

CNC-3axis Milling

Precix - 3 Axis CNC Milling workshop

Getting started with the Mill

The CNC Mill is only available to people who have been formally introduced to its method of use, and to the rules and procedures of the Milling Lab. This limits its availability to students who have taken a CNC Milling seminar or course at the ETHZ.

Glossary:

CNC – Computer Numerically Controlled

CNC Mill – a machine that uses a programmed path for a rotating cutter to carve a material and reveal a preprogrammed surface form – also called a **CNC router**.

Gantry – the arm that crosses the table moves in the X axis.

Spindle – the motor and cutting head that moves along the gantry in the Y direction and up and down in the Z direction.

Collate – the collar used to connect and fasten the bits to the spindle.

Bit – the tool tip used to cut or drill material, we have a number of different bit types. Also called an **Endmill**

Emergency Cutoff – large red button on the front of the controller box – on the front face of the mill. In case of emergency hit this button.

Vacuum head – The attachment used to hold the vacuum hose near the working piece. Note this head does not move up and down so it will not be used for pieces with large Z heights.

Absolute position – the xyz position for the machine – relative to the corner of the table.

Relative Origin – the position that the user sets to mark the 0,0,0 position from the digital file.

GUI – Graphical User Interface – the computer control interface.

Z-up – The position of the tip of the cutting tool ABOVE the material, used for making rapid plane movements.

Z-0 – The Z-origin, defined by the tip of the tool being placed immediately on the surface of the material.

Z-M – The Z-Minimum, the depth below the surface (in mm) of the material that the bit is allowed to cut. This value should be the height of the material – 2mm, **OR** a sacrificial layer should be installed below the material. **NOTE:** This value is what prevent the mill from milling straight into the table – please set it correctly.

Cutting Speed – the speed in X, Y, Z that the Mill will move while cutting.

Spindle Speed – the rotation speed of the drill or cutting bit.

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First checks:

Always perform these checks before powering up the mill:

- Clear the table of anything other than your material to be milled.
- Check the gantry for anything improper and ensure it is clear and clean.
- Check the vacuum hose and chip-bag, empty or replace if full.
- Ensure that the area around the Mill is free and clear; you should be able to walk around the mill unobstructed.
- Set up and plug in the labs vacuum cleaner and air compressor if required.
- Ensure that you have Safety glasses, ear protection, and a breathing mask if you will be milling hard or nasty material.

Starting the Mill

The fuse box is on the left side of the mill facing the hallway.

- Switch all the fuses to the ON position (up for the lower row, down for the main breaker on the top row).

The controller for the computer is the black box on the front of the mill.

- Switch the computer on using the red toggle switch.

The computer will boot up, and the controller program will launch. If the monitor does not activate – ensure that it is turned on (green led).

- Once booted, the computer will show the basic control interface. At the top right corner of the screen is a button “TURN POWER ON” click on it with the trackball it to activate the interface. The button will switch to “TURN POWER OFF” when the system is active

Homing the machine

At the beginning of every session (on power up!) the Mill need to know the absolute position of the gantry and spindle – the absolute 0,0 position. **Note the machine does not “home” the Z position!!!**

- Home the machine: On the computer - using the trackball, click the button “HOMING” in the upper right corner of the interface.
- The machine will move the spindle up to the top Z position, then the gantry all the way towards the front of the machine, then it will move the spindle all the way to the right corner.
- When finished, the mill is calibrated to the absolute 0,0 (as can be seen in the absolute position boxes: upper left of interface), and the Homing button will change to “HOMED”

Getting your job to the mill computer> **precix**:

The mill only accepts files generated as G-code with a file extension “.gc”. Once a .gc file has been generated on the lab computers, it can be placed in a folder on the mill computer (named: **precix**).

- To find the **precix** computer use the **Start>Search>Files>Computers** function on a networked lab computer.

Getting your job into the mill controller queue:

- On the interface, Click “add new job to queue” in the upper right panel.
- Navigate the folders and choose your .gc file
- Highlight the file in the active panel and click “Select as current job”
- Click “Job Output” to return to Mill controller interface.

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Attach the milling bit:

- Ensure that the bit you are choosing to attach is the same as the one chosen in the SurfCAM generated .gc file.
- When attaching the Bit please clean the collate beforehand.
- Clean the bit before mounting. Please note – bits are extremely sharp, gloves must be used when handling bits!
- Please make sure that the bit is deep enough in the collate (>2cm), then fasten the collate to the spindle.
- Use the two wrenches to tighten the collate to the spindle mount. Ensure that the collate is mounted properly and tightly.

