

Automating a Manual Machine

Converting the LMS 5100 Mini Lathe to
CNC

Converting the 5100 Mini Lathe to CNC



Convert this manual
lathe...
to this CNC lathe



Introduction

These instructions show you how to convert a High Torque Mini lathe, model 5100, from Littlemachineshop.com to CNC control. It is possible it would fit other 7x14 or 7x16 lathes, but we cannot confirm that. It was designed and tested and used in a class of 14 students at the CNC workshop in 2016, then re-designed for Meade Schools in South Dakota..

These instruction will discuss all the mechanical parts, electrical components, and software for the complete conversion.

The mechanical components include the ballscrews for each axis, and all the brackets, bearings, pulleys and nuts and bolts. We do re-use some bolts and brackets from the original machine.

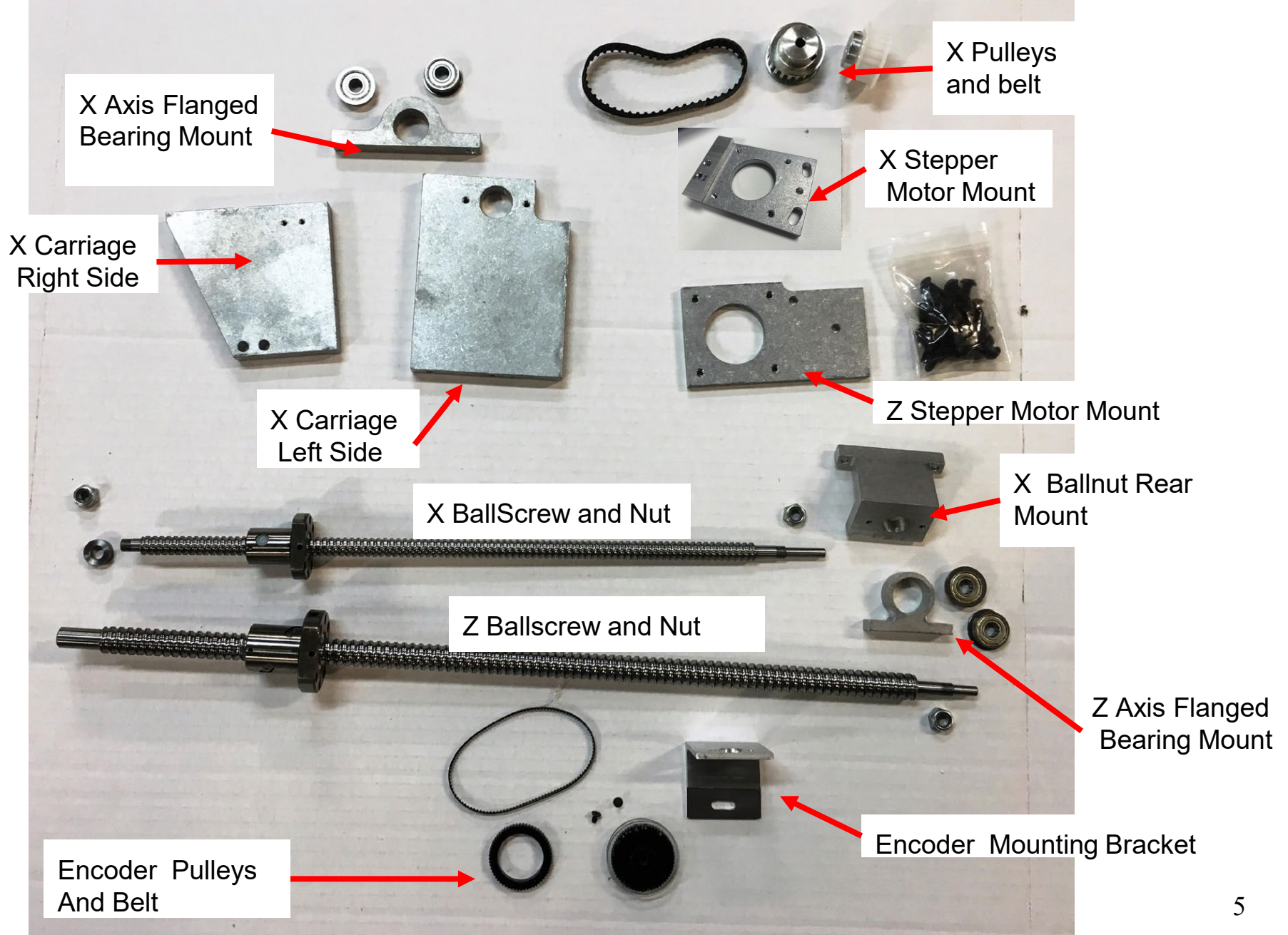
The electronics components controller for this conversion were produced by CNC4PC. It includes the control box itself, along with stepper motors, rotary encoder, and cables. This project differs from previous conversions in that it incorporates the use of closed-loop stepper motors.

The software used is Mach 4, provided by Newfangled Solutions. It includes the machine control software and some included “wizards” for the lathe.

Introduction (cont'd)

In this document, we use the standard CNC lathe conventions for axis definitions. The X axis is the cross slide, which determines the diameter of a part. The Z axis is the length of the part, between headstock and tailstock. There is no Y axis on a lathe.

Mechanical Components



CAUTION

Be extremely careful in handling the ballscrews to not let the nut reach either end of the screw. If the nut reaches the end, the balls will be released and the screw will be useless.


It is possible to replace the balls, but it is extremely tedious, and rarely completely successfully.

DO NOT LET THE NUTS GO OFF THE END

We will be adding stop collars at the end to prevent this.

Mechanical Components

Fastener List



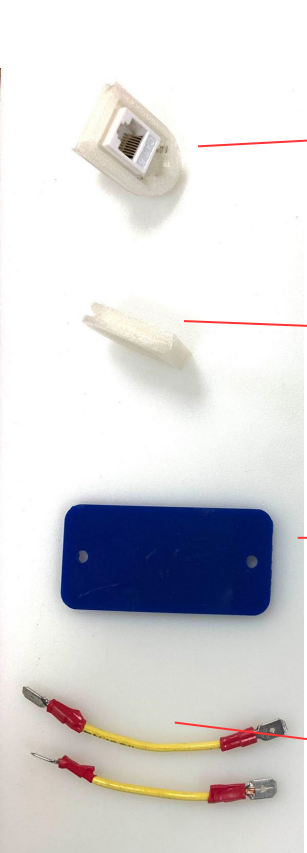
Description	Quantity	Usage
Screw-Button Head-M6 x 1 x 16mm	2	Z Screw Bushing Mount Attmt
Screw-Button Head-M6 x 1 x 16mm	3	X Stepper Motor Plate Attmt
Screw-Button Head-M5 x .8 x 20mm	2	X Bearing Mount Attmt
Screw-Cap Head-M8 x 1.25 x 20mm	2	X Carriage Top (Use Original Screws)
Screw-Button Head-M5 x .8 x 12mm	2	Z Stepper Motor Mount Plate Attmt
Screw-Button Head-M5 x .8 x 12mm	1	Encoder Bracket Attmt
Screw-Phillips- M3 x .5mm x 12mm	1	Encoder Attmt (Screw is incl w/encoder)
Screw-Button Head-M4 x .7 x 16mm	2	X Ballnut Attmt
Screw-Button Head-M4 x .7 x 16mm	2	X Ballnut Mount Attmt
Screw-Button Head-M4 x .7 x 16mm	2	Z Ballnut Attmt
Screw-Button Head-M3 x .5 x 20mm	4	X, Z Limit and home Switch Attmt
Screw-Cap Head-M5 x .8 x 12mm	4	X Stepper Motor Attmt
Screw-Cap Head-M5 x .8 x 12mm	4	Z Stepper Motor Attmt
Nut-Nylock Hex M8 x 1mm	1	X Ballscrew Stop Nut
Nut-Nylock Hex M8 x 1mm(Low Profile)	1	X Ballscrew Pulley Retaining

Misc Components



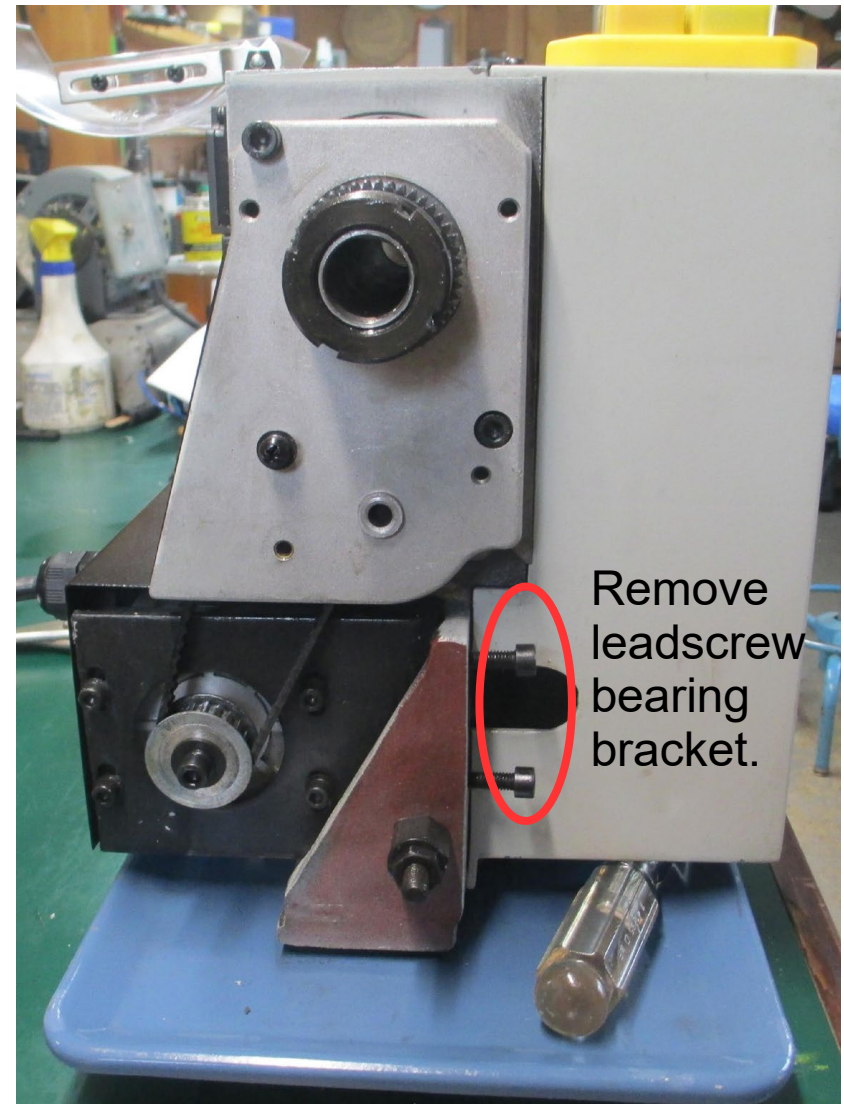
Description	Quantity	Usage
Gear Ring-XML 100 Tooth	1	Encoder Drive (Mounts on Lathe Spindle)
Gear with flanged sides and "D" Hole	1	Encoder Gear (Press-fit onto encoder)
Spacer-X-Axis Stepper Motor Bracket	2	Mounts behind X-Axis Stepper Brkt
Stop Collar-X-Axis Ballscrew	1	Mounts to X Ballscrew with nylock nut
Coupler-Flexible ¼" to 6mm	1	Couples the Z-Axis Motor to Z Ballscrew
Flanged Bearings	4	X and Z axis Bearing Mount
Stop Collar-Z-Ballnut	1	Mounts to Z Ballscrew on left end

Misc Components Electrical



Description	Quantity	Usage
Pass-thru Assembly (3D printed)	1	Manage RJ45 connector thru spd cntl box
Closeout (3D printed)	1	Close hole on rt side spd cntl box
Panel Cover-Power Switch (Laser Printed)	1	Close Opening left by on-off switch
Jumper wire-speed control	2	Bypass Power switch wiring

