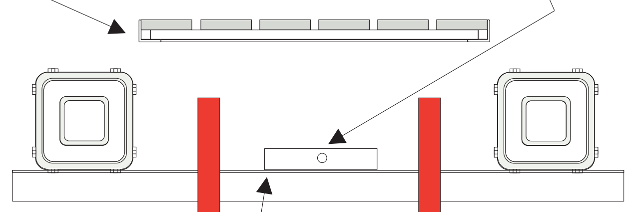
SIDE VIEW



Mounting holes for the Swing bolts are milled to accommodate the side to side adjustments needed to load the bearings against the 1.5”x1.5” Square Tube Guide Rails.

X-Axis Lead screw nut mounted in a through-hole of an Angle steel piece which is bolted to the Cross-Frame of the Gantry.

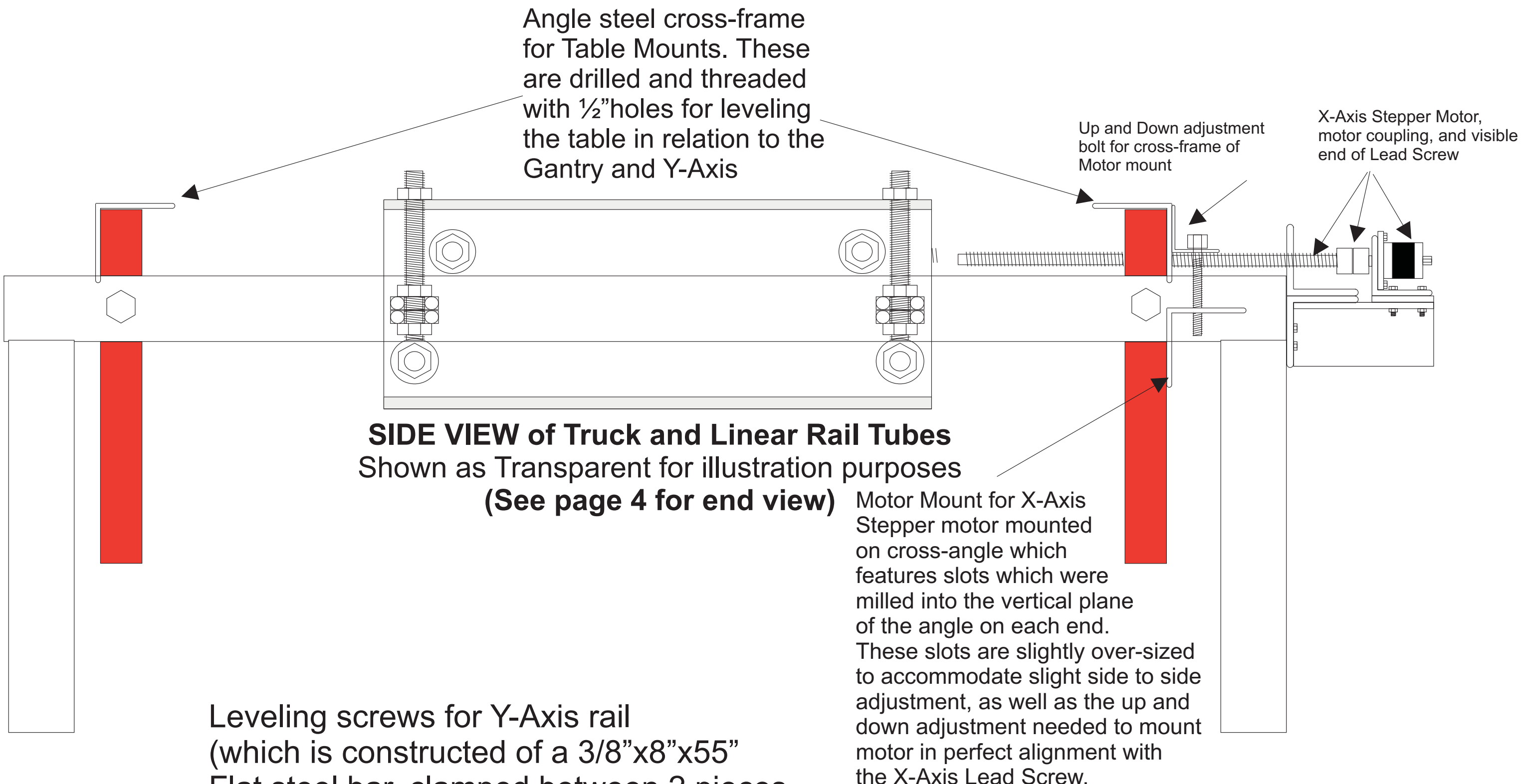
Table assembly



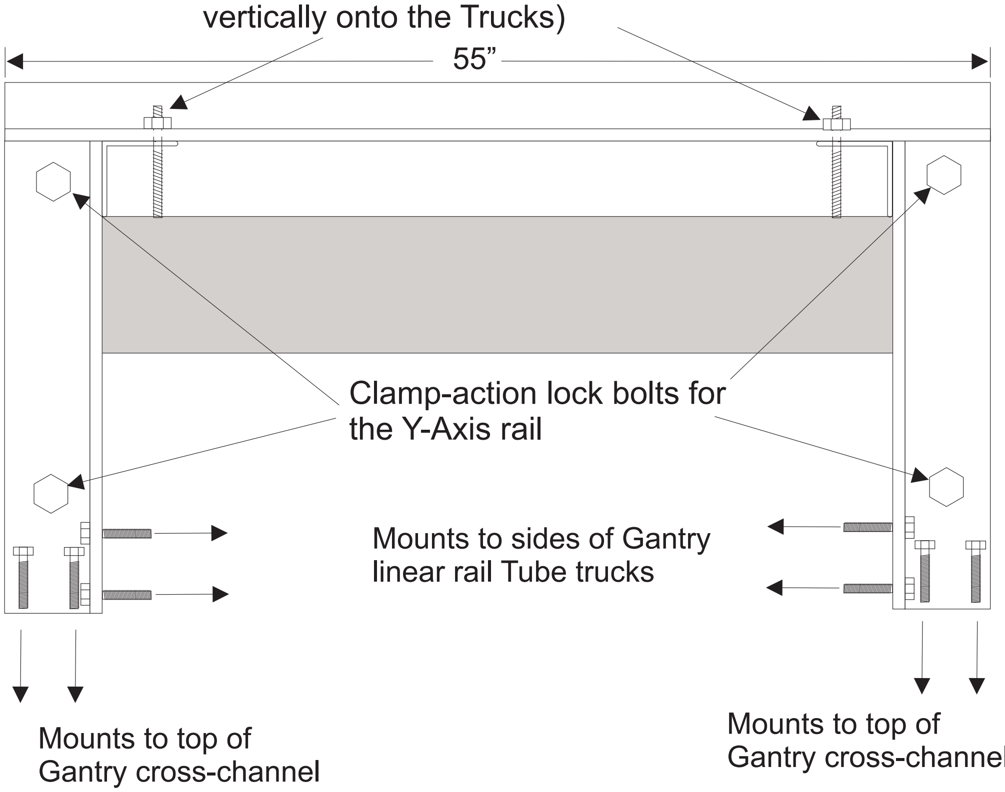
The Trucks are constructed of 4”x4”x12”x1/8”wall Tube Steel. There are four threaded rods mounted near the ends of the tube, which have been inserted through the walls of the square tube, and the eyes of 2 pairs of swing bolts. The holes for the lower threaded rods, as well as the swing bolts are slots which are milled 1/4” in length to accommodate adjustments of the rods, and swing bolts to load the bearings against the 1.5”x1.5”x1/4” steel tube Rails. The threaded rods were inserted through spacer bushings to secure the bearings onto the threaded rods. Lock nuts were installed on both sides of the bearings which were mounted onto the threads of the swing bolts. This provides a heavy-duty Linear Rail System on which the Gantry rides along the X-Axis of the table.

