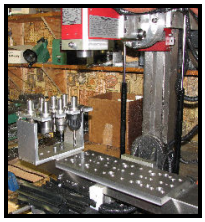


Automatic Tool Changer

This is Phase 1.
It consists of a Power Drawbar,Home Switch installation, electronics for spindle and solenoid valve control, Tool Holders, a Tool Rack and the software to get it all working together.
This is the simplest version that has a stationary tool rack mounted on the end of the mill table. The tools are mounted in different positions and the mill moves to whatever location is needed to change the tools.
Phase 2 will have an articulating tool rack that will rotate the tools around to meet the mill at a single location.

You can always check out my thread on cnczone.com, Hoss ATC Project, for all the info.

Power Drawbar

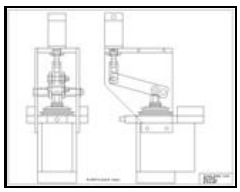
The Power Drawbar is modeled from the LMS Z-Bot but costs about $300 less.
An air cylinder pushes a cam and lever against the top of the drawbar that uses spring washers to retain the collet and tools. When it moves down on the drawbar with about 600-1000 lbs of force, the spring washers are compressed farther, the drawbar pushes the collet down releasing the tool. When air pressure is released, the air cylinder returns and the spring washers pull the collet back up grasping the tool. This video shows the operation,Power Drawbar Preliminary Test.

Power Drawbar Installation 1

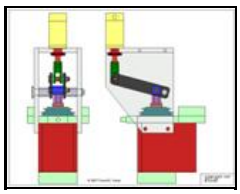
Power Drawbar Installation 2

Power Drawbar Installed 1

Power Drawbar Parts List



x2 power drawbar layout with 250 plate



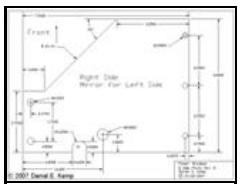
x2 power drawbar layout color coded

7.5 x 6.0 x .250 aluminum plate(2)
6.0 x 3.450 x .375 aluminum plate(for X2)
4.5 x 1.0 x .1875 steel plate(2)
.750 dia. x 5.0 steel rod (cam,spacers,washers)
.5 x 4.5 bolt(main pin)
.375 x 1.75 bolt (2) pins
.75 x.75 x 1.75 steel (clevis or McMaster Carr #6498K44)
7/16-20 jam nut
3/4-16 jam nut
1/8 cotter pins(3)
1/4-20 x .750 screws(6)
5/16-18 x .750 screws(4)

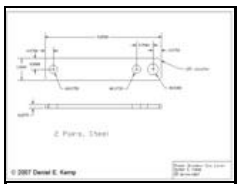
1.5 inch bore air cylinder, McMaster Carr # 6498K211
1/8 NPT 3-WAY 2-POS 24 VDC SOLENOID AIR VALVE
Spring Washers (4) or at McMaster Carr # 96445K267
1/8-NPT air fittings (3)
1/8-NPT plug fitting
Air line (6ft)
Compressed Air Source (100 PSI)
110 VAC switched source
Sieg X2 or other Minimill

Source for Metal Stock - Online Metal Supply
Check your local hardware store for screws and such.