Begin at the headstock End

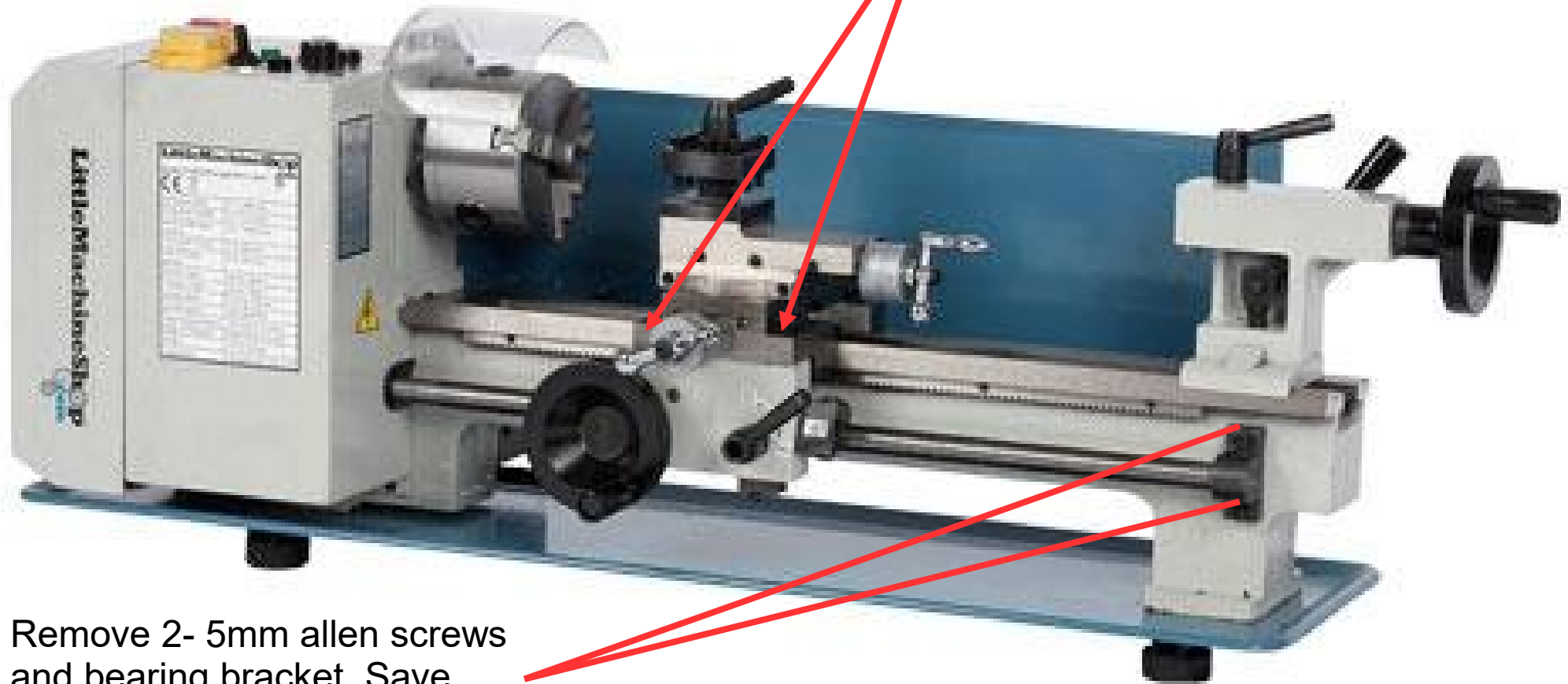


Remove the plastic cover. There are two allen screws in deep holes each side of the spindle. Save the cover and screws, Remove all the gears and change lever. It is not necessary to remove the gear on the spindle.

Remove the saddle and leadscrew.

Remove the backslash

Remove 2- 8mm allen screws. Save the screws



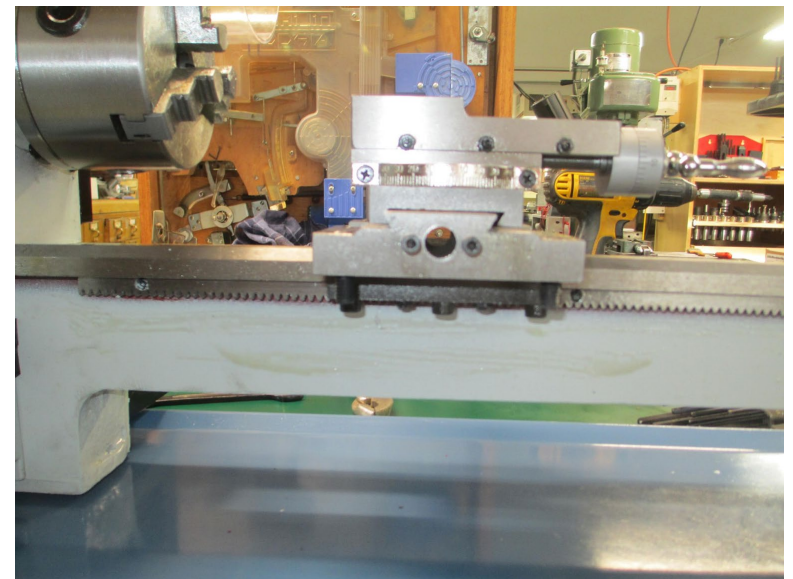
Remove 2- 5mm allen screws and bearing bracket. Save these parts.

You will want to remove the tailstock and the compound slide and tool post. These will be used in the finished machine, but you will want them out of the way for the next steps.

Remove the X axis parts



Remove the nut from the end of the X axis crank, Remove the crank. Pull off the calibrated collar- it is held on by a small leaf spring. Remove 2 allen screws in the bearing block. Unscrew the lead screw (you may have to put the crank back on to do this) Slide the saddle back and remove the brass nut from underneath- it is held by two allen screws from the top.



Saddle with all cross slide parts removed.

Optional Improvements

These lathes can use some improvement. First is simply filing off, or deburring all the sharp edges. Each edge of the cross slide casting and slide have sharp edges left by the machining. Careful use of a file will remove these, making a better looking machine and removing sharp edges.

They can also benefit from lapping the ways to improve sliding. This involves putting some lapping compound on the ways and sliding the parts back and forth. Be careful not to do too much, as this is essentially wearing the ways down. It can be a tedious process of adding compound, sliding a bit, cleaning off, testing and maybe repeating a few times.

There are many videos on Youtube showing this process. Done carefully, it will improve the performance of the lathe--done poorly, it simply accelerates wearing it out.

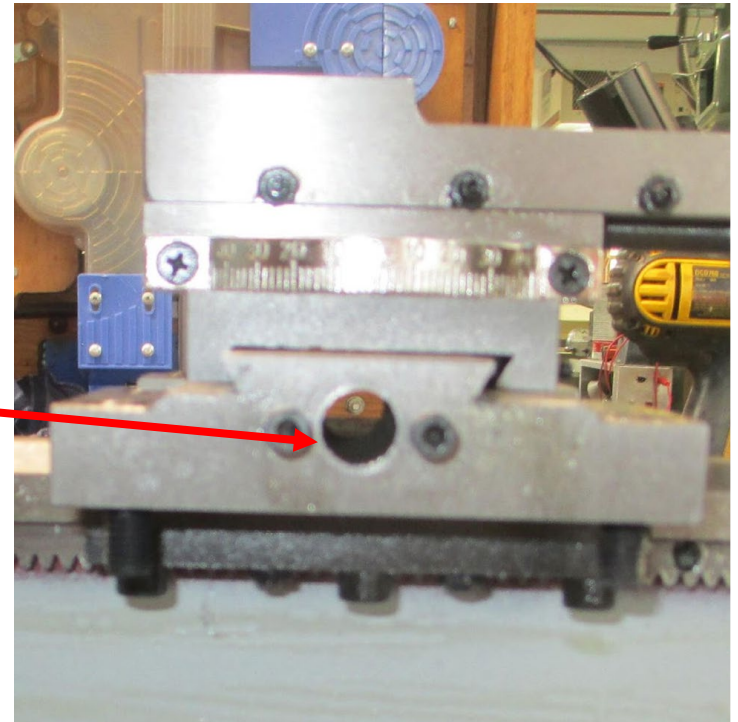
At this point, be sure both the saddle and cross slide are free to slide, but tight with no looseness or wobble. Add some way oil to sliding surfaces.

X-axis

Modifications and initial assembly

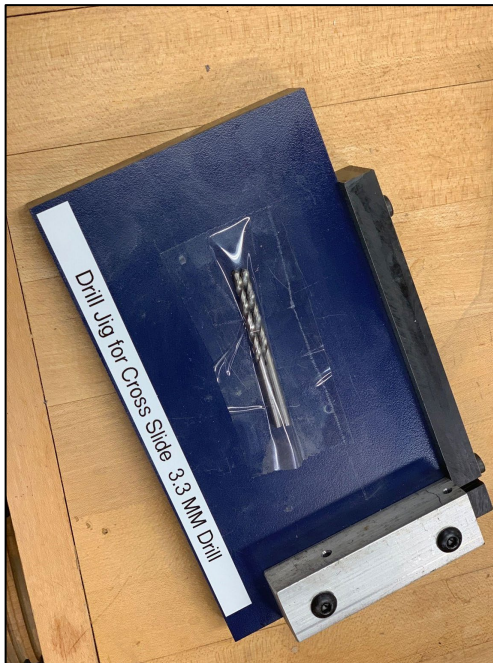
You will first need to enlarge the crossslide hole to 13 mm diameter to allow the ballscrew to have clearance. It is best to first use a 12mm, then a 13mm reamer. This process will maintain the centerline of the hole. Slide the X ballscrew through the hole in the cross slide casting, with the nut in back of the machine.

Ream out this hole to 13mm for ballscrew clearance. This operation can be completed while mounted to the lathe. Make sure you vacuum the dust while reaming.



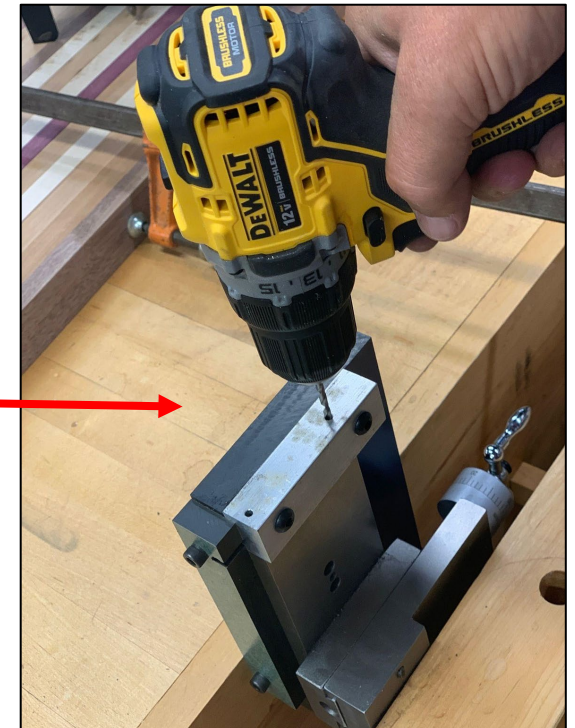
X-Axis

Drilling/Tapping Mounting Holes for Ballnut Bracket



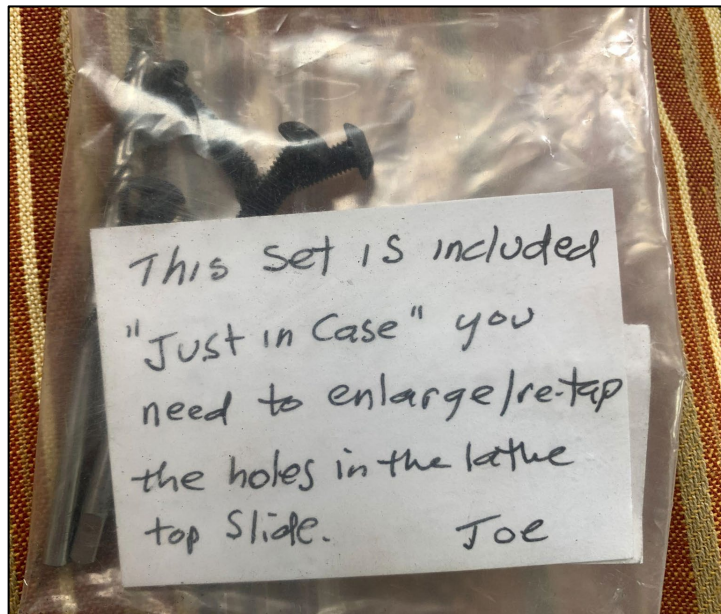
The cross slide will need to be drilled and tapped in 2 places for mounting the X-axis ballnut mounting bracket. The fixture shown on the left will assist in the accurate location of these holes. The cross slide will be drilled at 3.3 mm diameter for M4 x .7mm tapped holes.