Attaching your material to the milling table:

On the control interface click the “reset” button, then click on “preview”. This will give you a graphical representation of the ORIENTATION of how the piece will be milled on the table. The position of the material on the table surface is easily changed.

- Please vary the position of the work piece on the table for each different job, otherwise the belts on the mill wear out too fast!!!!
- Using double sided adhesive tape (with matrix backing – not plastic film) mount the piece on the table inline with the black table pad strips.
- Ensure that the piece is securely fastened to the table.
- For larger and heavier pieces several people may be required to place the piece on the table so that it is straight and aligned. Several tools and techniques have been developed for this – ask Russell for assistance if required.

Defining your relative XY origin (origin):

- Using the Z Up-Down buttons on the GUI (computer controller interface), move the spindle up so that it will definitely clear the material on the table.
- Using the direction arrow buttons on the GUI (computer controller interface), move the spindle to your desired X, Y starting point. **NOTE:** when the computer is facing the Mill, the arrow keys move the gantry in the OPPOSITE direction to the indicated direction (I know its annoying, I am working on a fix!)
- Using the Z Up-Down buttons on the GUI approximate the bit tip on the surface of the material.
- Fine tune the X,Y using the small arrows on the GUI
- Click “set origin” at the upper left of the screen under the “absolute” button (**Note:** This does not affect the z- axis!).

Setting the Z origin and Z values:

- Using the Z Up-Down arrow buttons on the GUI, move the spindle all way up.
- Click the Set “Z-up” button
- Move the bit tip to the surface of your block to mill, fine tune the position with the small arrow buttons. The tip is at the surface when you can JUST pass a piece of thin paper between it and the surface.
- Click the Set “Z-0” button
- Click in the Set “Z-M” number field. Values should be set in millimeters. Type in a value smaller than your Material Height (Height -2mm). Ex: a piece of material 10cm thick would have a Z-M value = 98.
- Double check that the length of the bit matches your project patterns, including a manual gouge check especially for the spindle and collate.

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Looking at the preview of your job:

- Click "Reset" again.
- Click "Preview"
- You should now see a graphical representation of the milling paths placed properly on the area of the table where your material is mounted. – double check your orientation and distances if it does not look correct!!!!
- Make sure that the job is in the right position and size.
- If you want to see the size on the table, move to the extreme points with the manual control panel, compare it to your work piece. The GUI will mark the movement of the spindle head with a green path.
- To change the position on the table, change the origin.

One final check that can be performed if you are concerned that you have not set up the job on the table properly:

- o Raise and reset the Z-origin by the thickness of your material. That way the job will be run in free air above the piece. This will allow you to see and verify the position, orientation, scale and measurements of the job.

If **YOU** are satisfied with the mounting, position, orientation, origin, Z-origin, and material heights – **then proceed to start the job.**

If **YOU are not** comfortable with your set up, **ASK** another student or a tutor to verify your job before starting the cutting process.

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Ready to start MILLING ???

Milling – Review of Lab rules

- Review the rules for the milling lab.
- Always wear safety glasses if you will be milling HARD material.
- Always wear ear protection when milling HARD materials
- Set up dust clearing and vacuuming for all materials.

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Milling – Starting the job

- Start Spindle manually, click the “Spindle ON” button.
- Manually increase the Spindle speed to 9000 rpm.
- Activate both “Speed override” buttons, Spindle and Cutting (both button green)
- Set Cutting Speed low (10)
- **THE SPEED OF THE SPINDLE DROPS IN THE MOMENT YOU START THE JOB – PLEASE INCREASE IT IMMEDIATELY!** To do this properly you must be fast with the trackball – to increase time, you can offset the gantry to the far end of the table before starting the job.
- **IF SOMETHING THAT YOU DO NOT EXPECT HAPPENS, YOU CAN ALWAYS STOP THE MILL BY EITHER HITTING THE**
 - **EMERGENCY CUTOFF BUTTON**
 - **OR CLICKING ON THE START/STOP BUTTON.**

Milling – Monitoring the job

- An operator must be present in the lab at all times while a job is being milled.
- If the mill is running smoothly, you can increase the cutting speed and the spindle speed slowly.
- Make sure the bit and the pieces are not vibrating and always slow down or stop the job when the mill sounds “not normal”.
- If the vacuum not removing the off-cut efficiently, then manually remove the dust with the lab vacuum.

Milling – Changing jobs

Most milling pieces will require a minimum of at least two cutting jobs: a rough cut - to remove material, and a fine cut - for surface carving.

