FAMU-FSU College of Engineering

DEPARTMENT OF **MECHANICAL** ENGINEERING

Safe CNC

Operation Manual

Version 1.0

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This manual has been reviewed and approved for use in the Senior Design Lab.

Version History

Version	Date	Description	Author/Reviewer
1.0	03/10/25	First draft with basic outline and subsystem.	T514

Table of Contents

1. Project Overview

This project involves the design and installation of a safety enclosure for the CNC milling machine located in the Senior Design Lab. The enclosure is intended to protect users and bystanders from hazards associated with CNC milling operations, including moving parts, flying debris, potential impalement, and dust. The goal is to provide physical barriers and fail-safe shutoff systems for these hazards.

Key Features:

1. Physical Enclosure: A rigid structure surrounds the CNC machine to prevent accidental contact with moving parts and to contain debris.
2. Automatic Door Shutoff: A system that stops power from going to the machine while the enclosure doors are open. The system also cuts power to the machine whenever the enclosure doors are opened while the machine is running.
3. Manual Emergency Shutoff Button (E-Stop): A clearly marked button that immediately terminates power to the CNC machine in an emergency and acts as a backup redundancy to the automatic door shut-off.
4. Dust-Extraction System: An integrated shop-vac and dust separator that collects any debris generated by the router.

The enclosure and electrical components are designed with future upgrades in mind, such as additional safety sensors, a different milling machine, or a new location for the enclosure. This manual will serve as the primary resource for understanding and maintaining the safety enclosure.

2. Component and Module Descriptions

2.1 CNC Milling Machine

The enclosure houses a Shapeoko 3 CNC milling machine. Relevant specs are as follows:

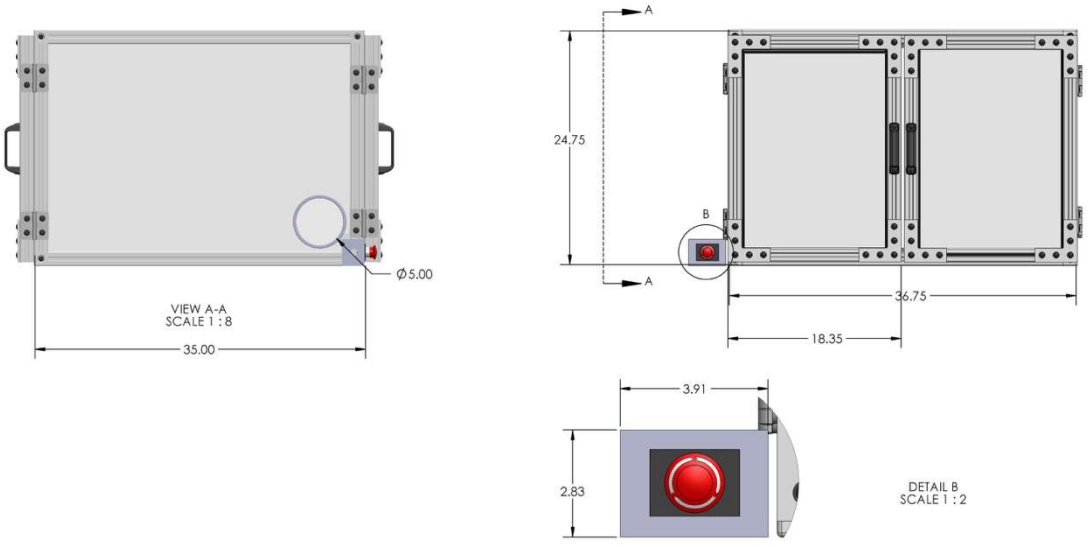
- Heavy-Duty Z (HDZ) carriage
- Standard cutting area
- 65mm VFD spindle (110V)

The CNC milling machine uses two free software applications: Carbide Create (to create designs and G-code) and Carbide Motion (to upload designs and control the machine).