The cross slide is held in the fixture with a vise. Make sure the top slide is located against the top and side fixture datums as shown. Drill the holes to a depth of 14-18 mm



X-Axis

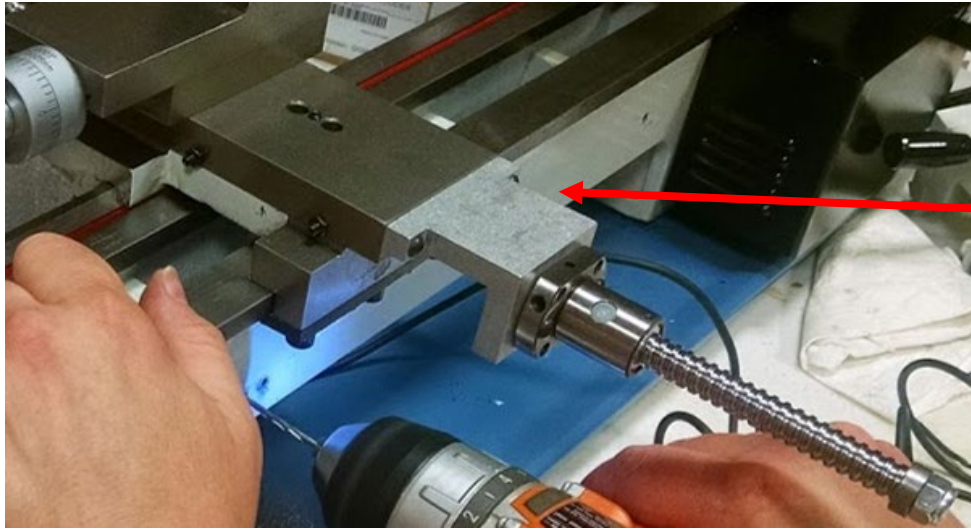
Drilling/Tapping Mounting Holes for Ballnut Bracket



Included in your "spare parts" box is a set of drill/taps/screws in case you need to enlarge these 2 holes. The replacement screws are M5 x 20mm long.

X-Axis

Mounting the Ballscrew Nut Bracket



Bracket is positioned about .010-.020" below the cross slide for future gang tool.

The X-axis Ballscrew nut is attached to the lathe cross-slide with (2) M4 x.7 x 16mm button-head screws. The lathe cross slide will need to be drilled and tapped for these (2) holes. There should be enough clearance between the screw and the hole to allow for the ballnut mount bracket to be positioned as shown above.

We have provided this long ballscrew with the extension brackets at each end to give the maximum possible X travel. This will allow a rear toolpost or a gang tool setup.

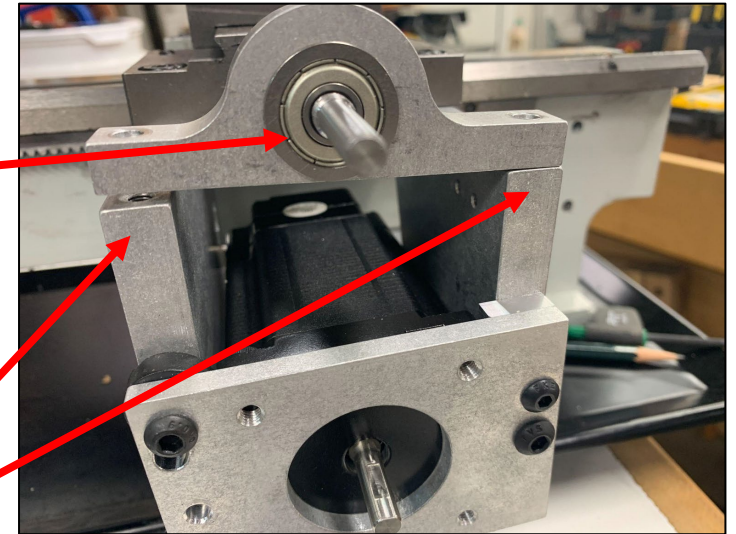
X-axis Ballcrew Mounting

Place a flange bearing on the screw, then the X bearing bracket, then another flange bearing and a lock nut. The flange bearings fit tightly, so you will need to press them in one-at-a-time using a vise with parallel jaws. A woodworking vise works well for this as it does not damage the bearing.

NOTE: the X-bearing bracket is not symmetrical- The longer leg will point toward the tailstock.

You will notice that one of the locknuts is thinner than the other 2--use the thinner one here. Tighten the locknut so there is a slight pre-load on the bearings- just enough to remove backlash, but not a heavy drag.

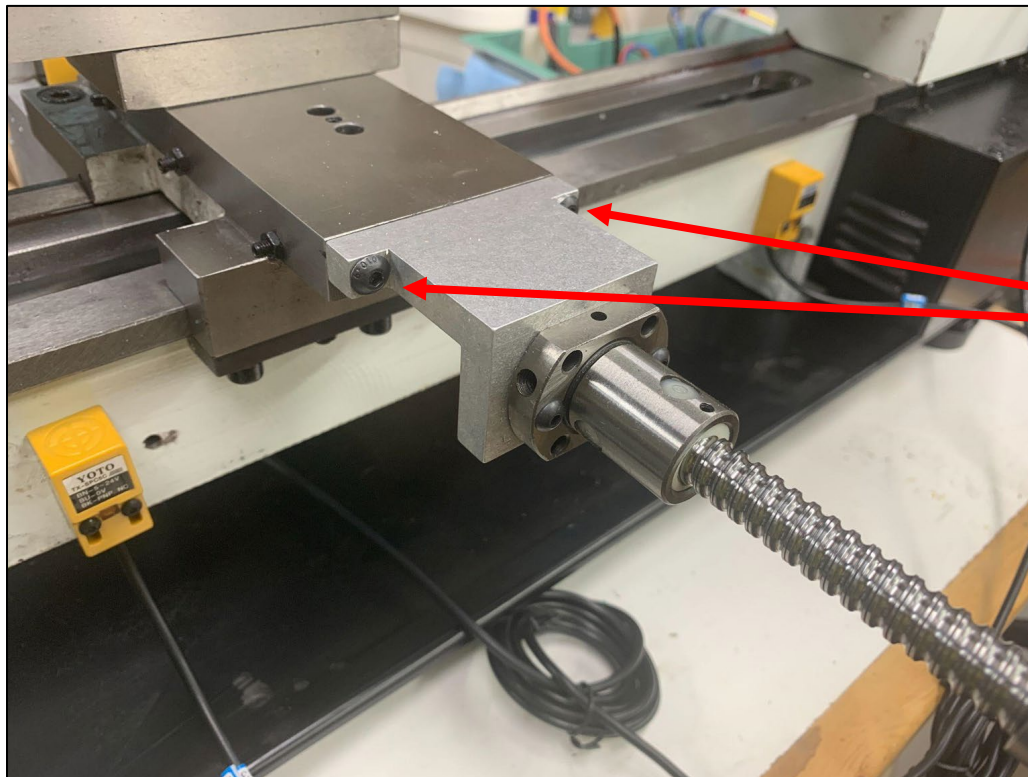
You may need to insert washers under the X-bearing mount for better X-ballcrew alignment.



X-axis

Alignment of the ballscrew

The X-axis ballscrew must be aligned so that it does not bind throughout its entire travel. Use the free play in the rear mounting screws of the bracket and ballnut, as well as the free play in the front bearing mounts. It is best to temporarily mount a pulley to the ballscrew so that you can use finger-pressure to sense drag on the ballscrew through its travel

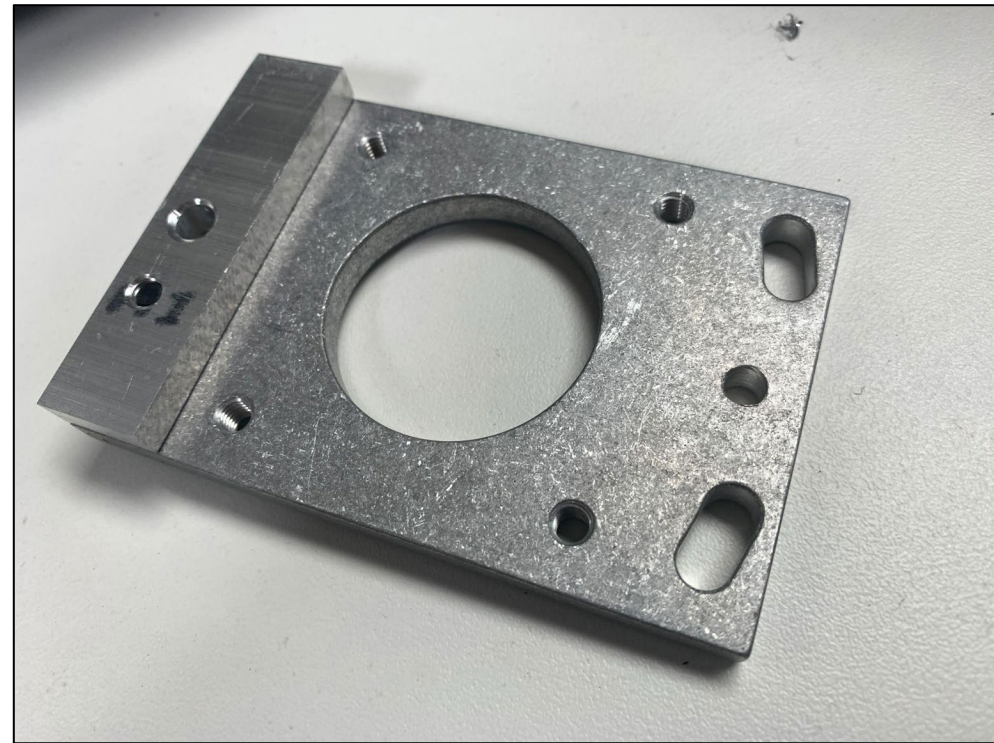
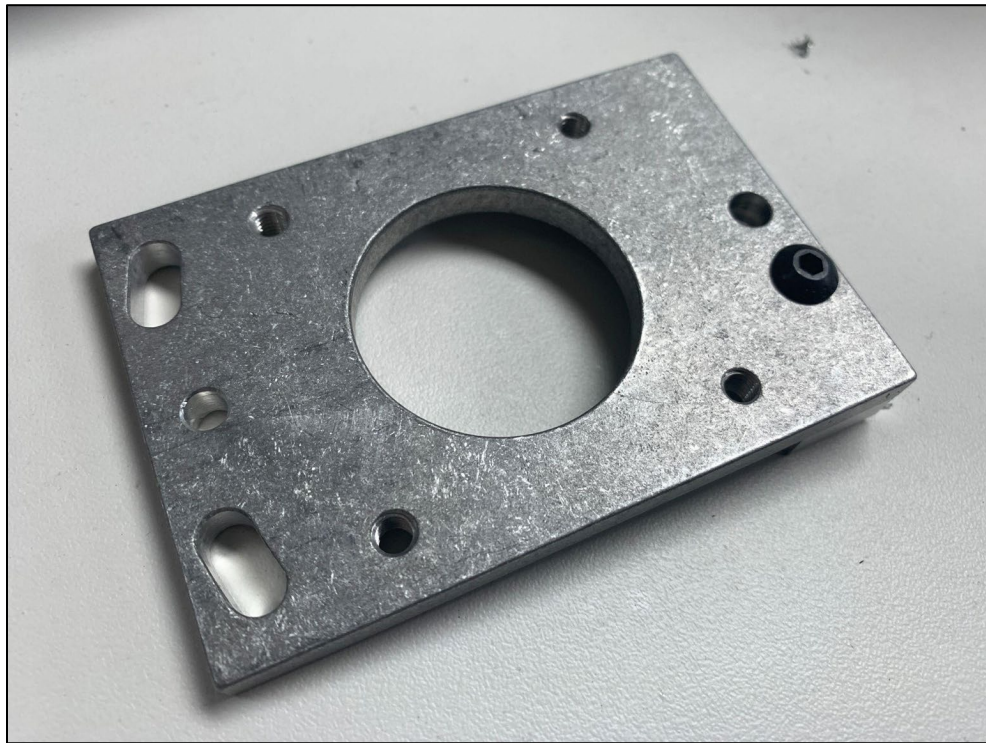


X-axis adjustment screws

X-axis

Mounting the Stepper Motor

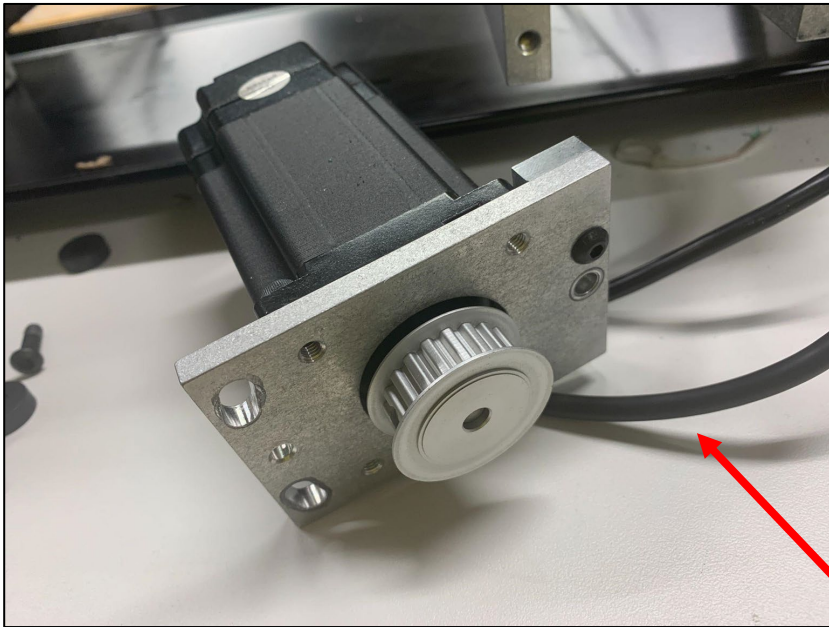
The X-Axis Stepper Motor Mounts to the bracket shown below. The bracket comes Pre-assembled with a $\frac{1}{4}$ " thick spacer. Use (4) M5 x 12 Cap Screws for this.