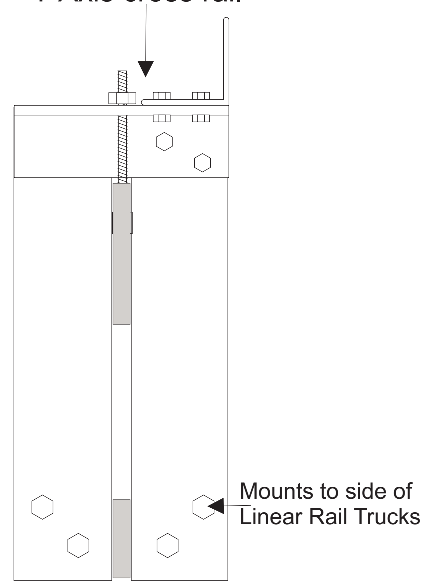
The cross-frame of the Gantry is constructed of a piece of channel aluminum , and mounted to the bottom of the Trucks.
The Linear Rail Tubes for the X axis are mounted with the bottom surface of the Tubes mounted onto the top surface of channel steel which has been mounted to the ends of the table’s Base Frame. (Which is constructed of 1”x1” tubular steel and Pictured in RED above). The 1.5”x1.5” tubular steel rails are supported by 3”x3” square tube legs at each end of the rails.

Design Details of My CNC Router Table



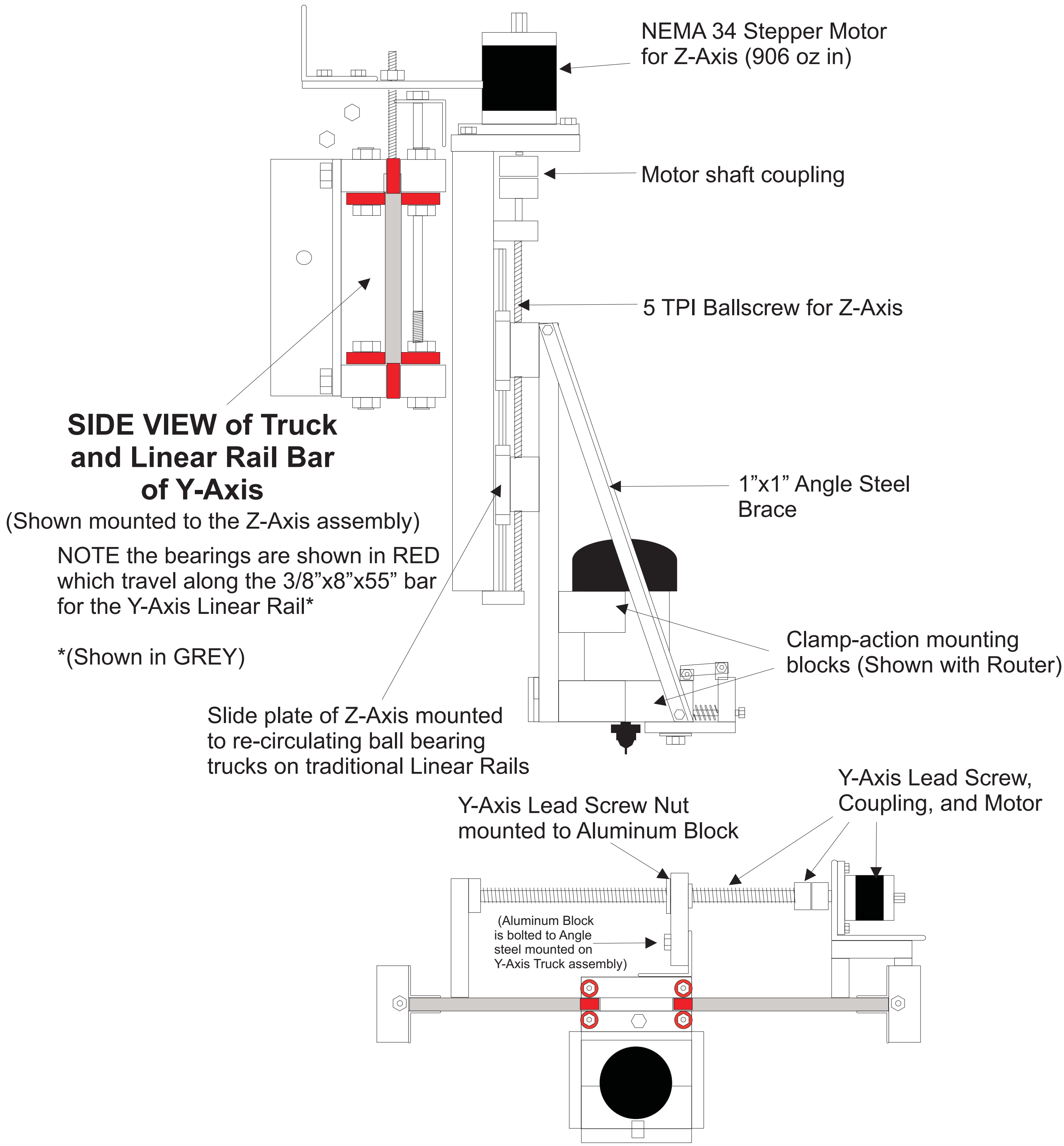
SIDE VIEW of Truck and Linear Rail Tubes
Shown as Transparent for illustration purposes
(See page 4 for end view)





Front view of Top Cross-Frame of Gantry showing the Linear Rail bar for the Y-Axis

Design Details of My CNC Router Table

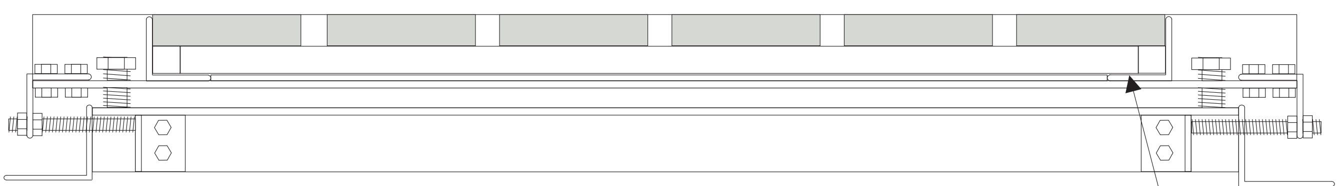


Top View of Y-Axis assembly
(Shown with Z-Axis motor mount
removed, so you can see top
view of Y-Axis bearing Truck)

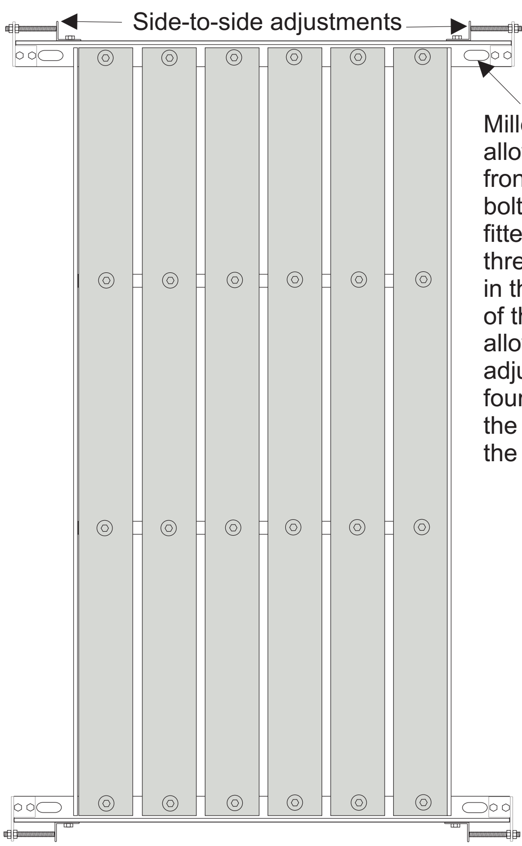
Design Details of My CNC Router Table

The Table surface is constructed of .750”x3.125”x48” slats of T6061 Aluminum, (spaced 5/8” apart) which is mounted onto a frame constructed of 1”x1” tubular steel. This frame was then mounted inside a second frame which is constructed of 2”x2”x3/16” Angle steel. After assembling the Table frame, I realized that this design created a “shelf” approximately 1” wide along the inner edge underneath the table. I decided to make use of this “shelf”, my making a set of six 2”x24”x1/4” adjustable hold-down clamp mounts Made of hot roll steel, each of these have been drilled, and tapped with ½”holes 13 TPI for mounting hold-down clamps. Since this “shelf” is 1” below the bottom surface of the Aluminum slats, I installed small pieces of angle steel onto the ends of each of these flats, and mounted small bearings on each. This raised the flats to within 0.040” of the bottom surface of the aluminum slats. (As well as making them easier to quickly slide from one position to another when mounting hold-down clamp bolts on the table surface).

