



# TNC-M34

## Four-Axis CNC Mill / Router Controller

*Standalone control of X, Y, Z and a 4th axis, with macro programming, work-offset recovery and pendant support.*

### OPERATION MANUAL

|              |                   |
|--------------|-------------------|
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THIS MANUAL CONTAINS INFORMATION FOR INSTALLING AND OPERATING THE FOLLOWING PRODUCT: TNC-M34, FOUR-AXIS CNC MILL / ROUTER CONTROLLER.

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# Revision History

| Revision | Date           | Timestamp  | Sections affected | Summary of change                                    |
|----------|----------------|------------|-------------------|------------------------------------------------------|
| R1.0     | September 2026 | 2026-09-12 | All               | First issue under the family documentation standard. |

# Chapter 1 — Safety Information

Read this chapter before the machine is connected to motors.

## 1.1 Warning Levels

| Level   | Meaning                                                                                           |
|---------|---------------------------------------------------------------------------------------------------|
| DANGER  | An imminently hazardous situation which, if not avoided, will result in death or serious injury.  |
| WARNING | A potentially hazardous situation which, if not avoided, could result in death or serious injury. |
| CAUTION | A situation which, if not avoided, may result in minor injury or damage to equipment.             |
| NOTE    | Information needed for correct operation. No injury risk.                                         |

## 1.2 Electrical Safety

### WARNING

E-STOP is not a firmware feature. The external E-stop chain must remove power from the drives by itself. The controller's E-STOP input tells the firmware what happened; it is not what makes the machine safe.

### WARNING

A limit or E-stop input stops motion at input-scan rate whether or not the screen is responding, and cannot be overridden by a program, a macro, or a probe cycle. While a limit or E-stop input reads active, the controller refuses to start any motion — jog, MDI, macro or program.

### WARNING

Limit override suspends limit protection so an axis can be jogged off a tripped switch. Nothing else about it is safe. Use it to recover, then release it.

## 1.3 Motion Safety

### WARNING

Homing drives an axis into a switch on purpose, at the configured seek rate. Set that rate to something the mechanics survive before the first cycle, not after.

### WARNING

Soft limits only exist once an axis is referenced. An unreferenced machine will happily drive past its travel bounds.

**CAUTION**

Z-Inhibit still moves the machine. Only Z is held; the other axes run the program in full (section 11.4, Z-Inhibit — Running the Path in the Air).

**WARNING**

The only instant stops are the protective inputs: E-STOP, and a limit switch trip. Both stop dead without deceleration, and after either you should expect to re-home. If the machine must stop right now, E-STOP is the control for that — the Stop key is deliberately not: it decelerates the machine at its configured acceleration first, to keep the position readout honest.

## 1.4 General Safety Rules

- Only trained personnel may install, configure or operate this controller.
- Reference every axis before running a program. Soft limits protect nothing until then.
- Never bypass a limit switch or the emergency-stop chain to finish a job.
- Never leave a running program unattended.
- Confirm every input on the Diagnostics page before trusting a mapping.
- Keep this manual with the machine.

## Chapter 2 — Product Overview

The TNC-M34 is a standalone four-axis CNC controller for milling and routing. It drives X, Y, Z and a configurable 4th axis as step-and-direction outputs. Everything runs from its own panel: configuration, file browsing, program viewing, MDI, macros and diagnostics are all on the controller, so no PC is needed at the machine.

This manual describes the machine as the firmware actually behaves. Where a setting has one name on the panel and a different name in its configuration file, both are given.

### 2.1 Key Features

- Four axes — X, Y, Z and a configurable 4th, rotary or linear — each with independent steps per unit, rate, acceleration, travel and backlash, so an axis driven through a different screw or reduction from the others is configured on its own terms.
- Six work coordinate systems (G54–G59), with the active offset and frame surviving a power cut.
- Automatic recovery after a power loss, with a guided four-step wizard before any motion resumes.
- A macro language for tool changes, probing routines and automatic tool changers, with variables, branching and prompts (Appendix D, Macro Programming Reference).
- Probing (G38) from MDI or a macro, with results captured on the motion processor for accuracy independent of the display.
- A three-zone 800 × 480 display whose live toolpath preview checks a program against the machine's travel before its first run, and an optional pendant carrying jog and zero keys and a handwheel for working away from the panel.
- Full G-code motion, canned cycles and work-offset handling, with unsupported modal codes refused at load rather than silently mis-run.
- Configuration held as plain-text files on the SD card, editable on the panel or on a PC.