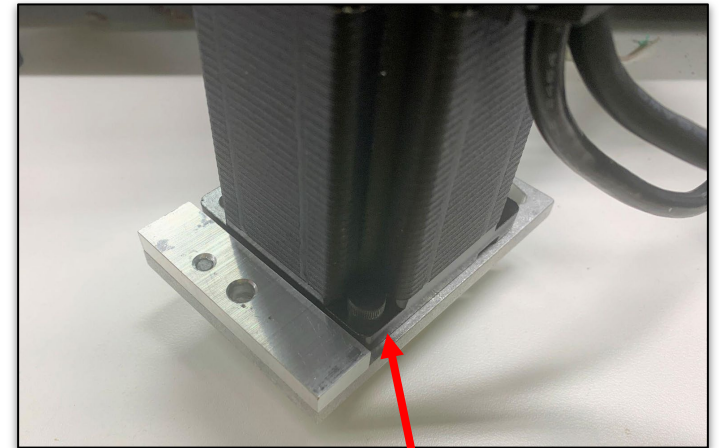
X-axis

Mounting the Stepper Motor

Mount the stepper motor to the X-axis bracket as shown. Use (4) M5 x 12mm cap screws. Note the orientation of the stepper motor to allow for cable clearance.



Note orientation
of stepper motor
cable on bottom.



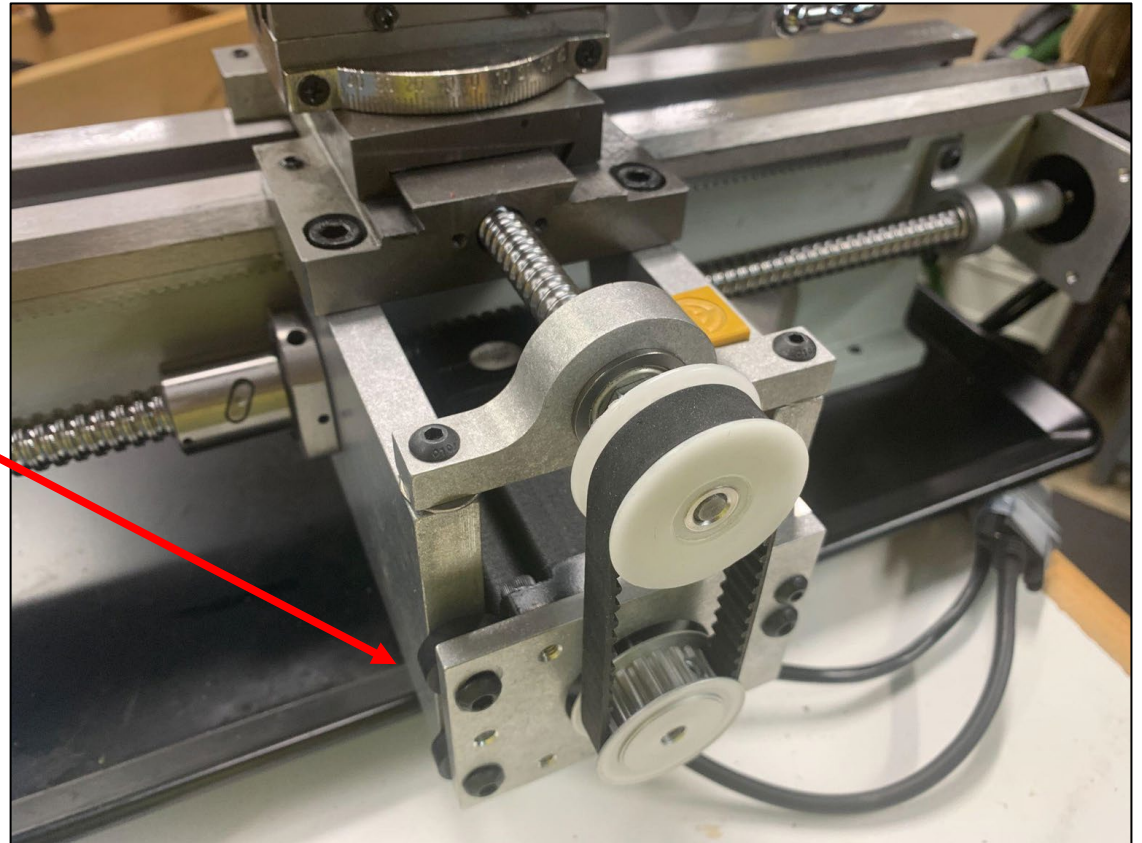
Mount stepper
motor using 4
cap screws.

X-axis

Mounting the Stepper Motor Plate

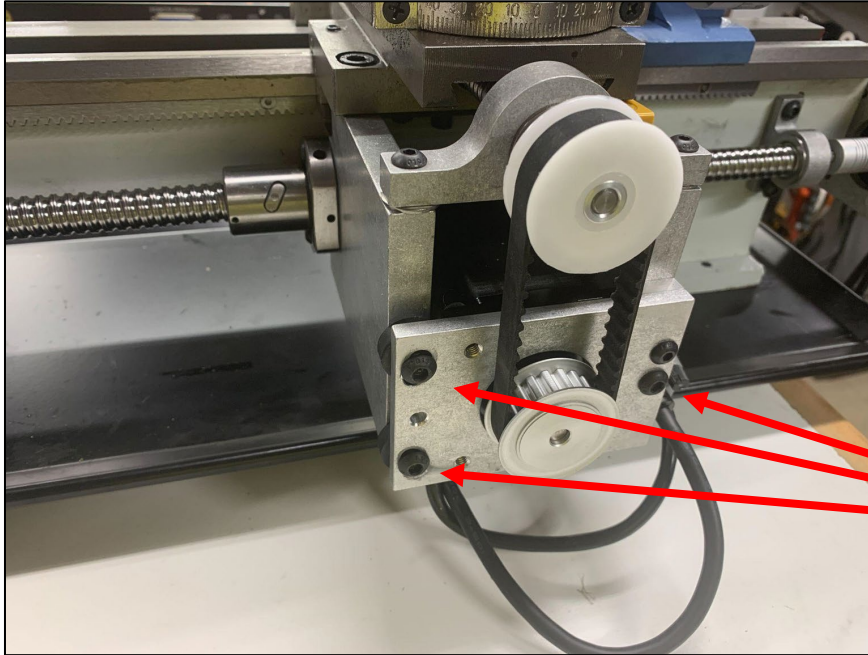
Mount the X-axis mounting plate to the left and right brackets. Use (3) M5 x 20mm button head screws. Note the (2) plastic spacers on the left side of the bracket.

Use (2) ¼" thick plastic spacers here.



X-Axis

Mounting the Pulleys



Note: White plastic pulley goes on top. You will need to adjust the in/out position of the pulleys to align the belt.

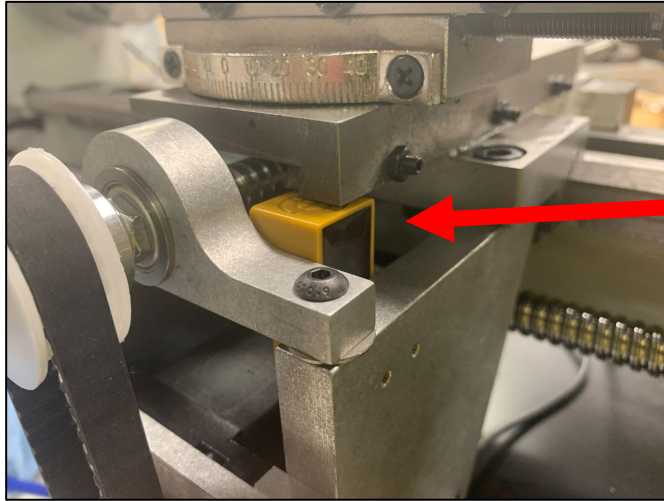
Belt tensioning screws. Loosen all 3 mounting screws to rotate the bracket around the right side pivot screw.

Place the pulley on the end of the X ballscrew, tighten the set screw well.

Place the lower pulley on the motor shaft, making sure that it is signed with the upper pulley. Tighten the set screw on the lower pulley. It may be good to file a small flat on the shafts for better hold of the set screws.

Put the belt in place and tighten the (3) belt tension screws. Tighten the belt to eliminate backlash, but not so tight as to put too much load on the pulley bearings.

X Axis Home/Limit Switch



Align the Home switch so that it just clears the lathe top slide.

The CNC Lathe uses the same type of proximity switch on both the X and Z axes. However, the X-Axis switch is programmed in Mach to act as both a Home and a Limit switch. It is used to reference the axis and also will stop travel to prevent hitting a hard stop on a X+ movement.

Mount the home/limit switch on the inside of the carriage side plate. Adjust it so it just clears the top slide and tripped when the cross slide moves outward to the end of its travel. A red indicator light will show that the switch is working.

Z-axis

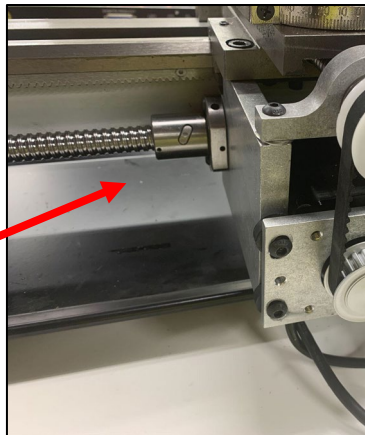
Place the z ballscrew through the left side X plate, with the nut to the left of the plate.

Attach the left and right plates to the cross slide using the 8mm allen cap screws that held the original carriage.

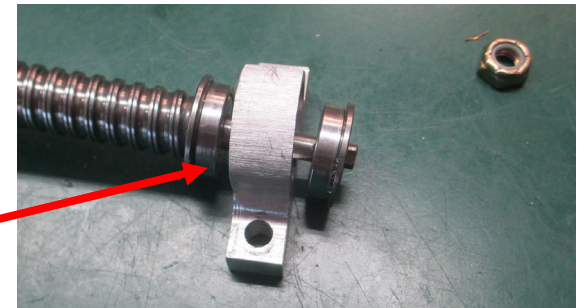
Use (2) 4mm button-head screws to mount the Z ballnut to the left side X-bracket. Do not tighten these yet, as they will be used to align the Z axis Ballscrew.

On the tailstock end of the ballscrew, place a flange bearing, the end bracket and another flange bearing, Press the flange bearings in place and tighten with a locknut as you did the X Ballscrew. Mount the end bracket with the original cap screws from the teardown. Do not tighten these screws yet.