Front View of Table Surface

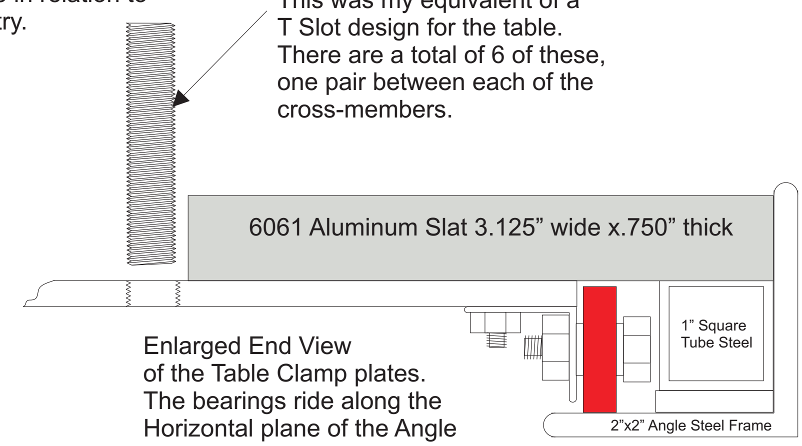


Top View of (Assembled) Table Surface



Milled slots over-size to allow slight adjustments front to back. ½”diameter bolts with flat washers fitted top and bottom are threaded into tapped holes in the front and rear Angles of the Base Frame. This allows the Table height to be adjusted on each of the four corners for leveling the Table in relation to the Gantry.

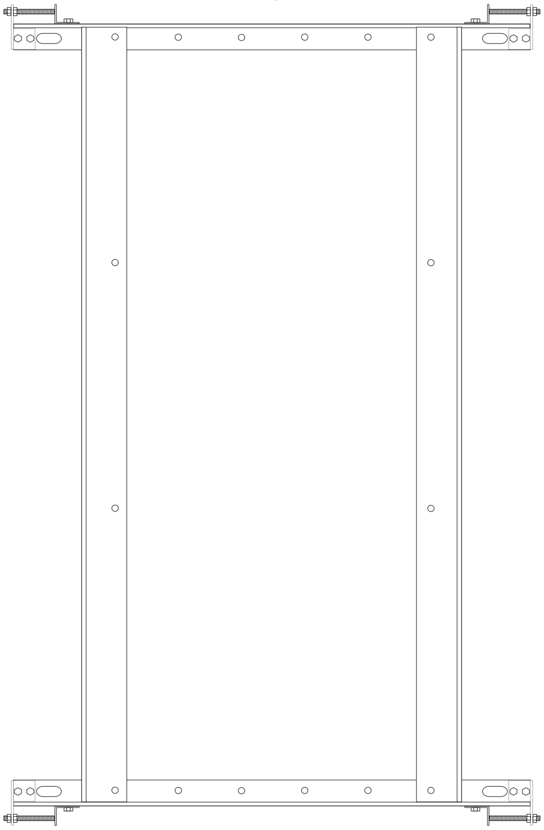
½”13 TPI threaded rod or Bolts can be secured in the Table Clamp plates from the top side of the table- the bearings on each end of the plates allow for easy positioning of the Table Clamps along the length of the table (Between the cross-members) This was my equivalent of a T Slot design for the table. There are a total of 6 of these, one pair between each of the cross-members.



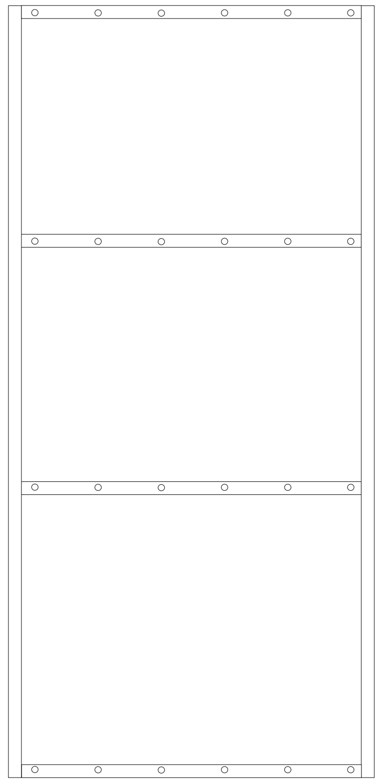
Enlarged End View of the Table Clamp plates. The bearings ride along the Horizontal plane of the Angle steel frame of the Table.

Design Details of My CNC Router Table

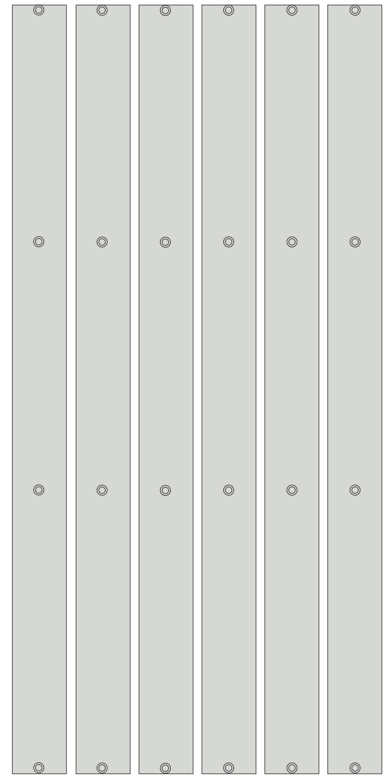
Top View of Angle Steel Frame



Top View of 1”x1” Square Tube Frame with 1”x1/4” Flat Stock mounted underneath

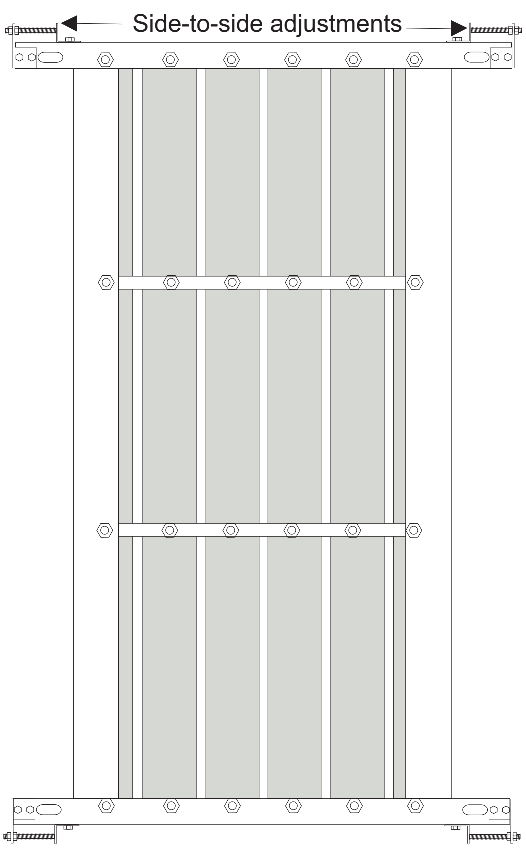


Top View of 3 1/8”x3/4” 6061 Aluminum Slats
Holes are drilled and counter sunk on centers to provide flat Table surface.



