PCB Milling Process

Using Carbide Nomad 3 CNC

Course: Advanced Manufacturing Techniques

Instructor: Dr. Alex Innovations

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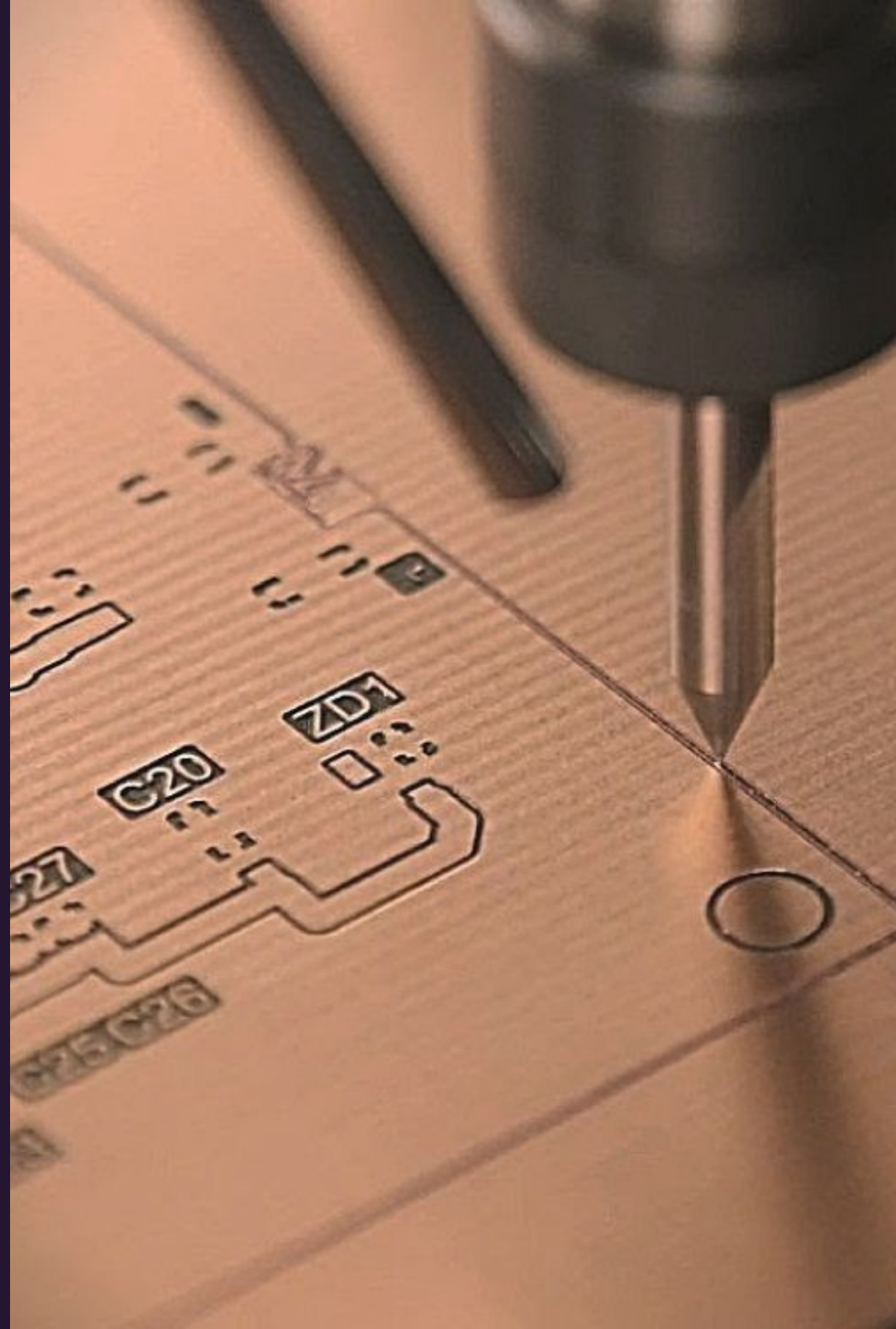