2.2 Enclosure Subsystem

Components of the enclosure subsystem include:

- Structural material(s): 1/4-inch polycarbonate panels for visibility and impact resistance, supported by an aluminum frame.
- Doors: Two hinged doors on the front and back of the enclosure, each fitted with safety interlock switches. A magnetic stop holds the door shut when it is closed.
- Seals: Rubber gaskets around edges reduce vibration of the polycarbonate panels and prevent dust escape.



Maintenance tips for the enclosure subsystem include:

- Inspect polycarbonate panels monthly for cracks or scratches. Polycarbonate is vulnerable to certain chemicals that can cause degradation or damage. To clean reference *Table 1:* Polycarbonate Panel Cleaning.
- Tighten or replace any loose fasteners on the aluminum frame, especially if excessive vibration is noticed during operation.
- Check door hinges for smooth operation and apply lubricant if needed.

Cleaners Allowed	Cleaners to Avoid
• Mild cleaners (diluted dish soap) • Wet towel or cloth • Non-abrasive sponges	• Solvents (i.e., acetone) • Strong acids and bases • Ammonia-based cleaners • Abrasive or etching cleaners

Table 1: Polycarbonate Panel Cleaning

2.3 Automatic Door Interlock Subsystem

Components of the automatic door interlock subsystem include:

- Door Switches: Mechanical limit switches are installed between the door and the main aluminum frame
- Control Logic: The switches are set to be normally open. When the doors are closed, the switches are pressed, and the connection is closed. If a door opens while the CNC is running, the circuit is broken and immediately removes power to the machine.
- Reset Procedure: After a door interlock trigger, close the doors and resume the program using the software.

Maintenance tips for the automatic door interlock subsystem include:

- Inspect switches monthly to ensure secure mounting and alignment.
- Keep switch contacts free of metal shavings or debris buildup.
- Replace worn or damaged switches/wiring promptly.

2.4 Emergency Shut-off Subsystem

Components of the emergency shutoff subsystem include:

- E-Stop Button: A large red push-button accessible on the front-right corner of the enclosure.
- Function: Immediately cuts power to the CNC milling machine when pressed. The machine cannot be re-energized until the E-Stop is manually released by resetting the button.
- Reset Procedure: Twist the button to the right until it releases. This indicates the switch is closed again, and power will be supplied as normal.

Maintenance tips for the emergency shut-off subsystem include:

- Test the E-Stop button weekly.
- Ensure the switch is not obstructed by dust or debris.
- Check that the button is not blocked by any objects before using the machine.

2.5 Electrical and Control Subsystem

Components of the electrical and control subsystem include the items listed below. The full wiring diagram is included below (see *Figure 1:* Component Wiring Diagram).

- Wiring: 8-gauge stranded wire.
- On/off switch: Primary power switch for the system. Used to turn the system on or off when all doors are closed.
- Instructor bypass key switch: A key-operated switch that will be managed solely by the instructors.

- Logic: A normally open switch that, when switched to closed by the key will allow for operation with the enclosure doors open.

