How to Build a CNC Machine

Rich Loen

• rich@loen.design
• www.loen.design
• instagram.com/loen.design
• youtube.com/richloen

Chris Manning

• @silver_hand most everywhere
• Offhours.show
Building a CNC Machine

- Overview
- Hardware
- Electronics
- Control PC
- Control Software
- Design Software and process
- Resources
- Questions

Going to focus more on CNC Routers, but most info applies to CNC Mills and Lathes as well.
Safety

• NOT A JOKE. WE ARE TALKING ABOUT VERY DANGEROUS MACHINES.

• This is the first machine in your shop that will move on its own and try to kill you.

• You need to think about escape routes, Emergency Stop, Limit Switches, How you will call 911.

• Test cuts in the air with the spindle OFF.

• MAKE A CHECK LIST AND FOLLOW IT BEFORE YOU HIT GO.

• Wear ear and eye protection

• Don’t leave it alone. You will be tempted to...
Why use a CNC?

- Very similar to the transition between using a typewriter and a computer.
- Accurate
- Repeatable
- Fast
- It can work while you do other things.
- You can try something, tweak it, and cut it again. Like reprinting a single page of a document.
- Always finding new uses
- Can work with larger bits
- Can work with extremely small bits
- Convenient when you have multiple items to make

But, it has its place.

Often still use a table saw, chop saw, planer, etc.
Furniture
Furniture
Furniture
Furniture
SketchChair
Furniture
Art
Art
PCBs
PCBs
Components of a Design
Components of a Design
Components of a Design
Components of a Design
Components of a Design
Components of a Design
Components of a Design
Components of a Design
Pens, Jewellery
Build vs Buy

- Lots of options. More coming every week.

- Small light machines: ShapeOko (carbide3d.com), X-Carve (inventables.com)

- Heavier Machines: CNCRouterParts.com, tormach.com, many others.

- EBay, banggood.com

- Auction web sites or in Montreal/Toronto. Often big machines for $2500 - $10,000. BUT, may need 3 phase power, etc. Can be complicated to program, calibrate, etc.

- Convert an existing machine
Hardware

- The key is rigidity, even for wood
- Machine structure - 8020 extrusions, wood, Maker Slide.
- Linear bearings
- Making things move
Wood Frame CNC Machine
Linear Movement

- Linear Rails
- MakerSlide
- Angle Iron
Linear Movement

- Linear Rails
- MakerSlide
- Angle Iron
Linear Movement

- Linear Rails
- MakerSlide
- Angle Iron
Linear Movement

- Linear Rails
- MakerSlide
- Angle Iron
Making things move

- Acme threaded rods
- Ball screws
- Belts, pulleys
- Rack and Pinion
- What is backlash?
Making things move

- Acme threaded rods
- Ball screws
- Belts, pulleys
- Rack and Pinion
- What is backlash?
Making things move

- Acme threaded rods
- Ball screws
- Belts, pulleys
- Rack and Pinion
- What is backlash?
Making things move

• Acme threaded rods
• Ball screws
• Belts, pulleys
• Rack and Pinion
• What is backlash?
2D vs 2.5D vs 3D vs 5D

- 2D means there is no Z axis. Plasma Cutter. Water jet.

- 2.5D means there may be parts of the design at different depths, but once cutting, the machine stays at a given Z depth

- 3D means that the machine can cut while moving in X, Y and Z simultaneously. V-Carving

- 4th axis = a rotary axis.

- 5D means a rotary axis in two orientations.
V-Carving
V-Carving
Conversion kits

- G0704 or similar - tons of info on google - Hoss pages are good.
- Taig mill conversions are common - They sell kits.
- Nice because you start with a solid platform.
Electronics

- Motors
- Controllers
- Limit switches
- Power Supplies
- PC's
CNC Electronics

- 30-60V 10-20A Supply
- 5-12V low current supply
- 3 or 4 Motor Drivers
- 5 or 6 Limit switches X+, X-, Slave-, Y+, Y-, Z+
- E-Stop Switch
- Relay Output
- Spindle Speed
- Vacuum
- Inverter
- 220V
- Spindle ON/Dir
- Smooth Stepper
- 5-12V low current supply
- Computer Running Mach 3
- 3 or 4 Stepper Motors
- 30-60V 10-20A Supply
- 110V
Stepper motors