### 2.2 Files on the Card

| Path                     | Contents                                                    |
|--------------------------|-------------------------------------------------------------|
| 0:/config/machine.cfg    | Axes, homing, spindle, limits, tool-zero, 4th axis.         |
| 0:/config/controller.cfg | Interface behaviour, key assignments, display brightness.   |
| 0:/config/stock.cfg      | Stock shape and size for the toolpath preview.              |
| 0:/config/io.cfg         | The input/output function map.                              |
| 0:/config/offsets.cfg    | Work offsets and the tool table.                            |
| 0:/gcode/                | Programs. Only files here are runnable.                     |
| 0:/macros/               | .mac macro files (Appendix D, Macro Programming Reference). |

Config files can be opened and edited on the panel, so a setting's stored value can be read without stepping through the menu to it.

#### NOTE

A program stored outside 0:/gcode can be viewed but not run — the file browser loads it read-only rather than listing something it cannot execute.

## Chapter 3 — I/O Functions and Mapping

Every input and output function is assigned to a pin on the MAPPING page — nothing is wired by function until that assignment is made.

Figure 3.1 — TNC-M34 Terminal Layout



### 3.1 Input Functions

| Function            | Notes                                                                   |
|---------------------|-------------------------------------------------------------------------|
| HOME X / Y / Z / 4  | Homing switch per axis; may share a pin (section 8.5, Shared Switches). |
| LIMIT X / Y / Z / 4 | Hard limit; stops motion immediately when active.                       |
| PROBE               | The probing and tool-zero input (section 15.1, Probing — G38).          |
| E-STOP              | External chain input.                                                   |
| CYCLE START         | Physical start button.                                                  |
| FEED HOLD           | Physical hold button.                                                   |
| STOP                | Physical program abort.                                                 |

| Function    | Notes                                                                                                                                                                                                                             |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MACRO 1...4 | Readable from a macro as #in_MACRO_IN1 to #in_MACRO_IN4 — a guard switch, for instance. Does not itself launch a macro.                                                                                                           |
| BLOCK RUN   | Toggles single-block mode on each rising edge (section 11.1a, Single-Block Mode). A mode switch, not a step button — the step input is CYCLE START. On a pin it shares with START, HOLD or STOP, this is the function that loses. |

#### NOTE

Several functions may share one pin, and some are meant to. PROBE and MACRO 1–4 are levels read on demand and share freely. LIMIT X/Y/Z/4 are combined into one kill signal by design — the shipped default points all four at one pin, so a trip stops the machine but cannot say which axis. E-STOP shares that arrangement and always wins. CYCLE START, FEED HOLD and STOP fire on the rising edge, and if a pin carries more than one, only the most conservative runs: STOP beats FEED HOLD beats CYCLE START.

#### WARNING

A home switch that is also a limit switch is common wiring. Homing drives deliberately into the switch, so with the hard-limit kill armed the controller would stop the machine the moment homing succeeds. Homing is refused in that case, naming the axis.

There are two ways past it. Turn the hard-limit kill off, or leave no LIMIT pin mapped (section 14.11, MACHINE → LIMITS) — the shared pin is then simply a home switch and homing runs normally. Or engage limit override, from the Limit-O key or DIAGNOSTICS F4 (Chapter 16, Diagnostics and Tuning), which suspends the kill for as long as it is on; an amber cue sits on the STATE panel the whole time. Hard limits are never suspended for you — they stay armed until you turn them off deliberately.