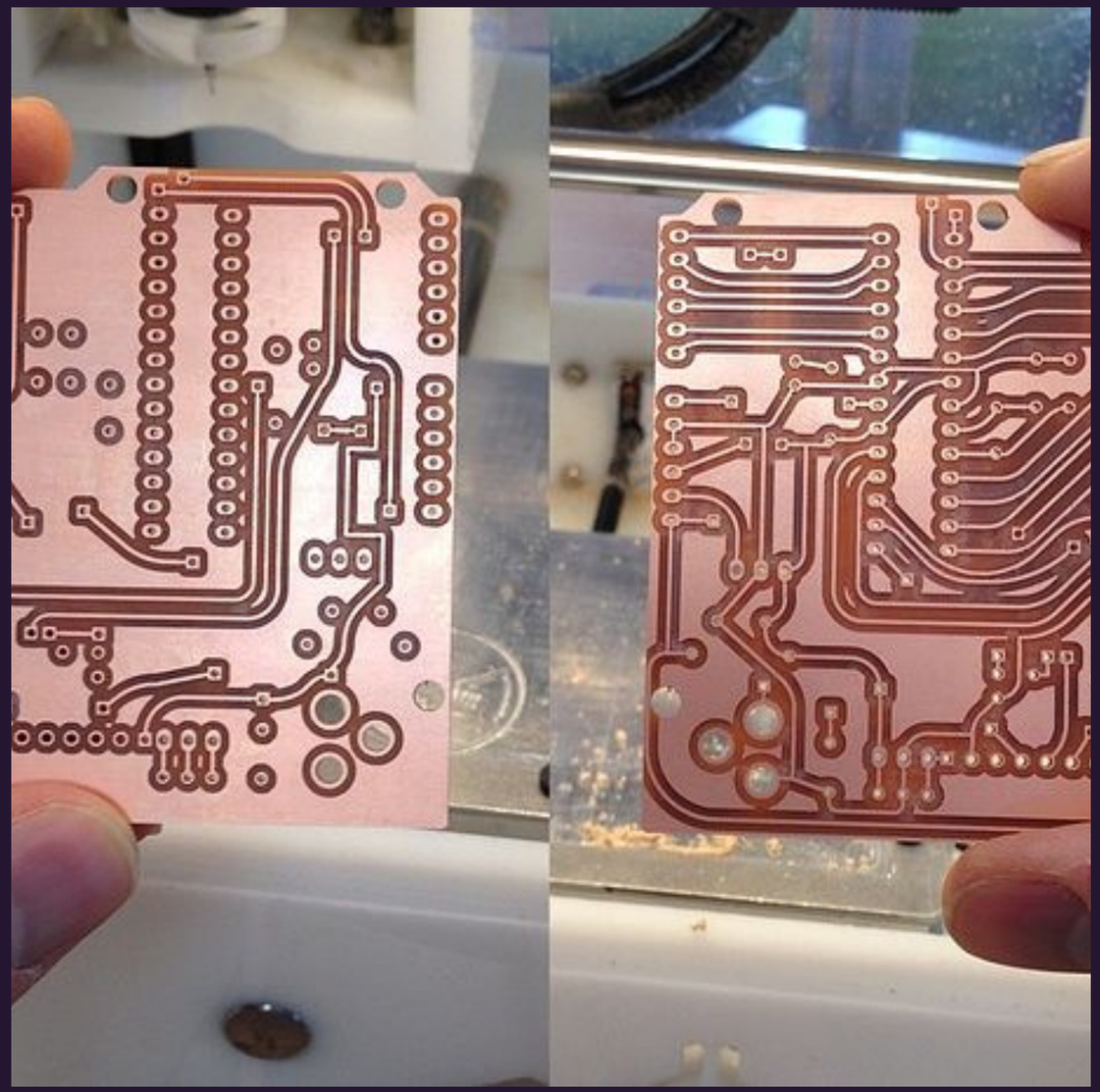
Introduction to PCB Milling

PCB milling is a subtractive manufacturing process that uses CNC machines to physically remove copper from PCB blanks.