The Aluminum Slats are spaced 5/8” apart to accommodate ½”13 TPI threaded rods, or bolts to be used to secure items to the Table surface.

Bottom View of Table Assembly



Trying to illustrate the Table assembly in a drawing in a manner which clearly demonstrates the design, has proven to be almost as much work as actually building it. Understanding the basic sequence of assembly, may help to clarify.

Begin by assembling the 2”x2” Angle steel frame. Then assemble the 1”x1” Square Tube steel frame. This particular part of the assembly also includes a “shim frame” which is basically just strips of 1”x.250” flat stock steel.

It is assembled onto the BOTTOM of the Square Tube steel frame, and acts as a reinforcement of the thin tube steel, as well as a shim, to bring the total height of the Table’s surface level with the vertical planes of the outer Angle steel frame. (Once the Aluminum Slats are mounted).

This creates a “Shelf” along the inner edges of the Angle steel frame, which is used as a rail for the Table Clamp plates described on page 7 to ride along.

To more fully describe the Table Clamp Plates, they are basically just a piece of 2” wide x .250” thick flat stock steel, with a small piece of 3/4” angle steel bolted onto each end. A hole is tapped into the vertical plane of the 3/4” angle, and a bolt is inserted through a small ball bearing, and threaded into the angle. This give the flat stock “Wheels” which serve two purposes:

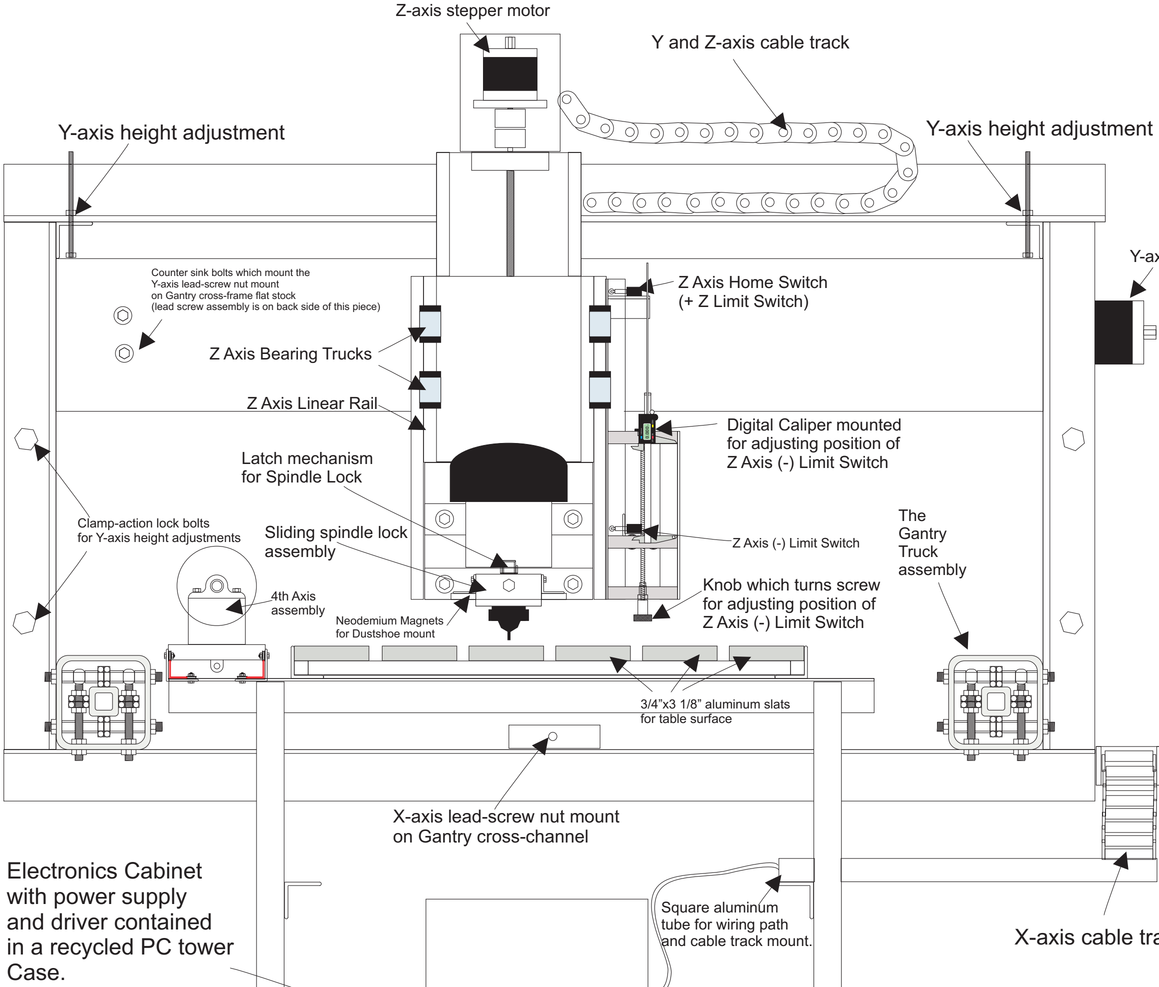
1-it raises the flat stock to within 0.040” of the bottom surface of the aluminum slats of the table.

2-it makes positional adjustments of the table clamps easier, since it simply “Rides the Rails” of the inner edge of the Angle frame.

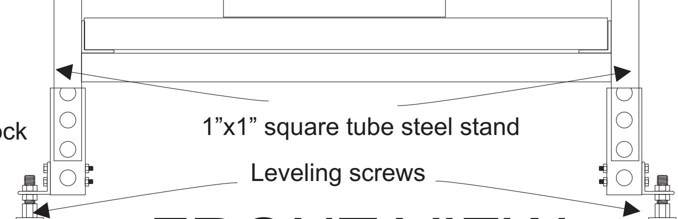
I have contemplated adding threaded rods underneath the table which could be threaded into angle stock mounted onto the bottom of the table clamp plates, and a knob mounted onto the threaded rods to adjust their position along the length of the table. However, I have found them to be simple to use as is.

And probably much faster to slide into a desired position, by simply threading a hold-down bolt into two locations to act as handles. And simply pushing, or pulling them into the desired position. The single bearing on each end of these plates allow for slight angular travel along the rails, and can be easily removed by simply reaching under the table, and “running them off the track” by rotating them to about a 45 degree angle. The end result, is that I now have a series of 5 “T-Slots” with the T Slot nuts (the threaded holes of the 1/4” thick flat stock) on Wheels!

Design Details of My CNC Router Table



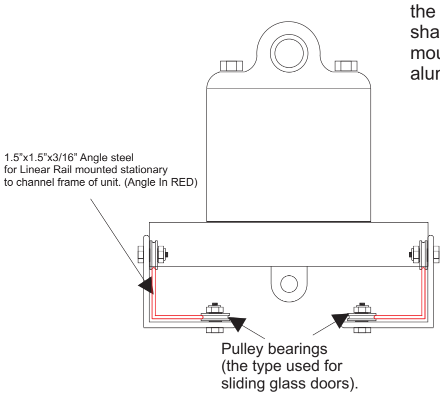
ABOUT THE 4th AXIS
I utilized the original design steel angles linear rails and truck assemblies to add a 4th axis to the machine. The angles were used along the left side to mount the headstock to the rails, and the original truck assemblies were used to construct an adjustable tailstock which rides on the angle rails. (See below)



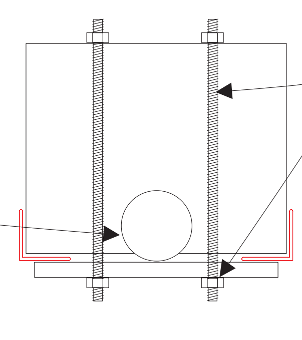
FRONT VIEW

NOT SHOWN:
Each end of the X axis linear rail tubes are mounted onto 3"x1.5" steel channels, which are mounted to the 1"x1" frame of the base.
These channels will later be mounted to 3"x3"x1/4" steel tube legs for added stability.
The expanded size of the machine (and increased weight) introduced a new problem with excessive rocking of the whole assembly as the gantry travels.