Z Axis ballnut

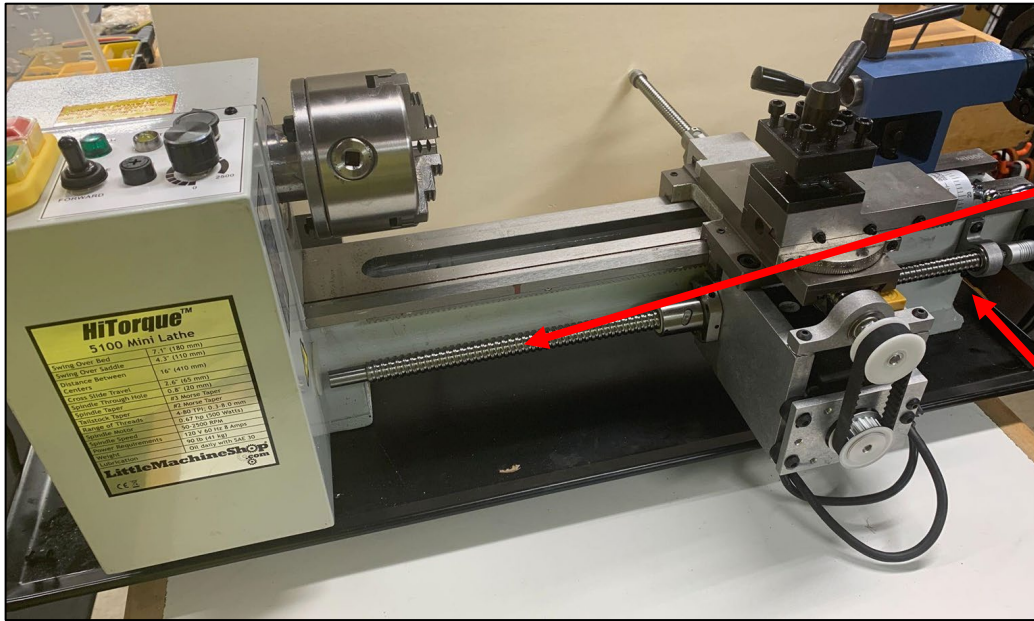


Z Axis end
Bearingst



Z-Axis Cont'd

Aligning the Z Ballscrew with the lathe bed



Make sure the Z-ballscrew is parallel with the lathe bed as viewed from the top and front

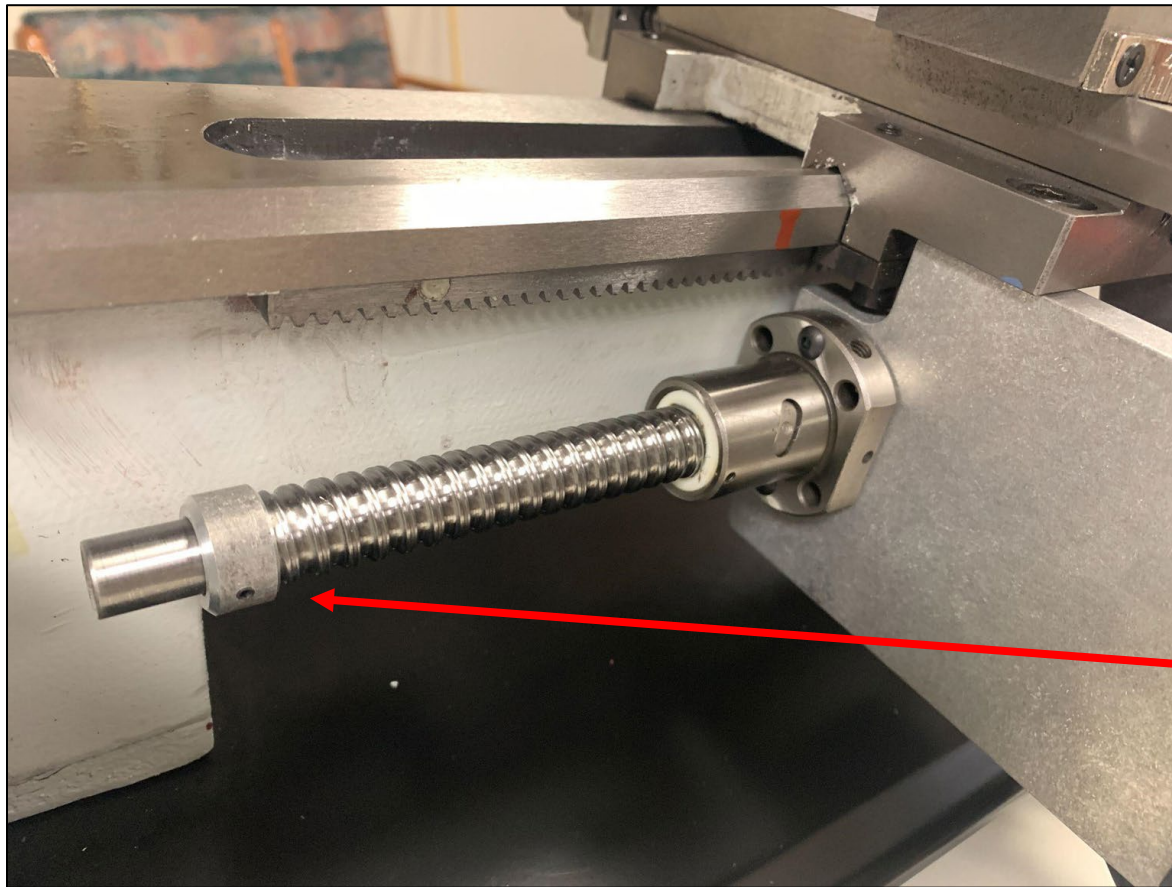
You may need to add washers under the bracket for alignment of the Z Ballscrew

When tightening the end bracket (the one with the flanged bearings near the tailstock), make sure the Z-ballscrew is parallel with the long ways of the lathe as viewed from the top and the front. Use the ballnut mounting screws as a means for alignment. You may need to place washers under the end bracket to align the ballscrew with the lathe as viewed from the top. After the screws are tightened, use a drill to run the carriage back and forth to make sure everything runs true and freely. You may need to repeat this process to optimize alignment.

Z-Axis cont'd

Ballscrew Stop Collar Mounting

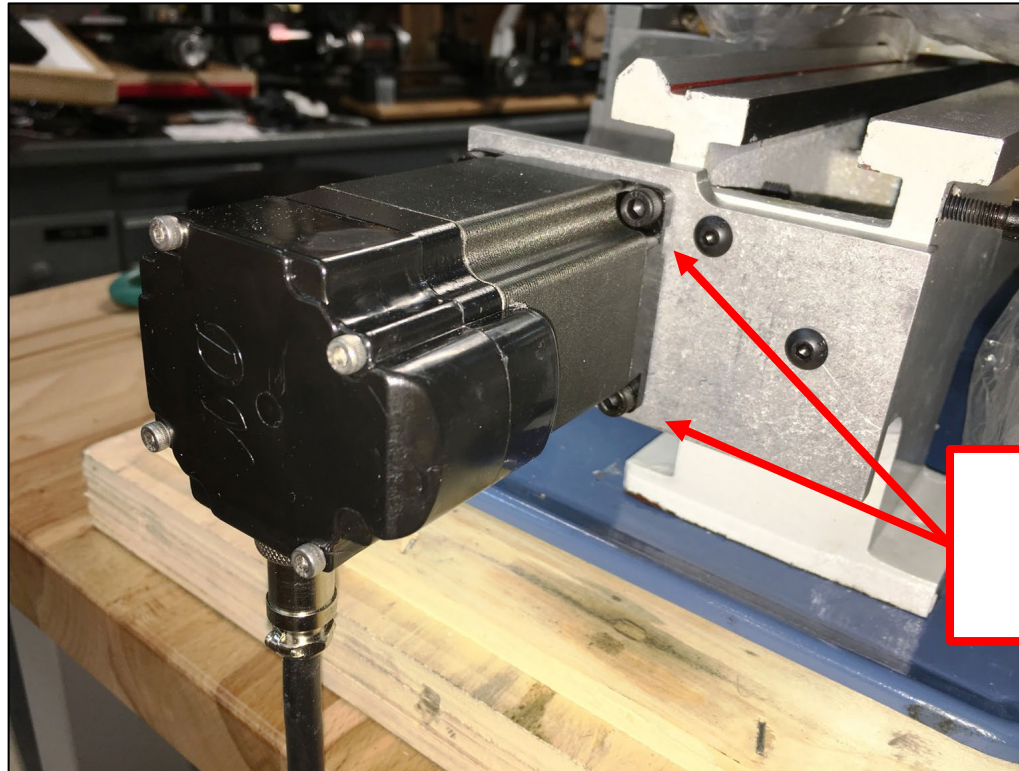
A stop collar is used on the left end of the Z Axis ballscrew. It prevents the ballnut from moving off the screw.



Mount the stop collar
on the left end of the Z
ballscrew

Z-Axis cont'd

Stepper Motor Mounting

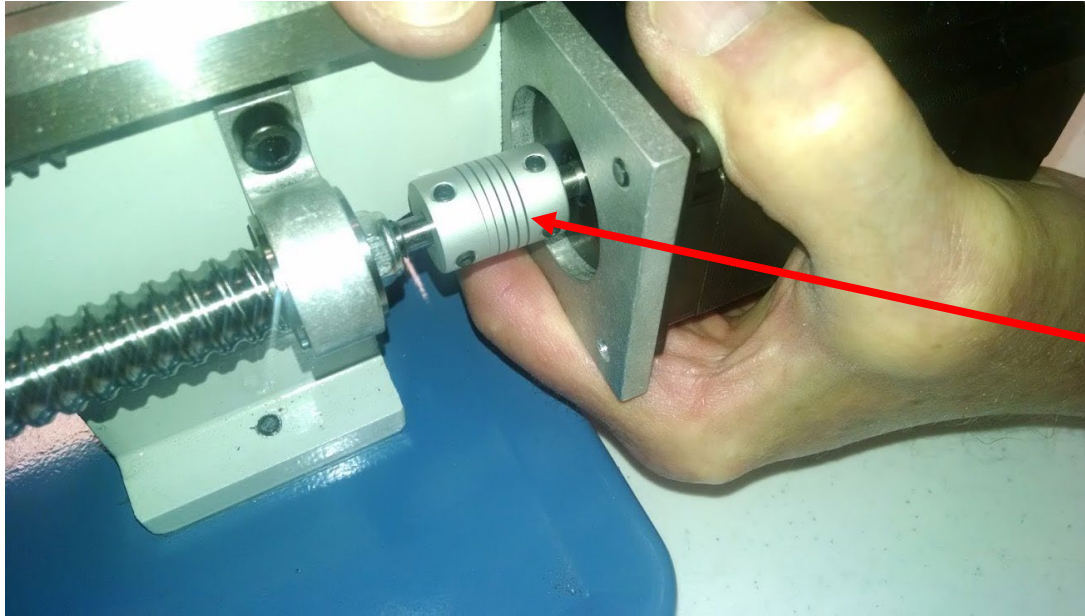


M5 x 10mm Cap
Screws (4 places)

Use (4) M5 x 10mm Allen Cap screws to mount the Z stepper motor to the Z axis bracket.

Z-Axis cont'd

Alignment of Motor



Align the Z motor bracket so the helix spacing is even

Place the helical coupling on the Z ballscrew. Tighten well.

Put the Z motor on the Z motor mount plate, temporarily use a couple allen screws to hold it.

Place the coupling onto the end of the motor shaft.

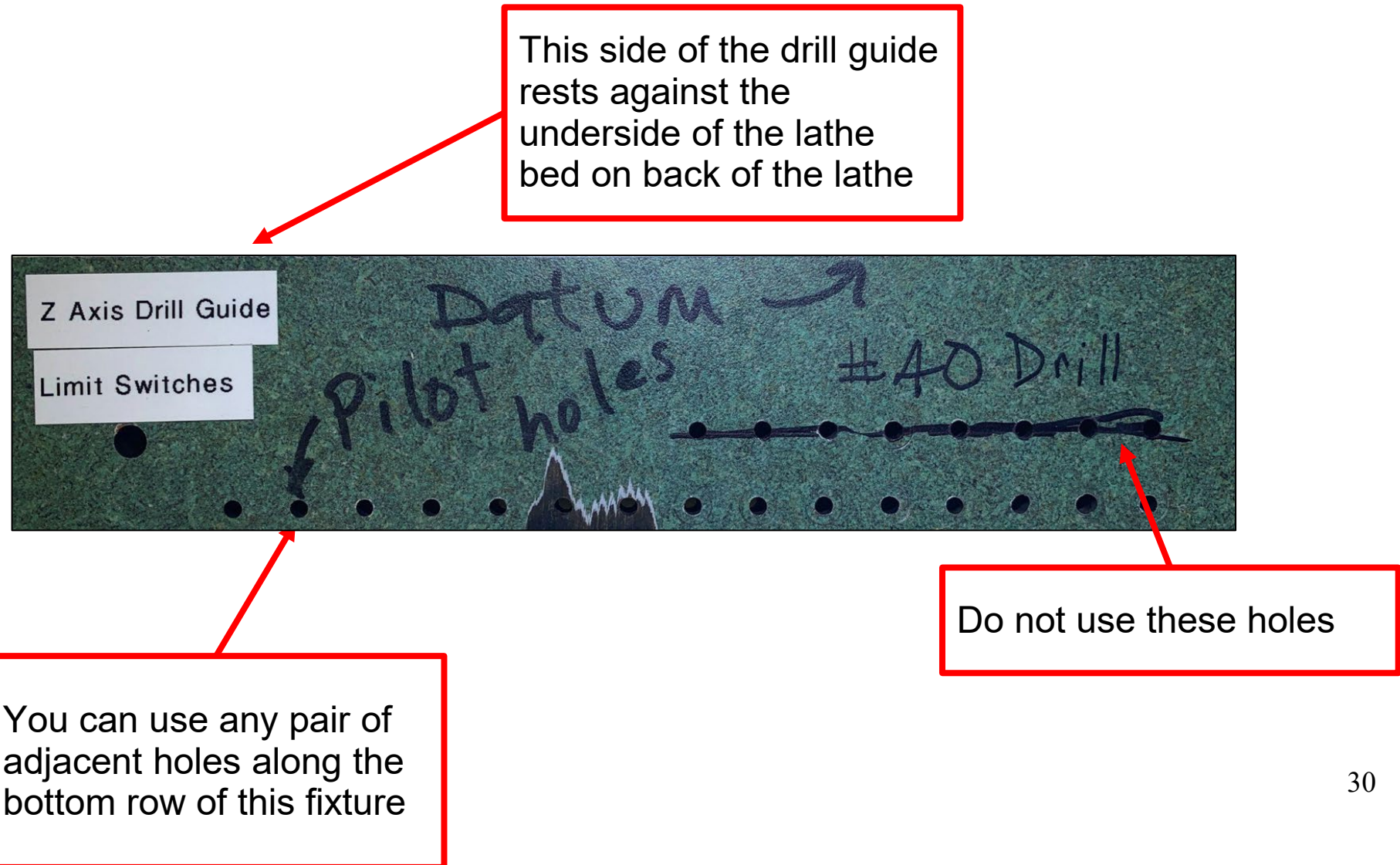
Carefully place the z motor plate onto the end of the lathe bed. Align it so there is no flex in the coupling. Use a clamp to hold it in place.