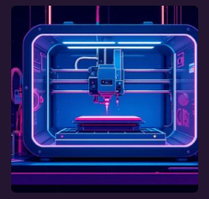
This method offers several advantages:

Ideal for **rapid prototyping** and small-batch production.

- Eliminates the need for messy chemical etching processes.
- Provides quick turnaround times for design iterations.



Overview of the Carbide Nomad 3



Desktop CNC Milling Machine

Compact and powerful, designed for precision in a smaller footprint.

Enclosed for Safety & Dust Control

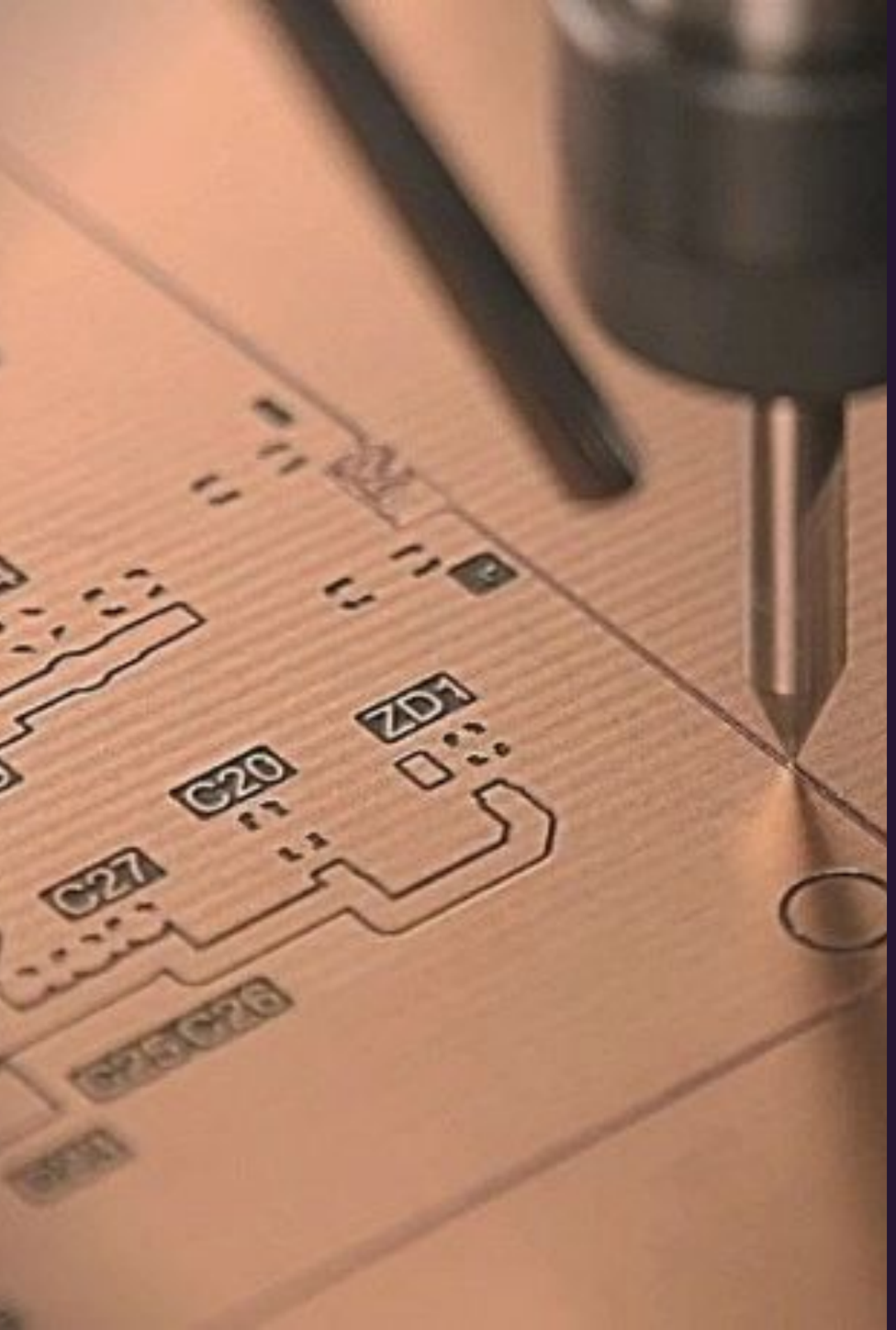
Ensures a safer working environment and minimizes airborne particles.