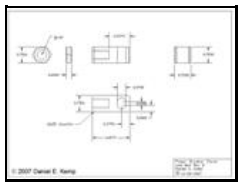
Prints



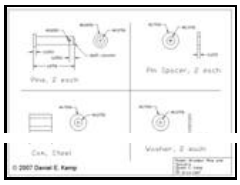
power drawbar 250 side plate rev b



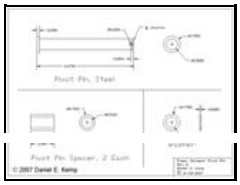
power drawbar cam lever



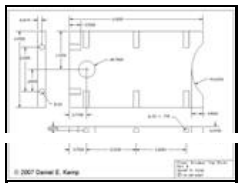
power drawbar clevis and nut rev b



power drawbar pins and spacers



power drawbar pivot pin rev b



power drawbar top plate rev b

Home Switches

A necessity for using an Automatic Tool Changer is Home Switches. It allows the machine to be 'Referenced Home', all the axis' are sent to set position to give Mach 3 a reference point so that it knows where the tools are in relation. Generally the Z axis is sent to it's highest + move (top of column), the Y axis is sent to it's farthest - move (table moves toward the column) and the X axis is sent to it's farthest - move (table moves to the right). The Machine Coordinates will be zeroed. Now all moves by the X and Y axis will be + moves and all Z axis moves will be - moves.
Home Switches, which can double as limit switches, are wired in series with each other. They are Normally Closed momentary microswitches with one wire connected to an open input pin on the breakout board and the other wire to 5V (see Wiring Sample 1). When you click the *Reference All Home* button in Mach 3, first the Z axis begins traveling
up away from the table. When it hits the home switch, it stops, then reverses travel until the switch is released, the axis is zeroed (if enabled) in the Machine Coordinates. next the Y axis travels toward the column till it hit's it's home switch, stops and reverses off the swtch and zeros. Finally the X axis does the same thing. This order of travel cannot be changed, Z then Y then X. Be sure to watch the 'Coordinate Systems' tutorial on the Mach 3 videos page. Watch them all, they are very informative. He also discusses how to use Soft Limits. Basically, the machine table travel limits are set in 'Home/Limits' under 'Config' and you click on the *Soft Limits* button after referencing home. Now if you or the G-code try to exceed these limits, Mach 3 will stop the motor when the limit is reached. See my video here.

I made some plastic covers for the home switches to keep the chips out, HDPE will work fine. See the video here.

X Axis Limit Switch

Y Axis Limit Switch

Z Axis Limit Switch

Limit Switch Covers

Limit Switch Covers 2

Limit Switch Covers 3

Limit Switch Covers 4

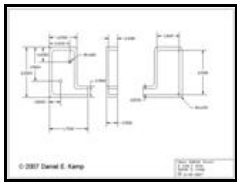
X Axis Limit Switch Covered

X Axis Limit Switch Covered 2

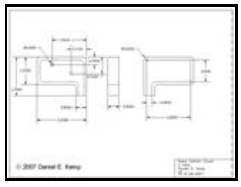
Y Axis Limit Switch Covered

Z Axis Limit Switch Covered

Prints



home switch cover x and y



home switch cover z axis

Electronics

The electronics needed for the ATC are a C6 Spindle Control Board, a Breakout Board and a Relay.

The C6 Board from Cnc4PC.com allows the spindle motor to be turned on/off using M3/M5 and to control the RPM using S2500 for example. The PDF '*Wiring the Speed Controller that comes with Sieg X3*' gives a wiring diagram for connecting the board to a Sieg motor control board.
WARNING: To keep the output signals optoisolated, these must not have common ground or current with other circuits you are using.
Use a completely different 12 volt power supply for the C6 board, don't share with any other circuit boards as a shower of sparks can result, I know first hand.
Cnc4PC does offer replacement chips for the board but I fried almost all of them.
Be sure to read all of the instructions. Visit the Yahoo forum for more info.
Watch my video for setting up Mach 3 for the C6 board here. (right click, Save As)

The C10 Breakout Board (if you don't already have a breakout board) will allow for connecting the PC, thru the parallel port, to the C6 board, Home Switches ,Relays etc. It provides many input and output pins and provides the 5VDC that the C6 board
requires for operation. Most newer computers and laptops only provide 3.3 VDC to the parallel port. If needed, you can add a second parallel port to your computer as I did. You will have to enable it in Mach 3 but more on that later.
Get a 2nd parallel port at your local PC or Electronics store or here.

You'll also need a relay to control the Power Drawbar solenoid valve. I ordered a second to control a flood coolant pump as well. Mach 3 can output a signal to the C10 board that will trigger the relay. These relays only require 3 VDC input to control
110 VAC.

During a typical tool change, the Spindle motor is turned off (M5 to the C6 board). The mill moves to the next tool position, lowers onto the tool rack, releases the drawbar (C10 board and relay activated) moves to the next tool postion,
grabs the tool (C10 and relay deactivated) moves back to the part and then the spindle motor comes back on (M3 to the C6 board) Coolant on/off with M8/M9 is optional. The Software section will explain in more detail.

Check out a couple videos that show the operation of the electronics.

Tool Holders

I made my own tool holders based on the Tormach Tool Holders available at Little Machine Shop. I used O1 drill rod but any steel would work. The Tormachs are hardened but I didn't bother hardening mine. Search Online Metal Supply for stock.
I made 3 sizes of holders but you could get by using 2.
There is only a small difference on OD's between the small and medium.
I made all the smalls holders only to find the small 3/8 drill chucks I wanted to use needed a slightly larger diameter to fit in the tool rack. I would recommend increasing the diameter on the small holders to match the mediums so that you would only need 2
hole diameters in the rack.
The small holders will be able to use endmills with up to .500 shafts.
The medium holders are for the small 3/8 drill chuck from Wholesale Tool and a .750 endmill.
The large holders are for a keyless 3/8 chuck from Wholesale Tool and a 3/8 JT2 chuck from Little Machine Shop.
note: I also turned the OD of a 1/2 JT2 drill chuck to fit with the large tool holders.