Spot through the holes in the plate for the mounting screws. Drill and tap two mounting holes.

Z Axis Home Switch

A home switch is used to provide a reference for Z axis. This is helpful when a part needs to be made from a program if the machine happens to be turned off. The switch should be located somewhere near the tailstock, but the actual location is not critical. A location of about 6 inches from the right side of the lathe works well.

The drill guide below is used to locate the pair of holes to be drilled.



Z Axis Home Switch

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Align drill fixture with the "Datum" against the bottom side of the Z travel (ways)

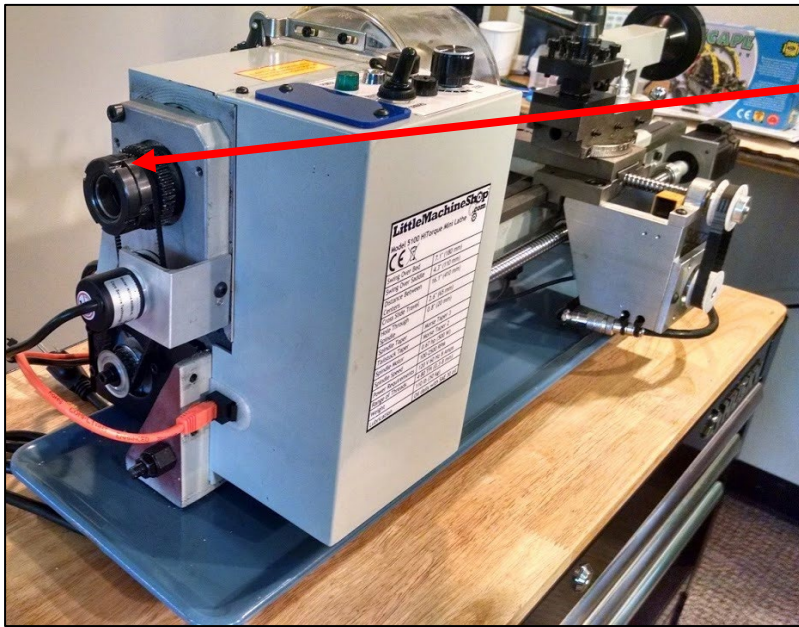


Tap the holes with a 3mm x .5 Metric tap. If you use a spiral tap, you can use a drill to tap the holes.

Using a #40 drill, drill through the lathe bed. You can use any adjacent pair of holes. Be careful to avoid lining up the hole with one of the webs inside the lathe.

You may want to drill extra pairs of holes on various locations.

Encoder and Pulleys



Remove these (2) nuts and install the encoder drive pulley.

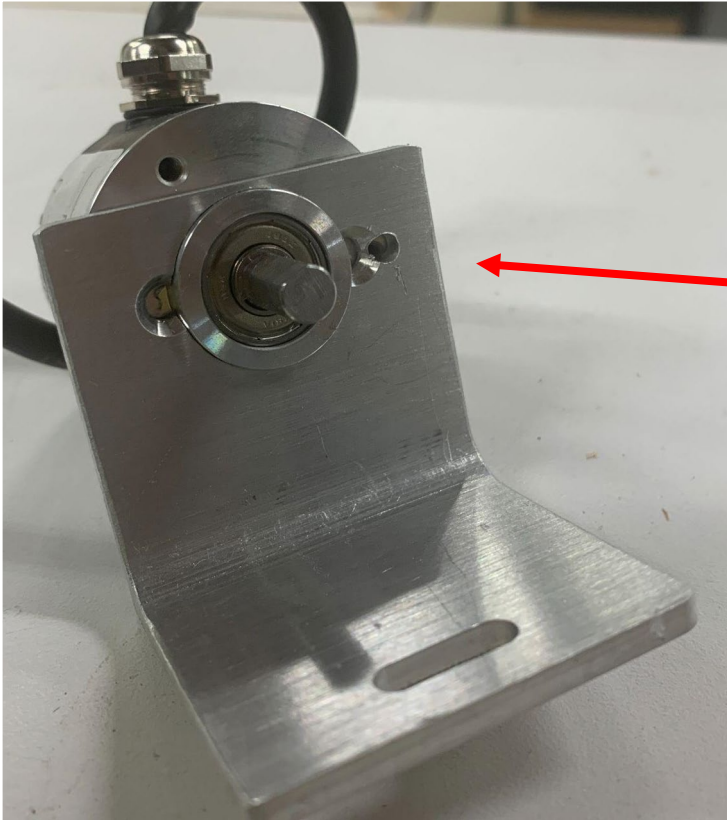
Install encoder drive pulley here



The encoder mounts to the headstock side of the lathe. It is driven by a 1:1 pulley system mounted to the lathe spindle.

First, install the Encoder Pulley Drive gear by removing the (2) nuts on the left end of the spindle. Then, install the drive pulley and replace the nuts. Tighten the nuts, but not so much as to crack the pulley.

Encoder and Pulleys Step 2

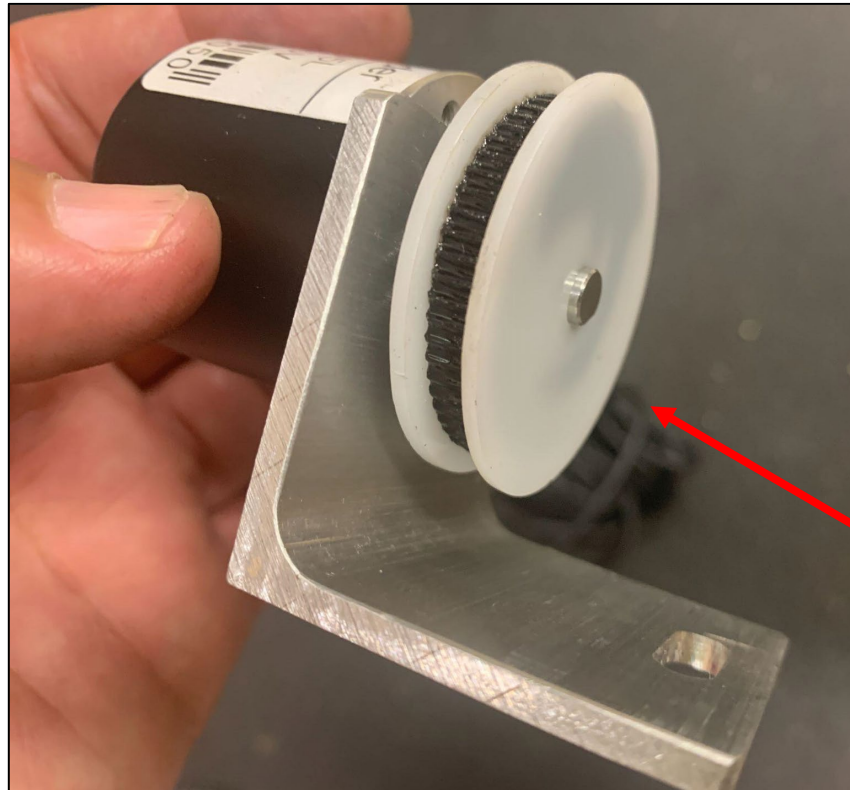


The encoder is mounted to the bracket with only one screw. You will need to rotate the encoder until the holes line up



The encoder mounts to its bracket with 1 flathead screw (provided).

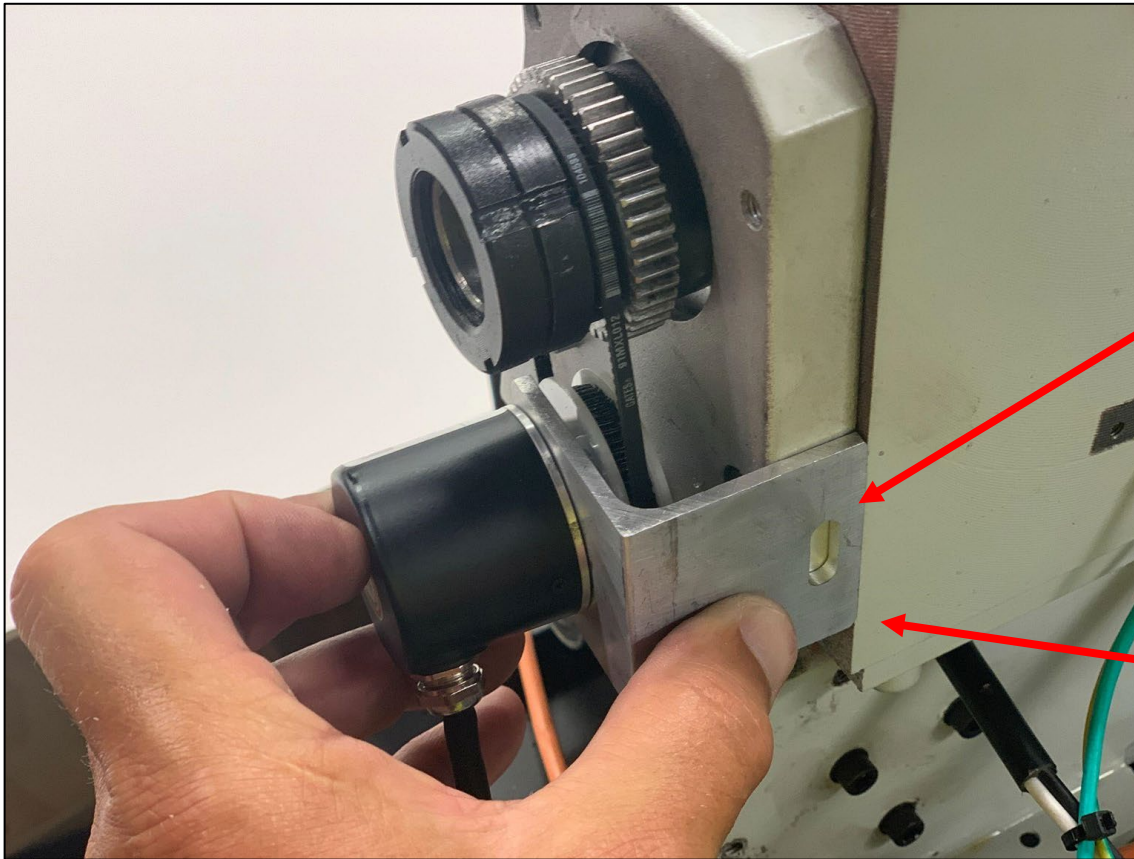
Encoder and Pulleys Step 3



The encoder pulley is hand-pressed onto the encoder shaft. Note the “D” shaped hole and align to the shaft.

The plastic pulley is press fit onto the pulley shaft. Note the “D” shaped hole for alignment to the encoder shaft

Encoder and Pulleys Step 4



Drill and tap for M5 x .8 button head screw. Use a #19 drill. Mark the hole location with a punch while holding the stepper motor in position with the belt mounted.

Hold the bracket against this edge when locating the mounting hole

Drill and tap (1) M5 x .8 hole for mounting the encoder bracket. Use a #19 drill for the tapped hole. First, mark the hole to be drilled with a transfer punch. Note that the belt is in place and tight when the mounting hole is punched.