High Precision for PCB Milling

Capable of intricate details required for complex circuit boards.

Compatible with Carbide Software

Seamless integration with Carbide Create for design and Carbide Motion for machine control.



Essential Components for PCB Milling

1

PCB Blanks

FR-1 or FR-4 Copper-Clad Board: The base material for your circuit. FR-1 is paper-based, easier to mill; FR-4 is fiberglass-based, more durable.

2

End Mills & Drill Bits

0.2–0.4 mm Flat End Mill: For precise trace isolation. **Drill Bits:** Various sizes for component holes.

3

Securing Materials

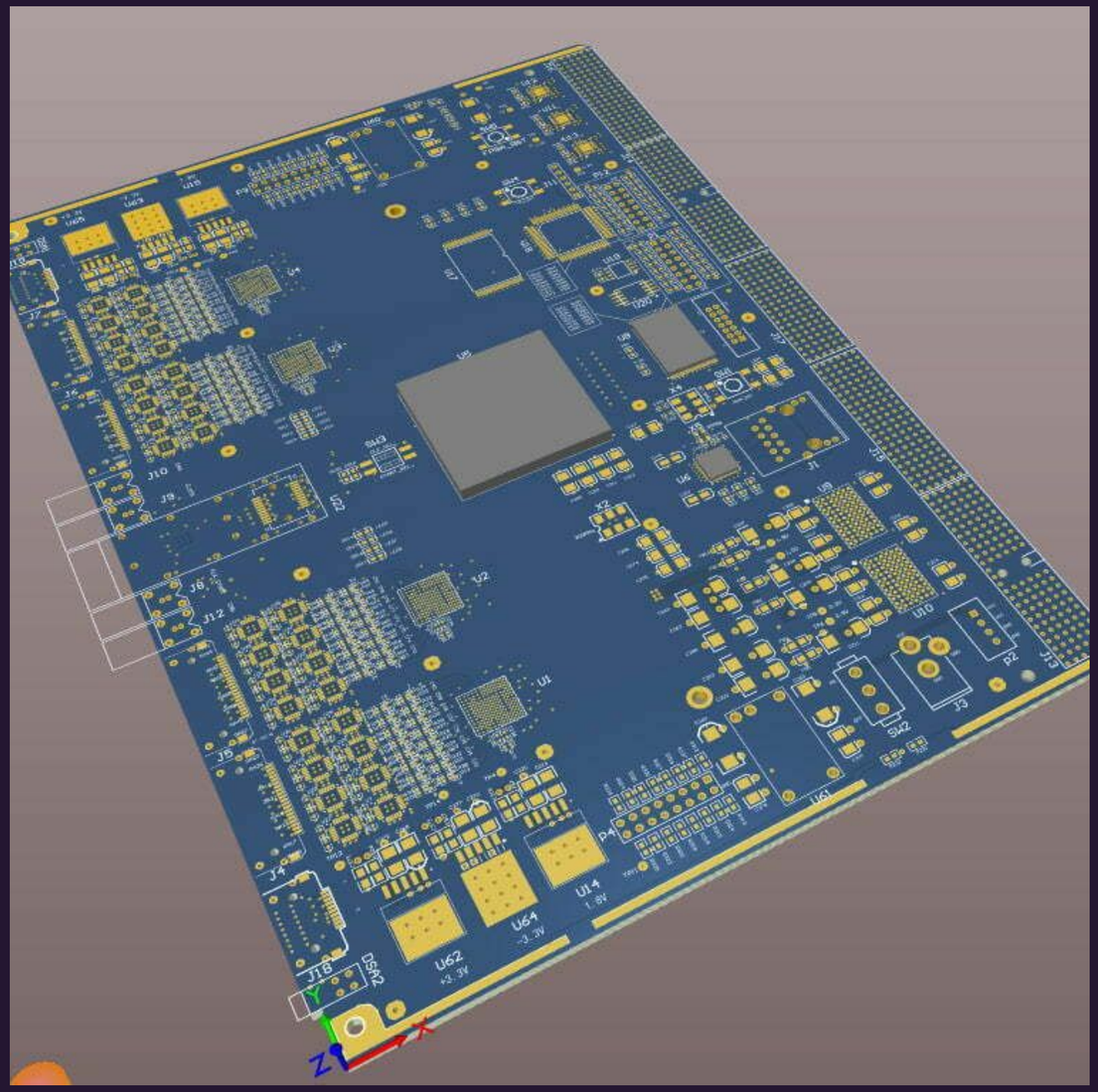
Double-Sided Tape: For temporary, secure board mounting. **Fixture Plate:** For more permanent or repeatable setups.