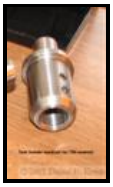
Small Tool Holders

Medium for 3/8 Chuck

Large for 3/8 and 1/2 in. Chucks

tool holder small for ATC

tool holder medium for drill chucks

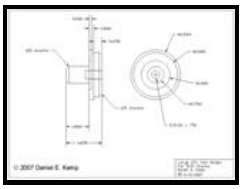


tool holder medium for 750 endmill

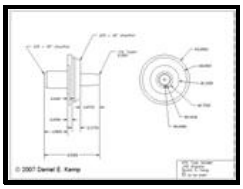
tool holder large for drill chucks

tool holder large for JT2 chucks

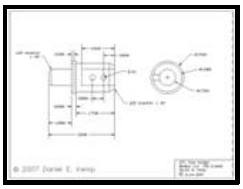
Prints



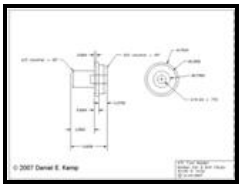
Tool holder large for drill chucks



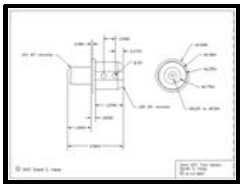
Tool holder large for JT2 drill chucks



Tool holder medium for 750 endmill



Tool holder medium for drill chucks



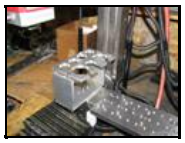
Tool holder small for ATC

Tool Rack

The tool rack I made holds 7 tools in 2 rows. There are many options for what kind and how many of each type of tool holders to use. Mine has 4 small tool holders, 1 medium and 2 larges. The biggest limit for the size of the racks is your available Y axis travel. It's not an issue with my X2 Freak with 12 inches of Y travel. The stock X2 usually only has about 4 inches and the X3 about 6 inches. You can decide for yourself what tools to run and make a tool rack based on that. Just keep in mind you'll need 1.625 in. between the small and medium holders and 2.500 in. between the large holders. I'll include a few possible layouts below. I added 3/8 diameter x 3/4 long springs between the tool rack top plate and the side plates. This gives the Z axis a little cushion when changing tools and gives a constant pressure against the spindle when releasing/engaging the drawbar.
The height of the side plates is determined by your max Z axis travel. I moved the Z as high as it would go and measured the distance between the spindle bottom and the table.
Subtract your longest tool height (3/4 endmill holder on mine) in the small holder side.
Subtract the tool clearance you want (I used 1/2 inch to be safe)
Subtract the tool holders flange to end height (1.250 in.)
Subtract the tool rack top plate and spring height (about 1.0 in.)
Whats left is the height available for the side plates.
The more you have, the longer bits you can use in the drill chucks. I had 4.5 inches to use.
You could also remove some material in the top plate to allow the tool bits to clear the rack without having to completely move up out of the rack. Notice the 3 holes on my rack for the drill chucks. This way you only need to clear the tool holders themselves when retracting.

Tool Rack Milling

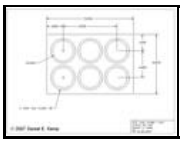
Tool Rack



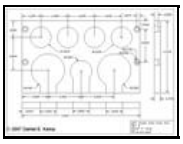
Tool Rack in position

Tool Rack with tools

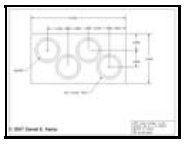
tool rack height



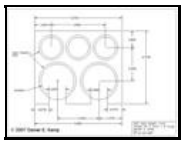
atc tool holder rack stock x2 3x2



atc freak tool rack 5x2 rev b



atc tool holder rack stock x2 2 x 2 smalls



atc tool holder rack stock x2 3 small x 2 large

Software

The main piece of software needed to operate the ATC is the M6Start macro for Mach 3.
There is a file named *M6Start.m1s* in the Mach 3 folder under *macros/Mach3Mill*. It is an incomplete file though.
You need to download and replace it with this file M6Start.m1s. (right click and Save as, remove the .txt)
You can also download it from the files section on the Mach Yahoo forum.
To see how to use it, watch the Tool_Change tutorial from Artsoft himself here. Watch a few times if necessary. I also found a little setup tutorial at Industrial Hobbies in the How-to section.
I have a couple of videos myself made during the build up that shows how it works.
I made a modification to the macro for my setup. This limits it from moving the Z axis all the way to the top between tool changes. I just wanted it to raise the Z enough to clear the tool holders by about a 1/2 inch between changes. It cut down on the total time. See images below.

m6start macro

m6start macro z travel tool change limit

You can always check out my thread on cnczone.com, Hoss ATC Project, for all the info.