Pillow Bearings were used to construct both the Headstock and Tailstock shaft assemblies. Both are mounted onto 1.5"x 7"x7" aluminum blocks.



I mounted another 1.5"x7"x7" aluminum block onto the angle rails which clamps directly to the rails with lock bolts. I then bored a thru-hole for a lead screw (which threads into a nut mounted on the bottom of the tailstock assembly itself) with a knurled handle to adjust the tailstock position up to 12" quickly. For longer stock, the block can be unlocked from the rails, and slid along the rails to the desired position.



This block was bored with thru holes from top to bottom and 8" x ½" threaded rods inserted thru the block, and then threaded into the lock plate beneath the angles. A nut was added to the bottom of the threaded rods to lock the rods into the lock plate.
With the threaded rods secured into the lock plate, nuts were added at the top end of these rods to allow easy top-side locking or unlocking of the Tailstock position.

Design Details of My CNC Router Table

LEFT SIDE VIEW

I added a spindle lock slide plate mechanism, to make tool changes easier. It is simply a 3/8" piece of flat stock, with a slot milled to a 1.125" wide at the spindle end. (the nut size on my Porter Cable 690LR Router). And a second slot milled 0.625" wide in the center of the plate.

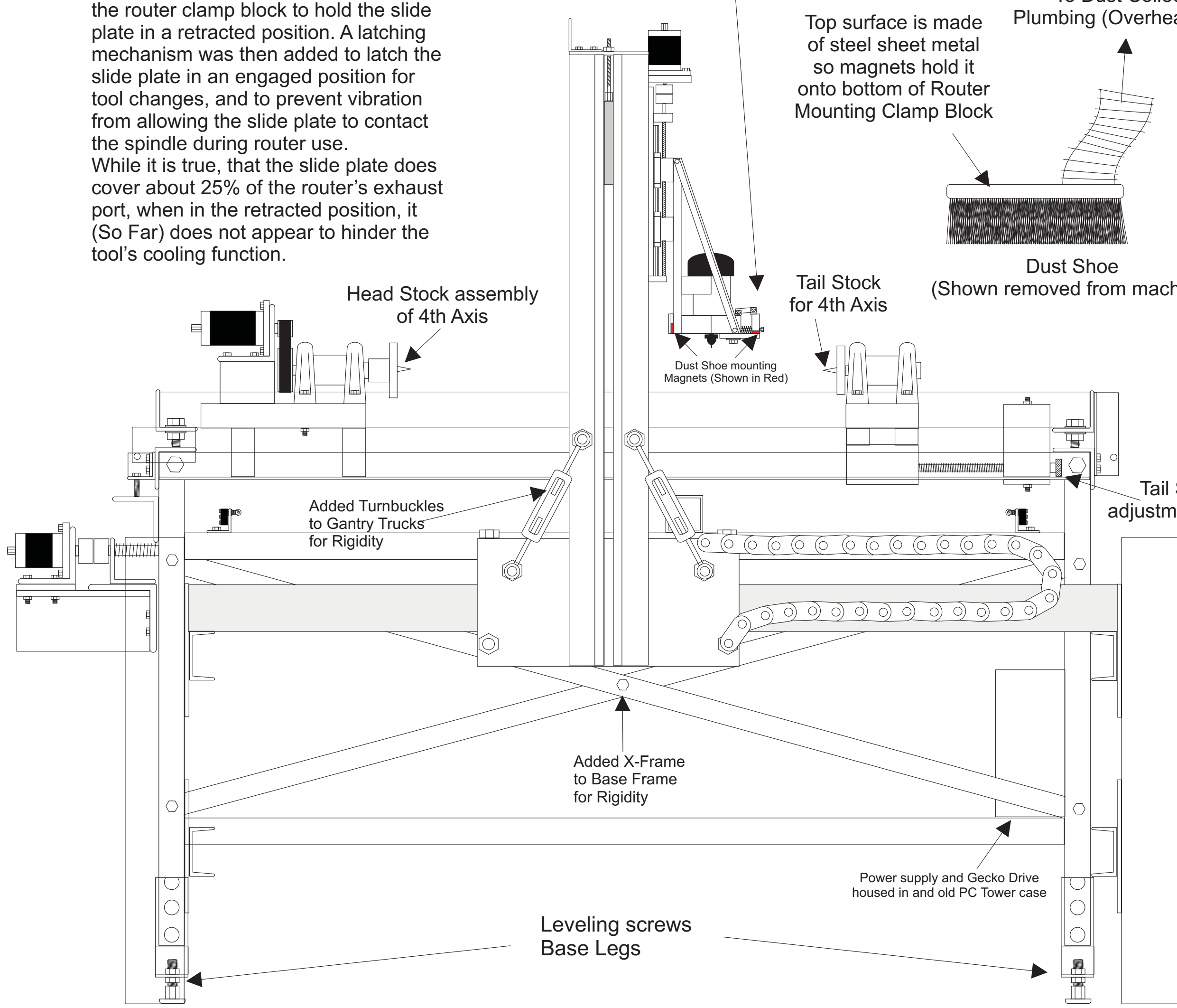
This allowed mounting to the bottom of the router clamp block assembly with a ½"diameter bolt, with a flat washer to hold the slide plate assembly suspended on the top of the flat washer. I tightened the bolt completely, then loosened about 1/8 of a turn to allow the plate to slide freely.

I mounted a piece of 3/4" thick bar stock to the top surface of the slide plate, which seats against the front surface of the router clamp block when engaged. I then bored a 3/8" diameter thru hole in the center of this block, and inserted a 3/8" diameter bolt which was threaded into the front surface of the router clamp block as a linear guide for the slide plate's front block. A Spring was inserted between the back side of the slide plate's front block, and the front side of the router clamp block to hold the slide plate in a retracted position. A latching mechanism was then added to latch the slide plate in an engaged position for tool changes, and to prevent vibration from allowing the slide plate to contact the spindle during router use.

While it is true, that the slide plate does cover about 25% of the router's exhaust port, when in the retracted position, it (So Far) does not appear to hinder the tool's cooling function.

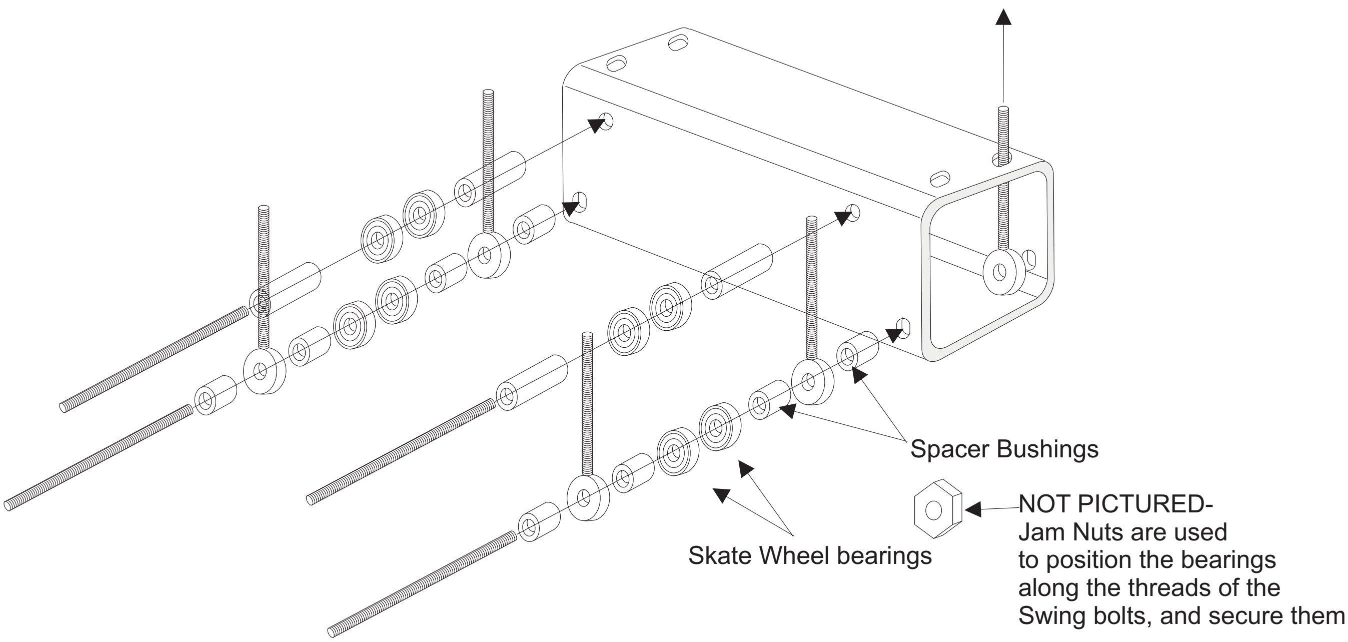
I also added a dust shoe mount. The dust that the router outputs has coated my entire shop with a fine powder-like coating of dust. I had previously mounted a dust shoe of sorts, using a shop vac. But the volume of air flow output by the router exceeded the volume of air flow drawn by the 1.5" diameter hose of the shop vac. So I invested in a 2 HP dust collector system, with a 4" diameter hose.