4

Cleaning Tools

Vacuum or Brush: Essential for removing milling dust and debris, maintaining machine cleanliness.

PCB Design Preparation

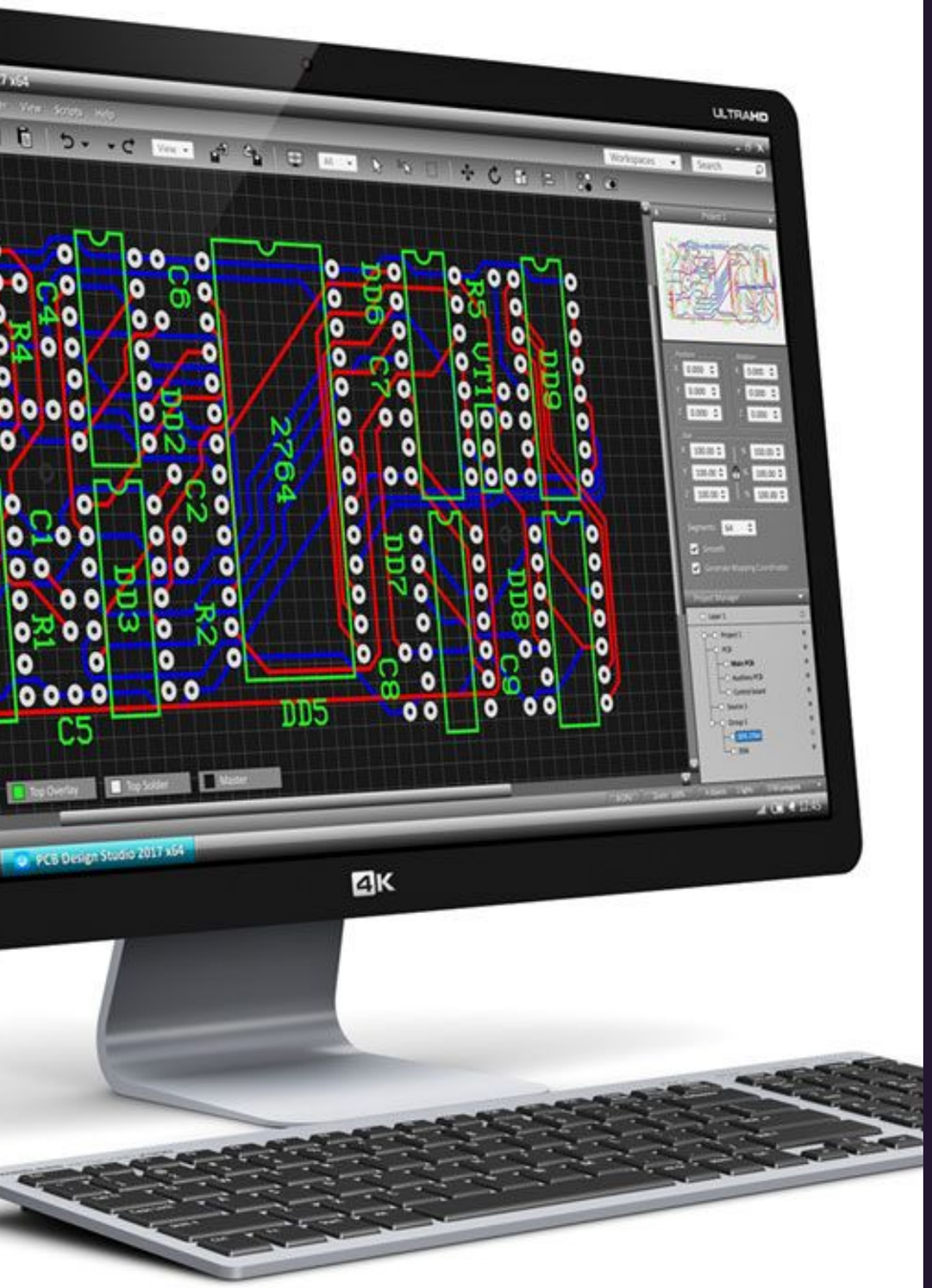


Before milling, meticulous design work is crucial. Use dedicated PCB design software like **KiCad** or **Eagle** to create your schematic and board layout.

Define appropriate **trace width and clearance** suitable for milling capabilities.

Perform a thorough **Design Rule Check (DRC)** to catch any potential issues.

Export standard **Gerber files** (for traces, silkscreen, and solder mask) and **Drill files** (Excellon format) for CAM software.



Toolpath Generation for Milling

Toolpath generation translates your PCB design into machine instructions. Software like **FlatCAM** or **Carbide Create** is used for this step.

Import Gerber Files

Load your exported Gerber and Drill files into your CAM software.

Generate Toolpaths

Create separate toolpaths for: **Trace isolation** (to cut around conductors), **Drilling** (for component holes), and **Board outline** (to cut the board shape).

Set Cutting Parameters

Carefully define **cutting depth**, **tool diameter**, and **feed rates** based on material and tool specifications.

Export G-code

Generate the final G-code file that the Nomad 3 will execute.

Machine Setup & Calibration

Proper machine setup ensures the accuracy and quality of your milled PCB.

Secure PCB Blank: Firmly attach the PCB material to the Nomad 3 bed using tape or clamps.

Install End Mill: Insert the correct end mill for the first operation, ensuring it's properly seated.

Set Work Coordinates: Define the **X, Y, and Z zero points** precisely. Z-axis zeroing is critical for consistent trace depth.

Surface Leveling: Highly recommended for optimal trace quality, especially on slightly uneven boards.

Perform Dry Run: Always run a simulation without cutting to verify toolpaths and prevent errors.

The PCB Milling Process

Once set up, the Carbide Nomad 3 brings your design to life. Monitoring is key for a successful outcome.

Isolation Milling

The machine begins by cutting the isolation traces, separating copper pads and lines.

Drilling Holes

Next, the appropriate drill bits are used to create all necessary component holes.