- **DO NOT REMOVE THE MATERIAL BETWEEN CUTS, IF POSSIBLE**
- this will eliminate the need to set up the job again and again. (Also note: if you are going to need to move the piece between jobs you should NOT rough-off your **ORIGIN POINT**)
- Load the new file as the “current job”, change the bit if the tool path was intended for a different bit – don’t forget to reset the Z-0 to the new bit length.
- Check again for possible Gouge’s with the length of the new bit.

Milling – Finishing the job

Once all the jobs for a piece are done, the spindle and gantry movement should stop, and the job progress bar will be at 100%.

- Click the “DONE” button.
- Move the spindle to “Z-UP” and move the gantry away from the piece.
- Click “Turn Power Off” on the GUI
- **Clean and vacuum** the piece as much as possible on the mill table ensuring that you do not scratch or mar the freshly milled surface.
- Remove the piece (carefully) from the table. Remove any stuck tape from the table.
- Remove the collate and bit from the spindle
- Replace all tools, bits, and safety equipment into the bins
- **Please clean and vacuum the lab after each job.**
- Empty any full chip-bags, and remove any garbage.
- Switch off the mill controller, and set all fuses to off.

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What to do if something goes wrong!!!

If someone is hurt:

- **seek first aid immediately.** The lab has a first aid kit.
- **If additional assistance is required seek it immediately - emergency telephone numbers are posted in the lab.**
- Contact and inform a tutor **immediately**, no matter how small the issue.

If the mill stops functioning, or if it is damaged:

- **EMERGENCY CUTOFF SWITCH** or click “stop job” in the controller
- Evaluate the problem, try to determine whether it is a G-code issue, a software problem, a hardware problem, or a human error.
- Attempt a fix if the problem is obvious.
- If the problem is not obvious, **STOP**, go and ask a tutor.
- If you have milled the table – raise the Z-M value, or install a sacrificial layer and reset your Z values.
- **DO NOT CONTINUE TO MILL UNLESS YOU ARE SATISFIED THAT THE SITUATION IS SAFE FOR BOTH PEOPLE IN THE MILLING LAB & FOR THE MACHINE.**

If a cutting bit is broken while cutting a job:

- **EMERGENCY CUTOFF SWITCH** or click “stop job”
- Evaluate why the bit broke (Z-up? bad G-code? Slow spindle speed?)
- If the problem is obvious, fix the code, replace the bit, & repeat the job.
- **Inform a tutor of the broken bit.**
- If a second bit breaks – **ask for help.**

If your job is damaged, gouged, or marred while being worked

- Stop the job, recheck the preview for inconsistencies
- Go back to SurfCAM and run a graphical verify in the operations manager
- Check bit mounting and length of bit in collate and spindle.
- Double check your Z-0 and Z-M values
- If collate is rubbing against the external edge of the extra material: Use angle grinder in lab to remove excess material from bounding material.

In all situations where problems occur, PLEASE inform a tutor of any problems, so that we can ensure SAFE and EFFICIENT use of the mill!

SAFETY GUIDELINES

CNC MILLING LAB

- Students are responsible for personal safety at all times while in the milling lab.
- While working in the milling lab, all persons must secure any loose clothing, long hair, and must remove any jewelry.
- Ensure your materials is securely fastened to the table
- Operator must be present whenever running a job.
- Always be prepared for an emergency shutoff.
- Wear safety glasses at all times.
- Wear ear protection when milling hard materials
- Wear breathing mask when milling dust-producing materials.
- Never reach over the machine and keep hands away from bit while the cutter is rotating.
- Use gloves when changing endmills
- If work piece material or machine begins to vibrate, or if the cutter makes excessive noise, stop cutting immediately.
- Always keep your job clean of any excess chippings and dust, vacuum regularly.
- Chips may be sharp. For cleaning shoot compressed air away from people or brush of the chips first.
- Before starting the router ensure that the spindle is free from the work piece or any other obstacles
- Keep the machine and the room clean
- No smoking in the CNC Milling lab.
- If damage or injury should occur, notify a tutor immediately!

If you do not know how to operate the machine, or do not fully understand the manual or instructions, ask a tutor so that you are certain about what you are doing.