The larger hose diameter demanded a complete re-design of the dust shoe. The size of the shoe was increased from 8"x8" to 8" x 15.5" to accommodate the larger hose diameter. I mounted neodymium magnets onto the side of the spindle lock slide plate, and onto the rear surface of the router clamp mounting block. The magnets hold the dust shoe in place during routing without any problems at all. And removal of the dust shoe is a simple matter of grasping the assembly and giving it a firm downward tug for tool changes.



Design Details of My CNC Router Table

Exploded view of the X Axis truck assembly



The bearings I used, are simply skate wheel bearings. A single Swing bolt is shown installed, to illustrate how to complete the assembly. The eye bolts are not your hardware store variety of eye bolts. I have seen them listed as Latch Bolts, and Swing Bolts at various places on the internet.

What inspired my thinking in this design, was an old style Christmas tree stand. The fact that you could fit flat slats of square-shaped wood to ANY size of tree trunk (Cylinder shape). And they would hold the tree with a firm grip.

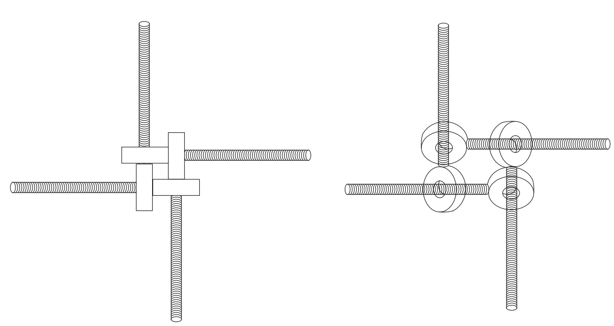
If you take 4 of these eye bolts, inserting the screw end into the eye of each bolt, you can slide them from their length size, all the way down to ZERO. (See the Crude illustration below).

However, when used as axles (as in this case) the scenario leaves only one end of the axle supported. Not good. So, an external support method was needed. This is where the idea of the square tube came into play. Once I assembled it, it did require quite a bit of adjusting, to get the assembly centered on the rails, but works great. (My Gantry weighs about 250 lbs. with the Router clamped on).

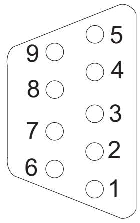
Some things I have learned about this assembly are:

1-Dust will quickly build up on the rails, so I added brush strips to the top edge of the truck, which keeps the dust swept off the top of the rails.

2-The hot rolled square tube steel I used for the rails, are not as hard as the steel the bearings are made of. This has resulted in grooves being worn into the rails by the bearings. Hindsight Item: AFTER drilling the mounting holes for the rails, FLAME HARDEN THEM, AND QUENCH THEM IN AN OIL BATH BEFORE ASSEMBLY OF THE RAILS! So far, the wear has been minimal, but has resulted in the need to frequently adjust the jam nuts to take up for this wear. (Keeping the bearings properly loaded against the rails to prevent Racking of the Gantry).



WIRING DIAGRAM FOR GECKO G540 4 AXIS DRIVE



DB9 Cable Conductor Colors

Black	Brown	Red	Orange	Yellow	Grey	Green	Blue	Purple
1	2	3	4	5	6	7	8	9
1K per A Resistor	Ground	Ground	Ground	1K per A Resistor	B+	B-	A+	A-

Pins 2, 3, 4: Ground

Pins 1 and 5: Set Resistor 3.3K Currently

Pins 6, 7, 8, 9: Motor Cables — Black, White, Red, Green

Motor Cables Translation	
Black	Brown Orange
White	Black White
Red	Blue Yellow
Green	Red Green

Parallel Port Pinouts (18 thru 25 to Ground)

10	11	12	13	17	1	No PP	14	No PP	15 16	No PP	No PP
1	2	3	4	5	6	7	8	9	10	11	12
Z	Y	X	A	Relay 1	Relay 2	VFD-	VFD Output	VFD+	Emergency Stop Button	Power Supply + +	Power Supply - -