Spindle Wiring

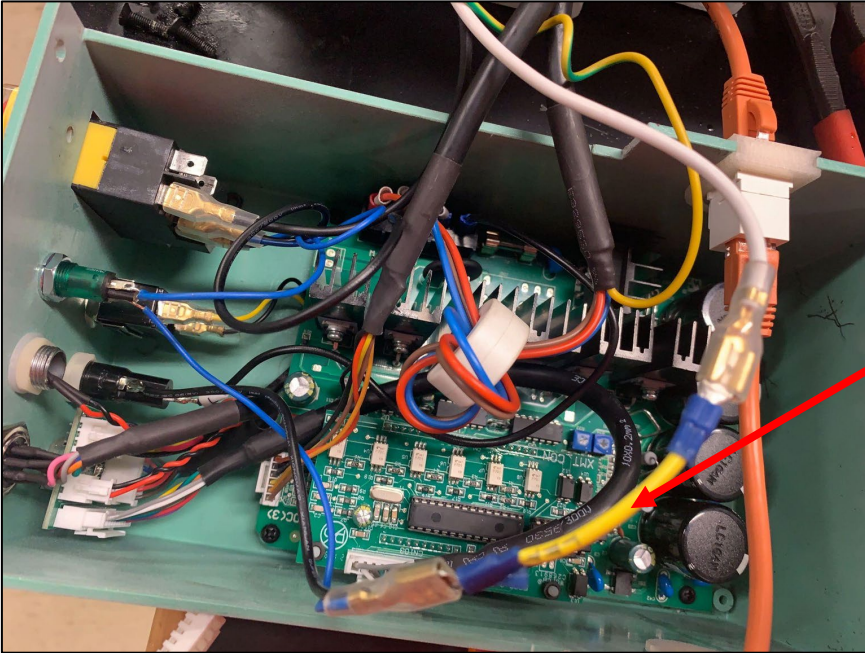


To prepare for the spindle wiring modifications to the lathe, first unplug the power cable to the lathe. We will need to bypass the on-off switch and the control wiring within the spindle control box. Remove the 4 philips screws holding the box to the lathe.

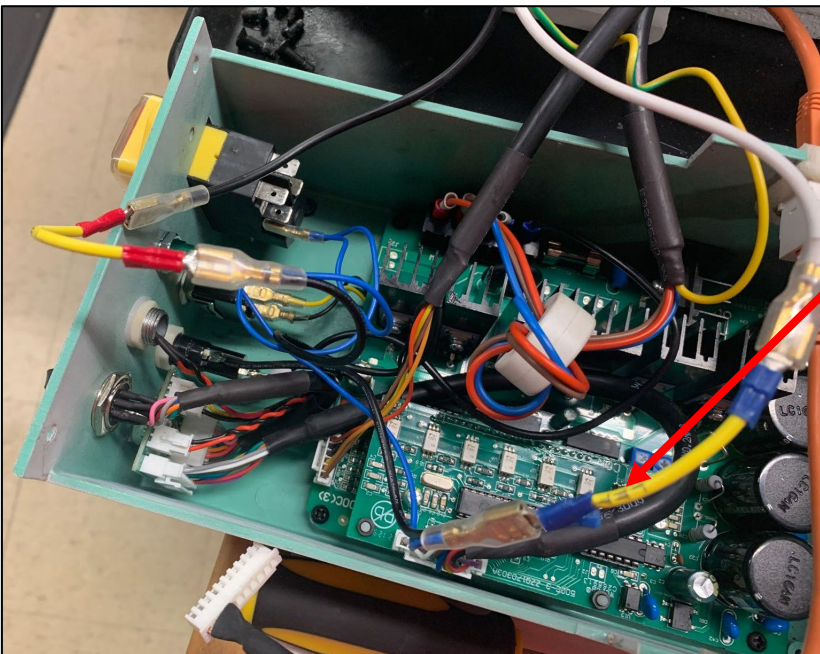


Note the color and positions of the wiring to the switch—yours may be different. Note the switch orientation—yours may be different, but the switches themselves are all the same.

Spindle Wiring-2

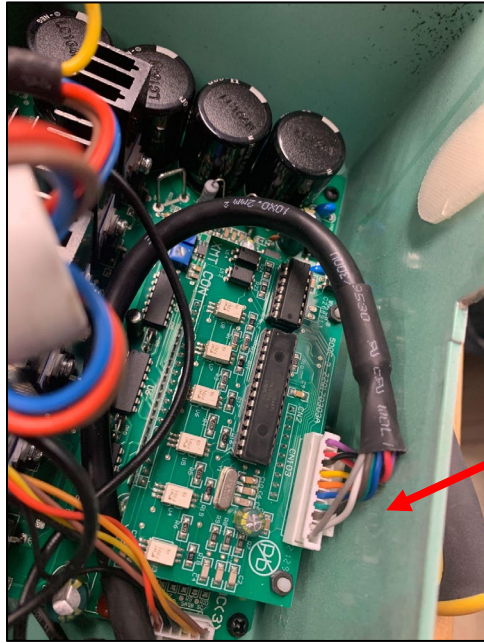


Remove the White wire and the Black/Blue wires from the same side of the switch and connect them with a jumper.

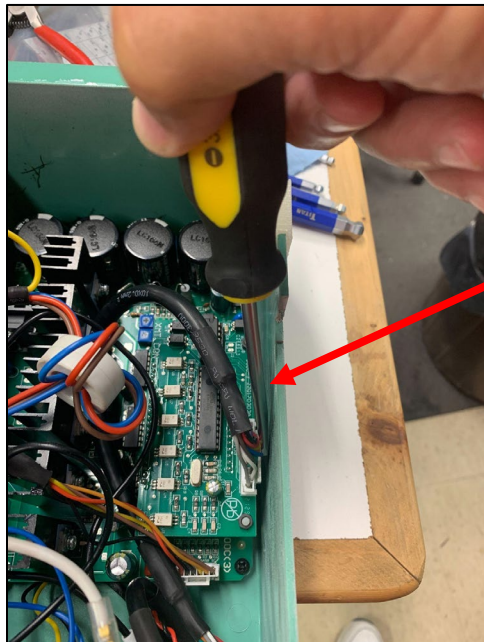


Remove the Black wire and the Black/Blue wires from the same side of the switch and connect them with a jumper. The switch should now have 4 terminals empty.

Spindle Wiring-Removing the Speed Control Connector

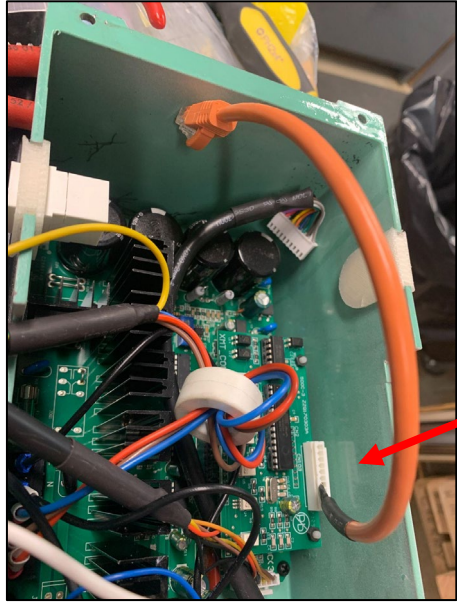


Remove the White connector the controls the speed of the motor. Note the screwdriver below

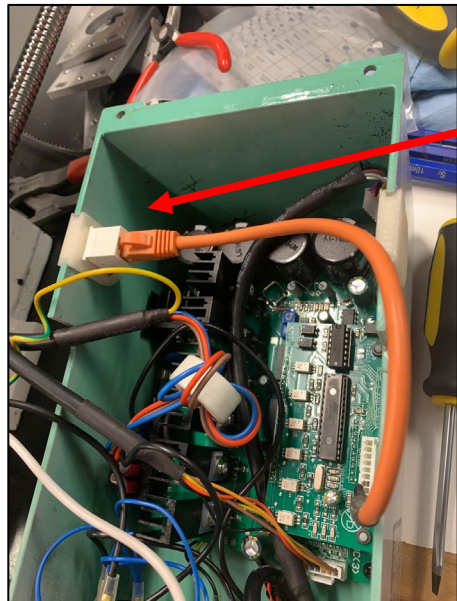


Use a screwdriver to pry the side of the clip to release it from the board.

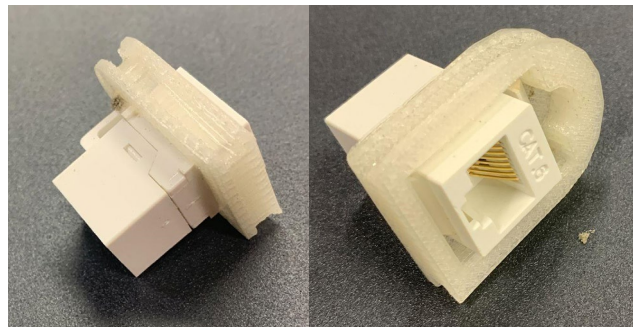
Spindle Wiring-Installing the new the Speed Control Jumper



Install the new jumper in place of the original speed control connector.

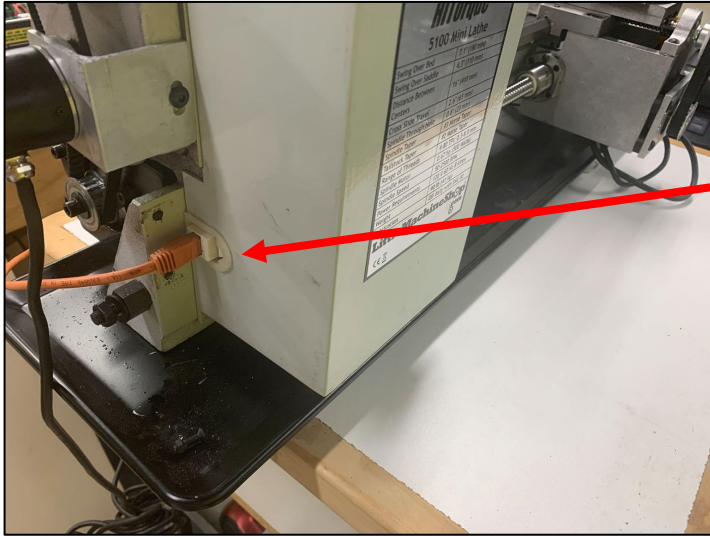


Clip the other end of the jumper in the pass-thru



Here is the RJ45 cable pass-thru-it fits into the slot in the spindle control box. The other side of the box uses a blank plate (included in th kit)