- Nema 17, Nema 23, Nema 34
- Ratings: Oz-Inch 100, 300, 500, 1000!
- Power supply - 24-48V 10-30A
- Stepper motor drivers
- Step and direction
- How to find winding pairs
Servo motor

- Overkill for most users
- Teknic SK Series is good
- Built-in driver
- Use with pulley and belt - reduction
- Use a beefy linear power supply
Control Hardware

• Smooth stepper - Connects to PC via USB or Ethernet

• G540 - The ole standby - but requires a 2-way parallel port

• Planet CNC or similar control computer

• Arduino-based controller. Some have built-in motor drivers, wifi, ethernet, usb, etc.
Control PC

- Parallel port vs USB vs Ethernet
- Get all s/w off the pc
- Use an older version of Windows - Windows 7
- Turn off auto-everything and every background task.
Manual control

- Xbox controller - find an old USB XBox controller.
- Special controller - pendant
- Keyboard
- Custom keyboard
Wires and connectors and Miscellaneous stuff

• For steppers, want braided, fairly heavy wires. 18 gauge

• Limit switches - mechanical vs hall effect.

• E-Stop is essential.

• Relay outputs - 2 is good for controlling other equipment, spindle motors, lasers, etc. Easy to control from G-Code

• Power supply - Switching vs Analog

• Use latching connectors. Don’t skimp
Spindle

- Simple: Use a small Dewalt Router or Bosch Colt. Mounts available.

- Air/water cooled spindle - many available on eBay. Think about collet size. Order spare collets. Don’t skimp. ER11 collets ok for 1/4” bits. ER20 good for 1/2” bit. ER32 good for a mill.

- 3 Phase Inverter Hitachi vs others - lots of instructions on setting these up. Need to set about 5-10 parameters - but set as few as possible!

- Speed control via computer - Can be done through a digital or analog connection.
Control Software

- Mach3
- Mach4
- LinuxCNC
- PlanetCNC
- Arduino + GRBL
- Gcode
Flow of operations

- CAD
  - Solidworks
  - Sketchup
  - Rhino
- CAM
  - Meshcam
  - RhinoCAM
- GCODE
- Controller PC
  - Mach 3
  - LinuxCNC
  - PlanetCNC
- Hardware
  - Smooth Stepper
  - PlanetCNC
- Motors
- Combined CAD + CAM
  - Fusion360
  - Vectric
Design Software

- Fusion 360
- Vectric V-Carve Pro
- Sketchup
- Rhino3D
- TinkerCAD.com
- OnShape.com
- libreCAD.com
- vectary.com
- OpenSCAD
- BobCAD

Good to know how to use more than one.
CAM is often built into the CAD software these days.
Feeds and speeds software

- GWizard is pretty good.
Work Holding

- Want low profile clamps
- Often good to make a jig
- Wood or Brass - less damage when the cutter hits it.
- Easy to screw into the spoil board
- There are plastic nails and special nailguns.
- Use tabs to keep work in place
- Vacuum Fixtures - MDF is porous!
CNC Lathes

- Conversion vs new build
- Spindle indexing for threading
- Differences in CAD and CAM
- Tool holding and changing
Machine Axis
Conversion vs Custom
How to make round things

- Lathe
- 4th Axis
- Stack slices
- Think outside the box
What goes wrong?

- Parts come loose. Fly across the room or jam up the cutter - break the bit.
- Forget to follow checklist. Forget to power on the inverter or similar.
- Wrong speed of cut
- Something comes loose. Locktite!
- Stepper misses steps. Can be mechanical issue or electrical (bad connector or noise)
- Don’t stand in the path of cutters/parts that might fly
Online resources

• https://loen.design
• Vectric.com forums
• CNCCookbook.com
• YouTube
  • Frank Howarth: youtube.com/user/urbanTrash
  • This Old Tony: youtu.be/YBGqknN3gGs
  • NYCCNC
• Lars Christensen
• CNCNutz
• Neo7CNC
Suppliers

- https://loen.design/suppliers-list/
- 8020 http://ipecautomation.com/
- CNCRouterParts.com
- Banggood.com
- Ebay
- http://www.automation-overstock.com
Thanks!

Rich Loen
• rich@loen.design
• www.loen.design
• instagram.com/loen.design
• youtube.com/richloen

Chris Manning
• @silver_hand most everywhere.
• Offhours.show