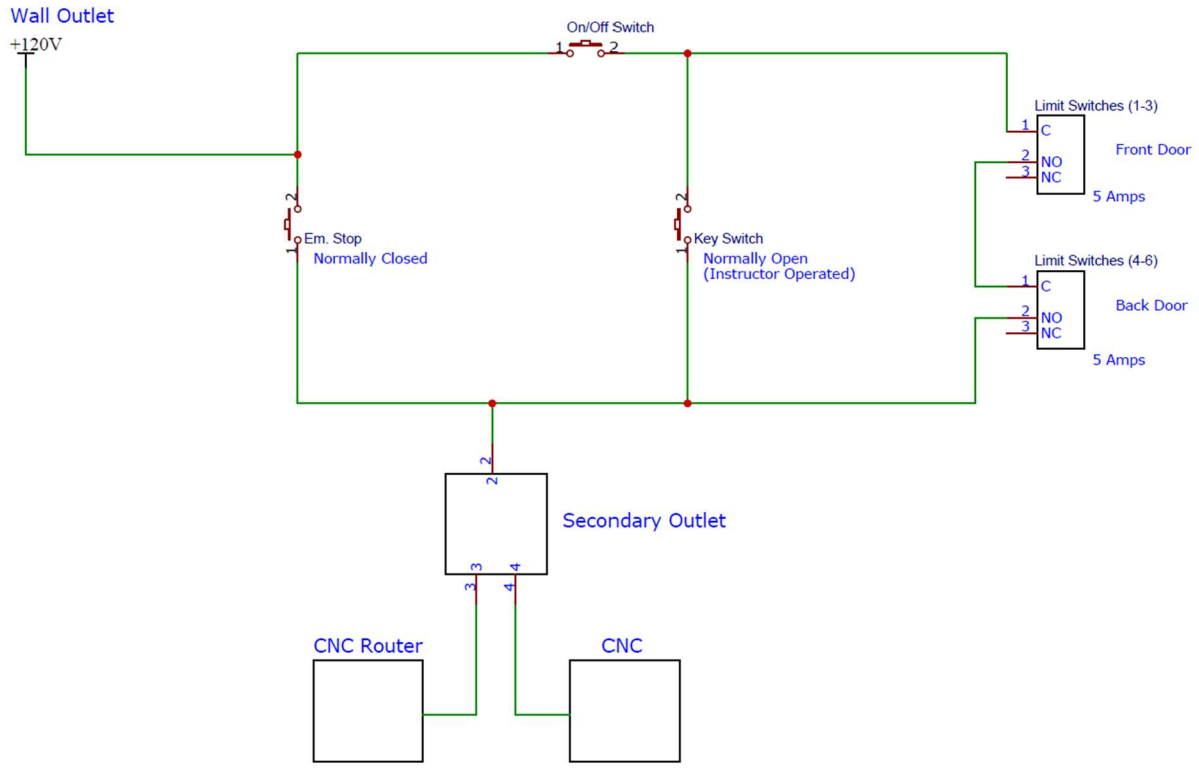


Figure 1: Component Wiring Diagram

Maintenance Tips:

- Check wiring connections for tightness and signs of wear.

2.6 Dust Extraction Subsystem

Components of the dust extraction subsystem include:

- Dust Sweeper: Carbide 3D attachment that connects to the spindle.
- Dust Separator: Oneida Air System Ultimate Dust Deputy Systainer Cylcone Separator located on top of the dust vacuum that separates the dust from the heavier particles.

- Dust Vacuum: Festool Dust Extractor Cleantex CT 15 E HEPA vacuum.

Maintenance Tips:

- Empty the Festool shop vac and Oneida regularly.
- If there is an excess of debris within the enclosure, check that the vacuum hoses are not blocked.
- For more details on dust separator and shop vac maintenance, refer to their operation manuals located in the manual basket and the team's website (see 3.2).

3. Integration

All subsystems are designed to work together to ensure safety and ease of maintenance:

1. Mechanical Assembly: The enclosure frame rests on a plywood base on top of the lab table. The enclosure can be secured to the plywood if needed to minimize vibrations. The door frames align with the door switches for interlock operation.
2. Electrical Wiring: E-stops and limit switches connect to the primary power sources for the CNC to allow for complete power shutoff when the switches are activated.
3. Control Logic Coordination: All the electrical components are on the same circuit. This is to ensure that the CNC can be turned completely off when any of the components are opened (on/off switch, limit switches, E-Stop button).

If the enclosure needs to be disassembled or moved:

- Power down and unplug the CNC from the power source.
- Label all wiring with cable tags.
- Remove the polycarbonate panels carefully to avoid scratches.
- Secure all loose components before transport.