Spindle Wiring- Box Pass-thru

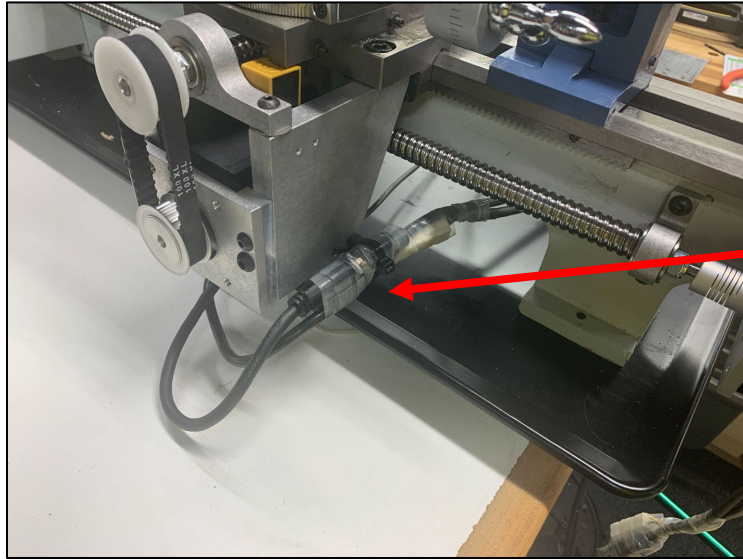


Pass-thru for speed control cable



Plastic close-out covers old leadscrew hole

Cable Management

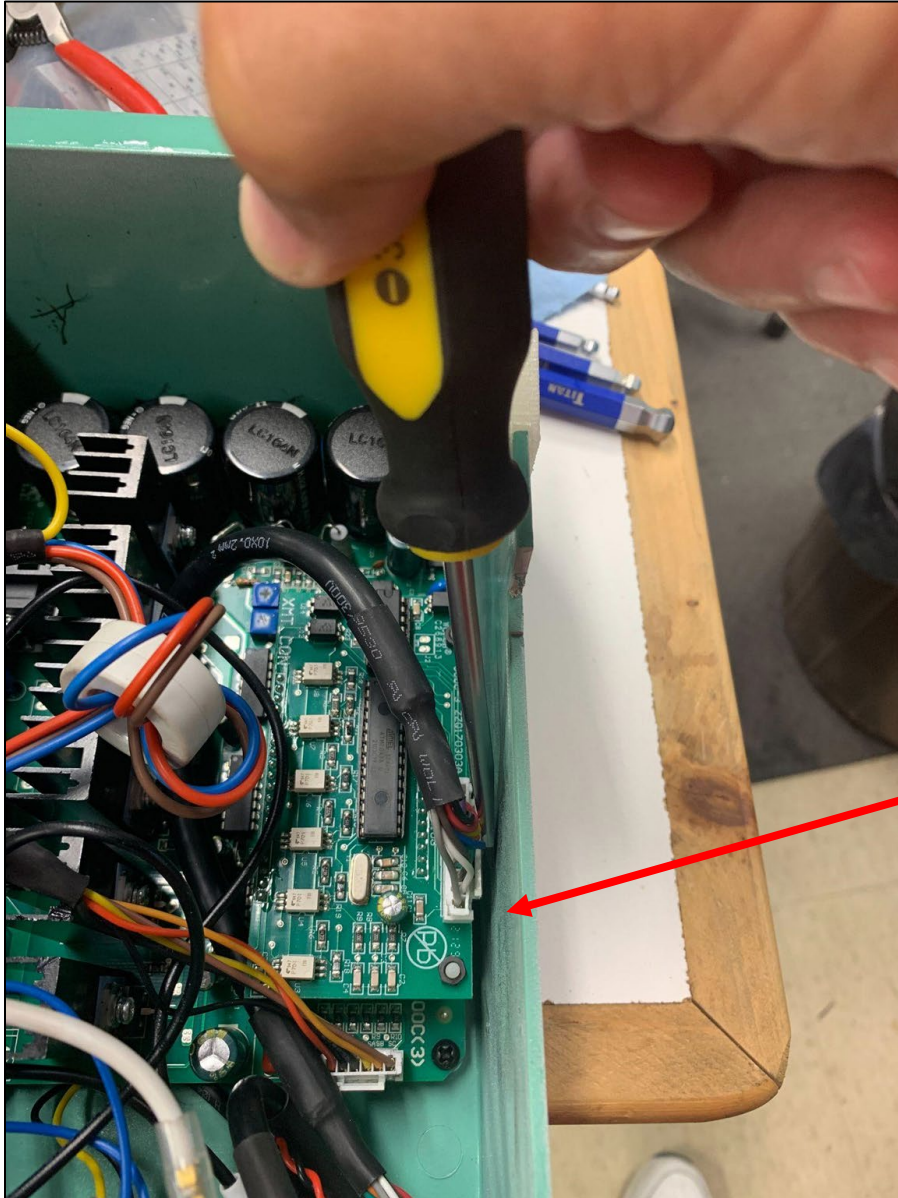


Routing of the X-axis cable under the lathe. Note that the connectors have been taped together and the bacles have been zip-tied.



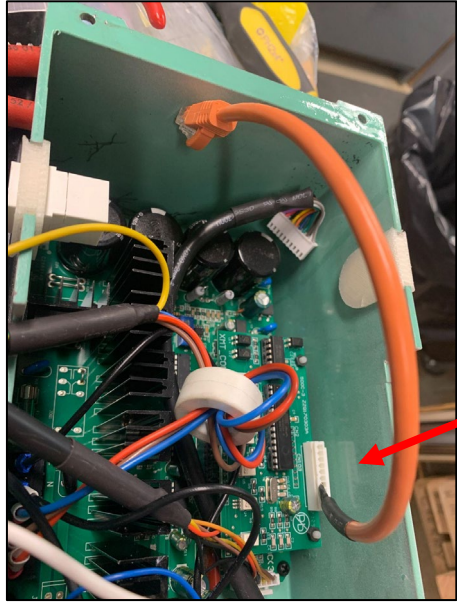
It's a good idea to tie the stepper motor cables together with zip-ties

Spindle Wiring-Removing the Speed Control Connector

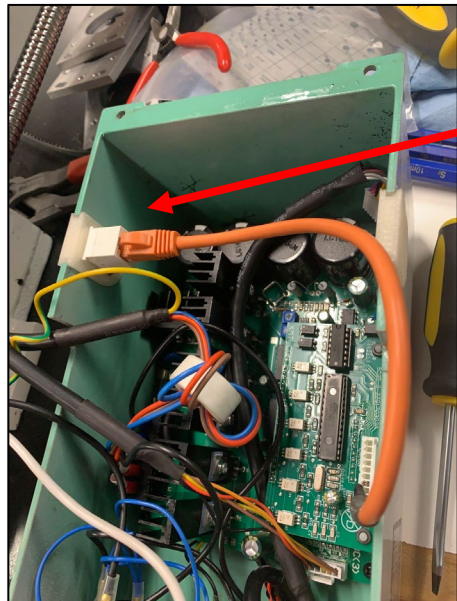


Remove the white connector to the speed control. A screwdriver can be used to release the clip on the connector

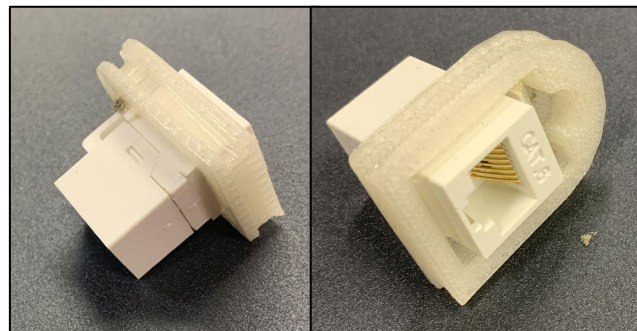
Spindle Wiring-Installing the new the Speed Control Jumper (cont'd)



Install the new jumper in place of the original speed control connector.



Clip the other end of the jumper in the pass-thru

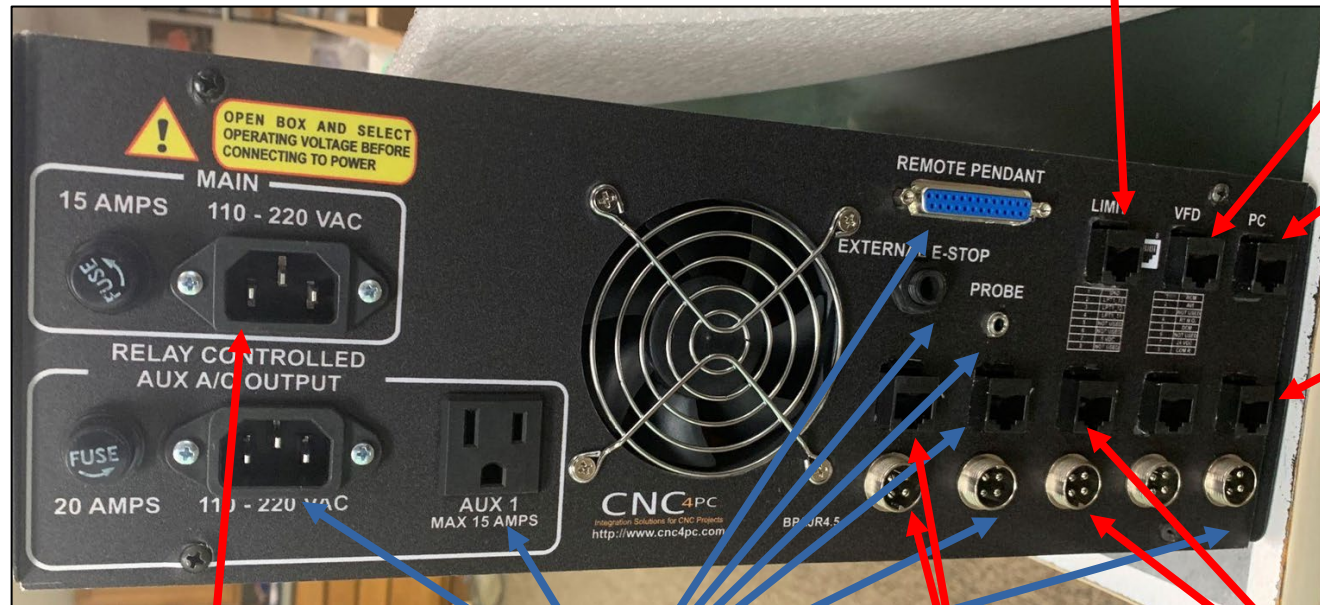


Here is the RJ45 cable pass-thru-it fits into the slot in the spindle control box. The other side of the box uses a blank plate (included in th kit)

Control Box Cable Hook-Ups

Note: Some of the connections on the back of the controller are not used.

They could be used in future applications



Limit/Home Switches

Speed Control Box

Laptop

Rotary Encoder

Note: Lathe Spindle 110 V plugs into wall outlet

110 Volt from Wall Outlet

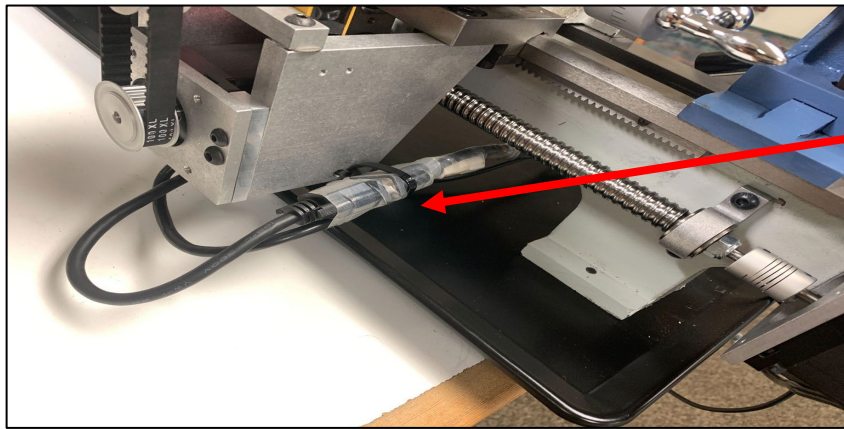
These are not used

X-Motor Cables (2)

Z-Motor Cables (2)

Cable Management

Tie the stepper motor cables together with zip-ties. For the X cables, include the limit switch cable in the bundle. Use the cable routing shown below for the X-axis cables.



X-Axis cable
routing under the
lathe

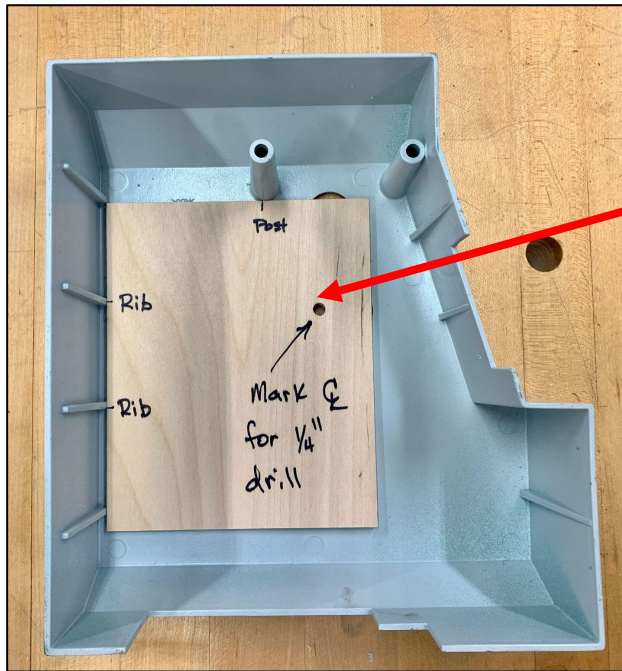


This is the Z-Axis
Limit Switch. You
can Zip-tie this cable
with the Z-Axis
Stepper Motor
Cables.

Bundle the X-axis
limit switch cable
with the stepper
motor bundle

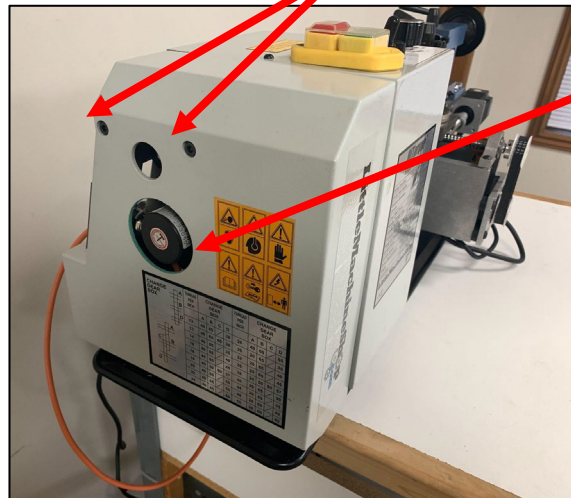
Left Side Cover

The left side cover needs to have a clearance hole drilled for clearance to the Rotary Encoder. There is a template that can be used to mark the hole location to pre-drill for a hole saw..



Use this template to locate the hole to be drilled. Make sure it is held tightly upward and to the left before marking the hole location. Drill a $\frac{1}{4}$ " hole thru the cover. That $\frac{1}{4}$ " hole can be used as a pilot hole for the $2 \frac{1}{4}$ " hole saw.

Use the original mounting screws to re-install the cover.



The final clearance hole is drilled with a $2 \frac{1}{4}$ " hole saw.

Completed Machine

Congratulations! You are now ready to use your CNC Lathe...