Normally Closed Home / Limit Switches

Normally Closed Home / Limit Switches

Normally Closed Home / Limit Switches

Normally Closed Home / Limit Switches

Router Motor ON / OFF

Coolant ON / OFF

Variable Frequency Drive Negative -

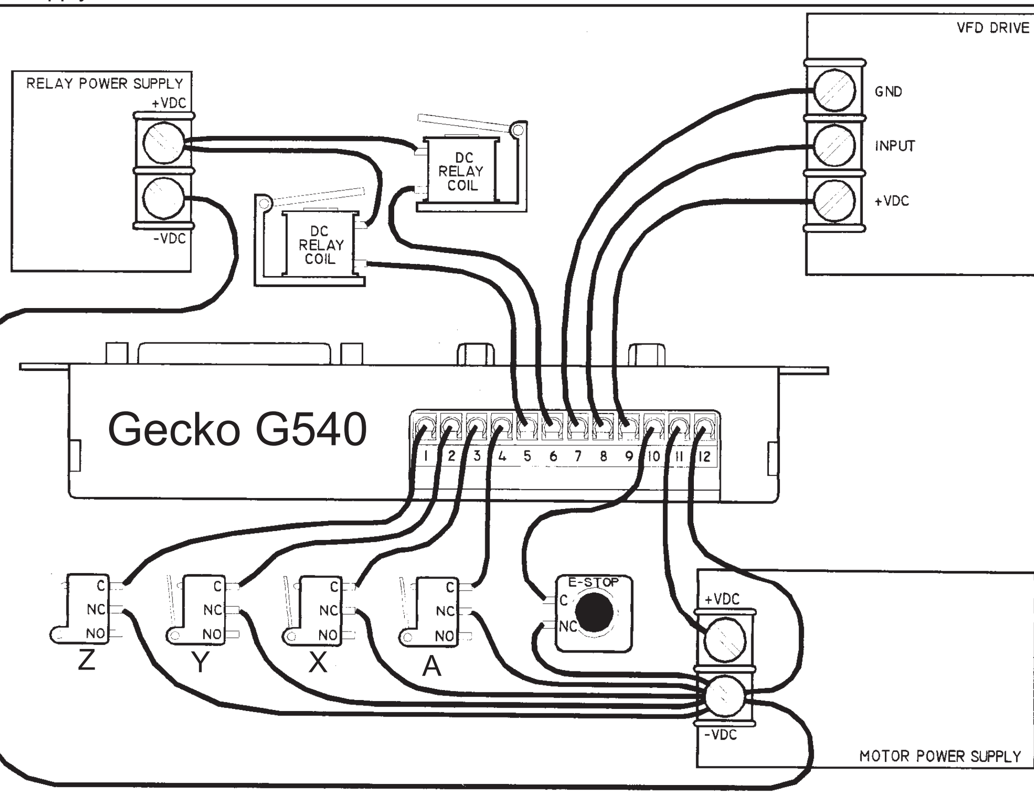
Variable Frequency Drive Output Signal

Variable Frequency Drive Positive +

Enable Charge Pump / Emergency STOP Button

+ Positive from Power Supply

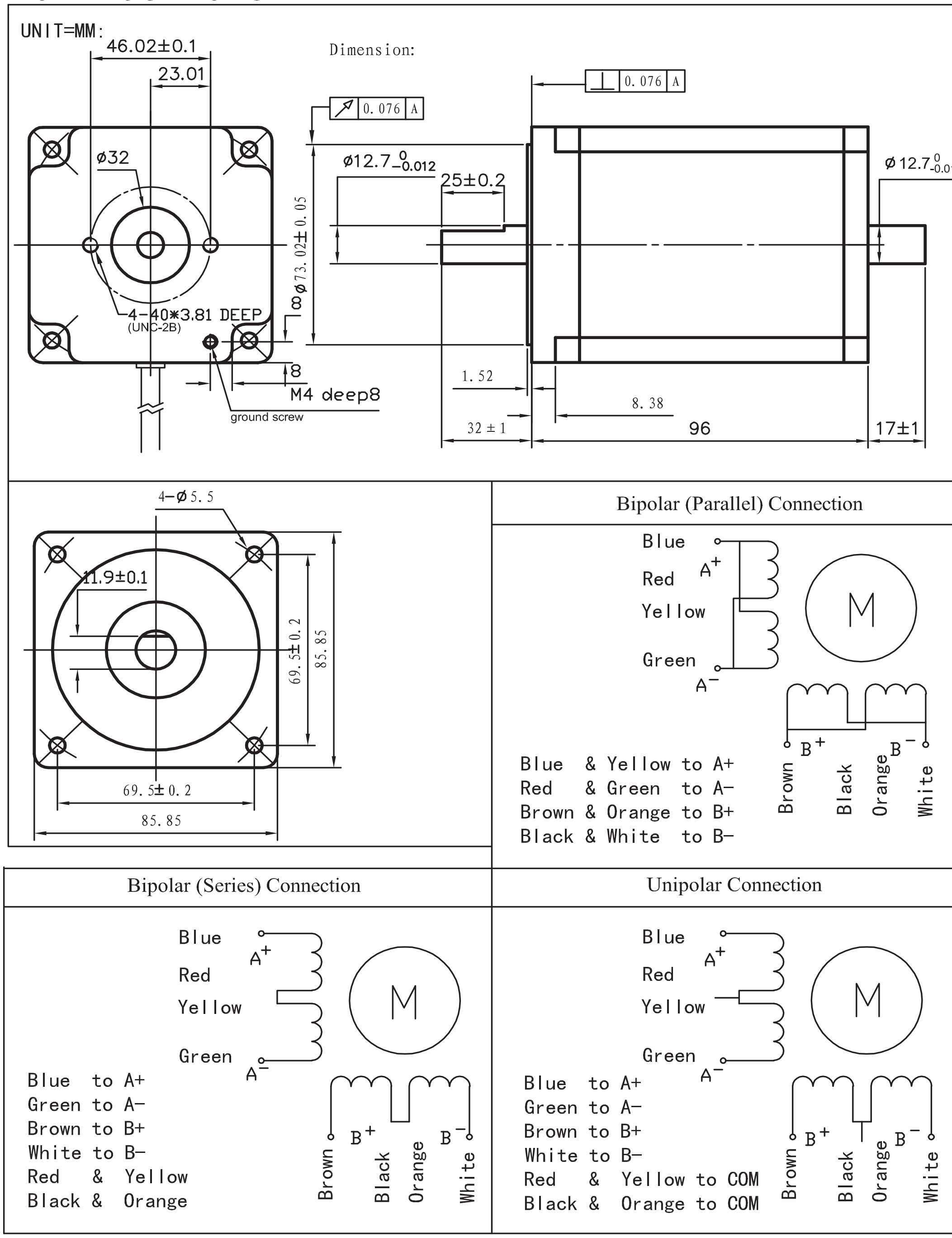
- Negative from Power Supply



The diagram below, is an import of the actual PDF file from Keling Technologies website for the KL34H295-43-8B stepper motors which are used on the X, Y, and Z axis of my machine. They are currently wired in Bipolar Parallel.

Hybrid Stepper Motor

KL34H295-43-8B



STEP ANGLE	CONNECTION STYLE	CURRENT	RESISTANCE	INDUCTANCE	HOLDING TORQUE	ROTOR INERTIA	WEIGHT
DEG/STEP		A	ohms	mH	OZ-IN	gcm^2	Kg
1.8	Parallel	6.1	0.35	3.3	960	1400	2.3
	Series	3.05	1.4	13.2			
	Unipolar	4.3	0.7	3.3	640		

The diagram below, is an import of the actual PDF file from Keling Technologies website for the KL34H2160-62-8A stepper motors. The actual motor which was used on the A axis of my machine is a KL34H2160-62-8B (Dual Shaft is the only difference).. It is currently wired in Bipolar Parallel.

Rev:01

Date:20051124

Hybrid Stepping Motor

Type:KL34H2160-62-8A

COMMON RATINGS

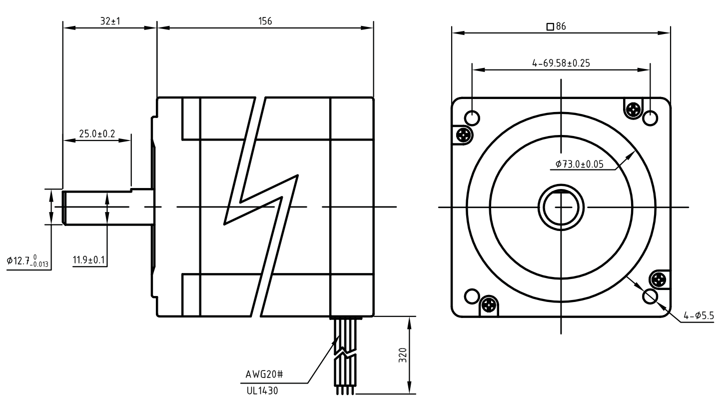
Step angle: 1.8°
Positional accuracy: +/-5%
Number of Phase: 4
Temperatuure rise: 80°C Max
Inertia: 4000 gcm^2

Dielectric strength: 500VDC
Insulation resistance: 100MOhm(500VDC)
Radial play: 0.025mm max.(load 450g)
Insulating class: B
Weight: 5.6 kg

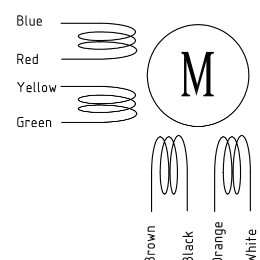
SPECIFICATIONS

	Holding Torque (2 phases on) N.m ±10%	Rated Current/Phase (Amps DC)	Phase Reslstance (ohms) ±10%	Voltage Current/Phase (V DC)	Phase Inductance (mH) ±20% Typical (1kHz)
Unipolar	9.0	6.2	0.75	4.7	5.0
Bipoar(Series)	12.8	4.4	1.5	6.6	20
Bipoar(Parallel)	12.8	8.8	0.38	3.3	5.0