3.1 Maintenance Summary

Ensure Enclosure

Weekly Check	Monthly Check
• Test E-Stop button • Test limit switches • Inspect the vacuum hoses • Check that the dust canisters are empty	• Test bypass key switch • Inspect polycarbonate panels for cracks • Inspect that fasteners and hinges are tight • Inspect limit switches • Check that the operation manual is in correct location and up to date

Table 2: Weekly and Monthly Maintenance Check

3.2 Important File Names and Locations

All the important files related to the Safe CNC project can be found on the project's website.

- https://web1.eng.famu.fsu.edu/me/senior_design/2025/team514/

Note: Always verify that the most recent version of the files is being accessed. If there are issues accessing materials, contact the lab coordinator or the school's IT manager.

4. Operation

4.1 Basic Usage

1. Ensure Enclosure is Clear: Remove any unnecessary tools or materials from inside the enclosure.
2. Close Doors: Confirm the doors are fully closed to enable power.

3. Power On: Turn on the main power switch to the CNC (located on the right side of the machine).
4. Start CNC Program: Load your G-code into the CNC control software on your personal computer and connect to the machine with the USB cable.

4.2 Safety Precautions

- Never bypass or disable door interlock switches.
- Always wear safety glasses and follow lab safety protocols, even with the enclosure in place.
- Do not open the enclosure doors while the spindle is in motion.
- In an emergency, press the E-Stop immediately.

4.3 Step-by-Step Instructions

1. Preparation:
    - Inspect the enclosure panels for damage.
    - Verify the E-Stop is released (in the “up” position).
    - Make sure the CNC control software is ready on the lab computer.
2. Machine Setup:
    - Load material securely on the CNC bed.
    - Place the alignment probe onto the bottom left of the material and attach the magnet to the spindle.
    - Install the correct cutting tool.
    - Close the enclosure doors.
3. Power and Start:
    - Turn on the CNC’s main power.
    - Load the G-code file into Carbide Motion.
    - Click “JOG” on the top right-hand side of the screen to position the spindle above the sensor.

    - Click “Probe.”
    - After probing is complete, return to “RUN” (at the top right-hand side of the screen) and start the job.
4. During Operation:
    - Monitor the job progress through the enclosure’s transparent panels.
    - Listen for unusual sounds or vibrations.
5. Completion or Emergency:
    - When the job is finished, allow the spindle to come to a complete stop before opening the doors.
    - If an emergency arises, press the E-Stop. Power will remain off until the E-Stop is manually reset.

4.3 Safety Override

Certain circumstances may require that the safeguards be overridden. To override the safeguards:

- The instructor must unlock the key switch to allow power to the CNC without the doors being shut.
- The E-Stop button will still be operable and capable of cutting off the power, but the limit switches will not affect the operation of the CNC in this mode.
- To return the safeguards to their normal operation, relock the key switch.

5. Troubleshooting

For troubleshooting, refer to Table 2: Troubleshooting below for symptoms, possible causes, and potential solutions.

Symptom	Possible Causes	Solution
1. CNC router will not power on	a. Door not fully closed b. E-Stop pressed c. Door switches not engaging	a. Close doors completely b. Release E-Stop and reset c. See Symptom #3
2. CNC router stops mid-operation	a. Door switch triggered b. E-stop pressed	a. See Symptom #3 b. Release E-Stop and reset
3. Door switches not engaging	a. Door misaligned b. Switch is broken	a. Fix door alignment so door is hitting the switches b. Replace switch if defective

Table 3: Troubleshooting

Additional Tips:

- Check the lab's main breaker panel if power is lost in the entire area.
- Inspect the power switch, E-Stop, and limit switches in the enclosure's power line.
- For software-related issues, consult the G-code documentation or the CNC controller software manual.

Final Notes

Keep this manual in an easily accessible place near the CNC machine or on the lab's shared server. Regularly update it if the design or software changes. Always prioritize safety by verifying that all enclosure features (E- stop, door interlocks) function correctly before operating the CNC machine.