Emergency Numbers at ETH Zürich

Emergency / Alarm Central – internal ETH phones

Notfälle (24h), ab allen internen ETH Apparaten 888

Alarm Central – external phones

Emergency services (24h) 01/342 11 88

Fire Department (&Environmental hazards) 0-118

Ambulance – Medical Emergency 0-144

Poison Control Centre 0-251 51 51

In Case of Fire

1. **Alarm**
Pull Alarm, or where missing Tel. 0-118 from any phone.
2. **Rescue**
Evacuate and assist any hurt or disabled persons away from the area, if possible.
3. **Extinguish**
With portable fire extinguisher, or house water hose, extinguish the fire if possible. Close all windows and doors.

ETH Security Department

07.30-17.30, Mo-Fr

HCH E 14 (Hochstrasse 60)

Email safety@su.ethz.ch

Tel: 01/632 20 53

Fax: 01/261 56 73

SICHERHEITSRICHTLINIEN

BETRIEB CNC LAB

- Studenten sind für ihre Sicherheit im CNC Lab selbst verantwortlich.
- Während der Arbeit müssen lange Haare und hängende Kleidungsstücke zurückgebunden werden. Ketten sind nicht erlaubt.
- Vergewissere Dich, dass das Material auf dem Schneidetisch sicher befestigt worden ist.
- Die Maschine darf nie unbeaufsichtigt arbeiten.
- Sei immer vorbereitet die Maschine per Notunterbrechung zu stoppen.
- Trage immer eine Sicherheitsbrille.
- Ein Ohrschutz muss beim Fräsen von harten Materialien getragen werden.
- Trage einen Mundschutz beim Fräsen von stark staubenden Materialien.
- Körperteile von der Arbeitsfläche fernhalten. Niemals mit den Händen in den Bereich des Bohrkopfes kommen.
- Benutze Handschuhe für das Wechseln des Bohrers.
- Bei abnormalen Vibrationen oder Geräuschen im Betrieb sofort die Maschine unterbrechen.
- Achte darauf, dass während des Fräsens die Arbeitsfläche stets frei von Spänen und Staub ist.
- Die Späne können scharfkantig sein. Richte das Hochdruckgebläse nicht gegen andere Personen oder fege die Späne weg.
- Ueberprüfe vor dem Betrieb, dass der Bohrer das Material nicht berührt und das sich keine Hindernisse auf der Arbeitsfläche befinden.
- Halte die Maschine und den Raum sauber.
- Im Fräsraum darf nicht geraucht werden.
- Informiere sofort einen Assistenten bei einem Unfall oder einer Verletzung.

Frage einen Assistenten, wenn du nicht weisst wie die Maschine funktioniert oder Du Fragen zu der Betriebsanleitung hast, damit Du sicher bist was Du machst.

Notfallnummern der ETH Zürich

Alarmzentrale/Notruf Notfälle (24h), ab allen internen ETH Apparaten	888
Alarmzentrale Pikettdienst (24h)	von extern 01/342 11 88
Feuerwehr (und Gewässerschutz)	0-118
Unfälle (Ambulanz)	0-144
Vergiftungen (Toxikologisches Informationszentrum)	0-251 51 51

Im Brandfall

- 4. Alarmieren**
Handalarmtaste drücken, oder wo nicht vorhanden Tel. 0-118
- 5. Retten**
Verletzte Personen ausser Gefahr bringen und gefährdete Personen alarmieren
- 6. Löschen**
Mit Handfeuerlöscher oder ab Haushydrant, Türen und Fenster schliessen

Abteilung Sicherheit

07.30-17.30, Mo-Fr
HCH E 14 (Hochstrasse 60)
Email safety@su.ethz.ch
Tel: 01/632 20 53
Fax: 01/261 56 73

MILLING CHEAT SHEET:

20 steps to successful milling

1. Make sure your .gc file is loaded onto the PRECIX machine
2. Clear the area around mill and clean the table – make it SAFE
3. Turn on all fuses and controller computer
4. **TURN POWER ON** and **HOME** the mill
5. Load your .gc file into the current job for the mill > **Job Output**
6. Ensure you are mounting the correct milling bit for your file, and make sure the bit is tight
7. Make sure that the bit is long enough > gouge check.
8. **PREVIEW** your job on the mill & **CHECK ITS ORIENTATION**
9. Mount your material securely to the table
10. Mount the vacuum hose, as required
11. Define your XY origin
12. Define your Z-0 origin
13. Define Z-UP, and Z-M (material thickness)
14. Double check the preview, placement and orientation of the job
15. Turn on the vacuum equipment
16. click **cutting speed** on & set it to a slow starting speed
17. Milling – click **START** & check the spindle (speed > 9000 rpm)
18. **IF REQUIRED** - adjust the spindle speed
19. Monitor the job and adjust as necessary
20. Clean and order the lab when done