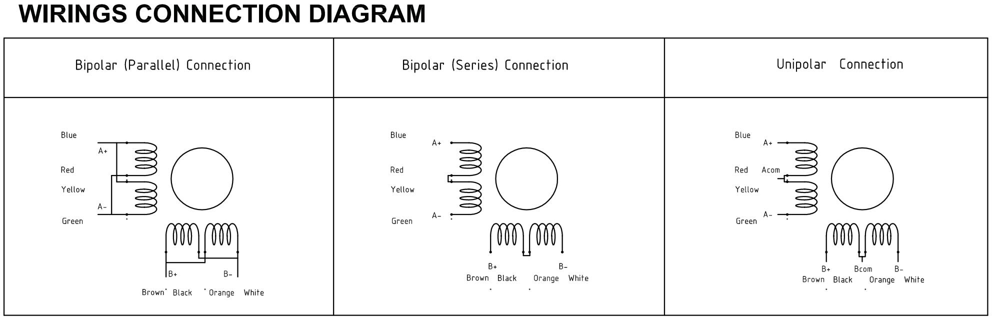
DIMENSIONS unit=mm



CONNECTIONS



WIRINGS CONNECTION DIAGRAM



The only limits to
CNC technology are your own imagination. The machine was originally only a 3 axis machine. However I have added a 4th axis to expand the machine's capabilities. This will give me true 3D capability (the ability to carve complete statues, etc.). At least on a small scale. For larger scale true 3D, a 5th or 6th axis is needed. Just out of reach financially right now.....
UPDATE: I have discovered some amazing software called MeshCAM Art. After using the free trial download of the software, I was simply amazed at the capabilities of MC Art. All that is needed to create a 3D tool path, is to create a simple bitmap, and import it into MC Art, edit the desired heights for each color, and save the file as a G-code file. Launch Mach 3, load the G-code file created in MC Art, and carve away! I actually wrote a users guide for the software's author, about the experience. Visit www.grzsoftware.com to learn more about MeshCAM Art.
I also discovered another great website: www.geargenerator.com
It allows you to create gear profiles which could actually be printed out, and glued to a block of wood for cutting on a bandsaw, or scroll saw. The registered version will output DXF files so that it can be loaded into LazyCAM and toolpaths generated to cut gears!

Update: Another discovery
www.cncwrapper.com Using the CNCWrapper software, any Gcode can be imported into the program to create a toolpath for a 4th axis! The CNCWrapper software itself will generate a 4th axis toolpath for turning things like stair spires, table legs, etc. Or to simply turn a piece of square stock into a round stock item for later importing a 3D file created in software such as MeshCAM Art! I have been busy updating the drawings in this book, to reflect the many changes made to the machine.

Update 4/1/2011:
Well, the 4th axis project has resulted in a complete re-engineering, and reconstruction project. The original design of my machine has been altered so drastically, that it is no longer the same machine!

During this process, I have added:

1- 4th axis assembly along the left side of the table
2- Expanded the table width by 7”
3- Increased the Z travel from 3.125” to 13”
4- Added a spindle lock to aid in tool changes
5- Added a Dustshoe and 4” diameter vacuum hose
6- Installed a 2 HP dust collector system
7- Improved linear rail design along the X Axis
8- Added flexible conduit for all wiring on the machine
9- Mounted the controller box beneath the table
10- Added brush sweeps to the X Axis trucks to eliminate dust build-up which cakes onto the bearings (resulting in “bumps” along the X Axis travel).

To Do List:

11- Add sturdy 3”x3” square tube legs to stabilize entire assembly (to reduce rocking and vibration).
12- Plane the table surface after leveling table in relation to the gantry for an absolute “Flat” Table surface..
13- Add a tool probe device to aid in setting the Z axis to zero
14-Modify the screen set in Mach3 to utilize the Autozero macro function for setting the Z axis to zero after tool changes.
15-Teach the machine to cook Breakfast, wash the dishes, feed the cat, check the mail, pay the bills, file income taxes, sell jobs, and answer emails.

Please feel free to email me with any suggestions for improvements to my design. And include drawings which illustrate your ideas (even if it is just a scanned pencil sketch). I have learned, that it is sometimes difficult to communicate design ideas using words alone. The old adage that “A Picture is worth a Thousand Words” holds true. I long for the day, when I can afford to purchase a 3D CAD/CAM program. As it is sometimes difficult to express through illustrations a concept, or idea in only two dimensions.

If you should decide to build a copy of my machine, please send me a photograph or two. Also, any photos of pieces carved using the machine. I have invested many long hours in designing, building, wiring, diagnosing, fine-tuning, and learning how to use this machine. And quite possibly, just as many hours in creating the illustrations, and writing shown in this book.

Some folks say that I should patent the design. This is something I have researched before, and I have learned that a Patent isn’t all that most people think that it is. Even if you are successful in obtaining a Patent on a given idea, it is still up to you to defend the Patent in court. Often at an expense which far exceeds any profits you may have realized.

Also, a Patent granted by the U.S. Patent Office, does NOT automatically grant you a world-wide patent! The best strategy one can hope for, is to build as many items of your idea as you possibly can, THEN apply for a temporary patent which gives you one year of protection, during which you can sell, sell, sell. Because when the year is up, no matter how sharp of a patent attorney you may hire, someone else will probably make some small change to your idea, and get a patent granted ahead of you.

Learning this fact, was a major disappointment for me. And the fact that a patent is only good for 20 years! Welcome to life in the 21st Century.

Update 10/10/2011:
Page 9 of this document has been updated to show the addition of a (-) Z Limit switch which I installed, (and enabled in Mach3) after many occurrences of ruined work, table damage, and broken cutting bits. Which have happened during extended cut times of several hours (left running un-attended). Which is NOT a recommended practice!!!

What was apparently happening, was at some point a lost-steps error occurred during the cut cycle. This resulted in Mach3 “losing it’s reference” as to where the tool was physically located. For example: during a Positive Z movement, for whatever reason, the machine experienced lost steps (physically did NOT move upward)- although commanded to by Mach3. Since Mach3 has no method of sensing this condition, program execution continues normally. However, since the tool is now physically located LOWER than Mach3 thinks it is, further Negative Z commands result in cuts which are deeper into the work material than Mach3 is even aware of. Sometimes MUCH deeper, (actually causing the tool to cut completely through the work material, and into the surface of the table!!!).

Obviously, something had to change. So, I installed the (-) Z axis Limit Switch to address the problem. Although this adds to the procedure for tool changes, it is an important safeguard which has successfully overcome the lost steps problems which sometimes occur. The new process for tool changes is outlined below:
1-Change the tool
2-place a sheet of paper onto the surface of the work piece
3-jog the tool down until it contacts the paper
4-set Z Zero
5-jog the Z Upward enough to clear all surfaces of the work piece
6-jog the Y axis in a negative direction until tool is completely off the edge of the table
7-jog the Z axis to the Z Zero position (Z0)
8-unlock the (-) Z Limit switch
9-adjust position of the (-) Z Limit switch until it is triggered
10-(Reset the Limit Switch Triggered Error in Mach3)
11-reset the dial caliper on the (-) Z axis Limit Switch indicator to Zero
12-reading the digital caliper, adjust the position of the (-) Z axis Limit Switch to match the maximum cut depth of the current program (switch the power OFF on the digital caliper to conserve battery life)
13-Lock the new position of the (-) Z axis Limit Switch
14-jog the Z axis Upward enough to clear work piece
15-click Start Cycle in Mach3 to continue the cutting program

The advantage here, is that in the event of lost steps during program execution (and any attempt by Mach3 to move the tool in a Negative Z movement which physically extends deeper into the work material than called for by the program), the (-) Z axis Limit Switch is triggered, and all operations by Mach3 are stopped dead in their tracks!

This allows the user (upon returning to check on the machine’s progress) to re-home the machine, and continue program execution right where it left off at! Even if the user’s return doesn’t happen until HOURS later!

This procedure may still fail in saving the work piece, (as the tool briefly plunges deeper than programmed, during a lost steps condition). However in a wood routing operation, this usually results in a small hole that is only a couple of thousands of an inch deeper into the material than programmed. Instead of a completely ruined work piece/damaged table surface/broken bit that would otherwise happen in a lost steps condition!

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