Board Outline Cut

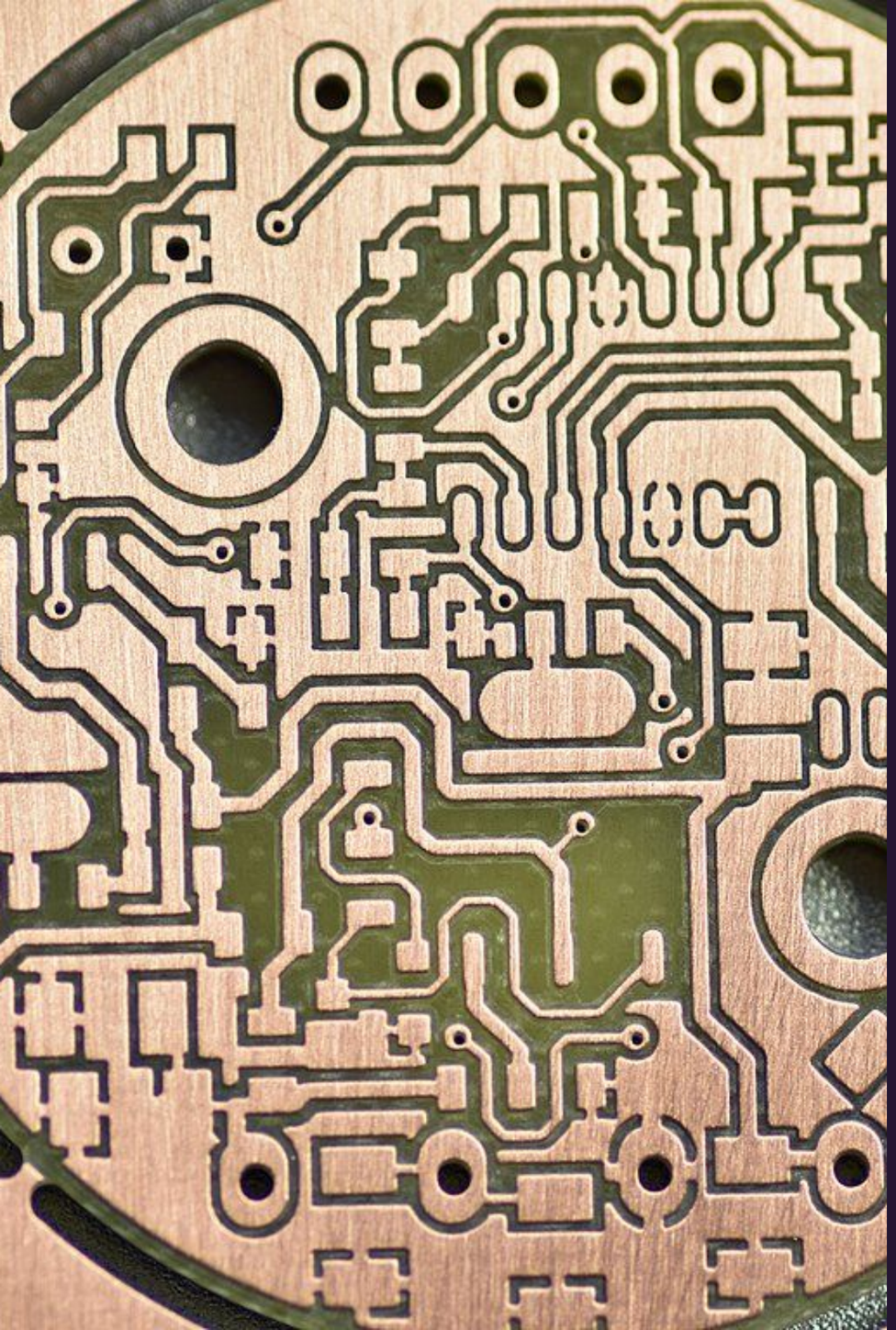
Finally, the machine cuts out the overall shape of your PCB from the blank material.

Monitor closely: Keep an eye on the process for any signs of tool wear, excessive vibration, or tool breakage. Pause the machine if issues arise to prevent damage.

Post-Processing & Assembly

After milling, the final steps involve preparing your PCB for component assembly and testing.

Clean PCB Surface: Thoroughly remove any remaining dust or burrs from the milling process.
Inspect for Shorts/Opens: Use a multimeter to check for any unintended shorts or incomplete traces.
Solder Components: Populate your board with electronic components, carefully soldering each in place.
Continuity Testing: Verify electrical connections after soldering to ensure everything is correctly connected.
Rework if Necessary: Address any identified issues or faulty connections.



Safety, Limitations, & Best Practices

Mastering PCB milling involves understanding its nuances, ensuring safety, and knowing its practical limits.

Prioritize Safety

Always keep the enclosure closed during operation and ensure proper ventilation.

Optimize Parameters

Use appropriate feeds and speeds to prolong tool life and achieve quality results.

Understand Limitations

Less suitable for fine-pitch components or complex multi-layer boards.

Ideal for Learning

Excellent for rapid prototyping, educational purposes, and exploring electronics design workflows.

Key Takeaway: PCB milling with the Carbide Nomad 3 enables fast, precise, and chemical-free electronics prototyping when proper design rules and machine setup are followed.