## 3.2 Output Functions

| Function    | Notes                                                                               |
|-------------|-------------------------------------------------------------------------------------|
| SPINDLE EN  | Spindle enable.                                                                     |
| SPINDLE DIR | M4 reverse; unassigned by default.                                                  |
| FLOOD       | M8 flood coolant. Stored and scripted as COOLANT; both names reach the same output. |
| MIST        | M7 mist coolant.                                                                    |
| MACRO 1...4 | General purpose, driven from macros and M62–M65.                                    |

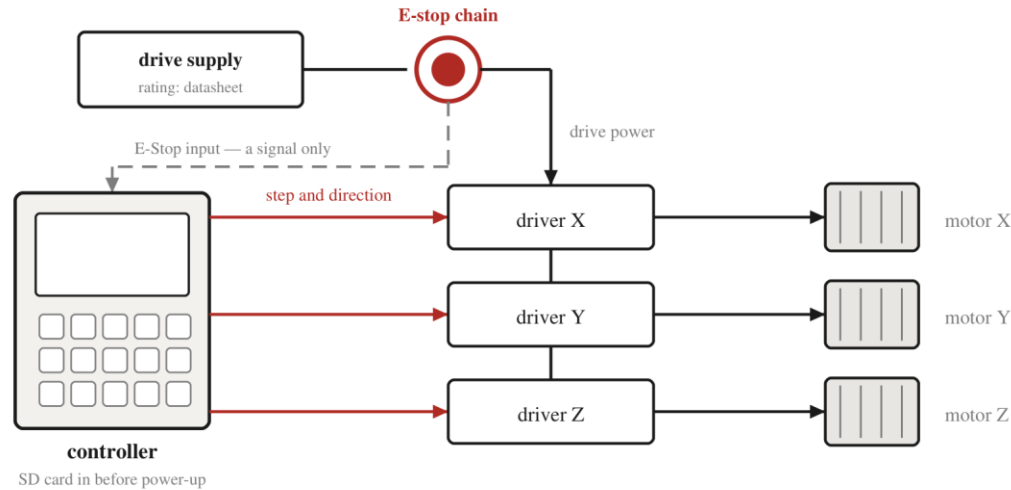
Pins are numbered 0 to 15 for both inputs and outputs. Inputs are marked In-0 to In-15 on the board, except input 7, marked In-U7; that marking is a misprint. Outputs 0 to 11 are marked Out-0 to Out-11. Outputs 12, 13, 14 and 15 are the M3, M4, M7 and M8 relay contacts, which carry no number on the board (Appendix B, B.6, Board Terminal Markings).

Each input carries an invert flag — active-low is the normal-open-switch case — and each output likewise. Polarity lives on the MAPPING page, not in the homing settings; the homing invert setting is seek direction, not switch sense.

## Chapter 4 — Quick Start

This chapter takes a new controller, out of the box, to a first program run.

**Figure 4.1 — What the Quick Start Assumes**



The quick start begins here — wired, powered, and with the card in.

The E-stop chain removes drive power by itself; the E-Stop input only tells the firmware.

1. **Insert the SD card** before power-up. On a blank card the firmware writes default configuration files and continues — every value can then be edited on the panel (Chapter 13, Menus).
2. **Set the machine table.** MENU → MACHINE, in this order: axis steps per unit, travel limits, maximum rates and accelerations, then homing (Chapter 14, Settings Reference).
3. **Assign the I/O.** MENU → MAPPING, every input and output actually wired. Nothing is assigned by function until you say so (Chapter 3, I/O Functions and Mapping).
4. **Jog each axis** and confirm it moves the expected distance in the expected direction (Chapter 9, Jogging).
5. **Home the machine**, or reference it in place if it has no switches (Chapter 8, Referencing and Homing).
6. **Load a program** from Files and preview the toolpath (Chapter 10, Files).
7. **Set the work offset** by touching off, or by probing (Chapter 7, Coordinates and Work Offsets).
8. **Press Start.** (Chapter 11, Running a Program.)

### NOTE

Two things new operators get wrong.

Soft limits only exist once an axis is referenced. A freshly powered machine has no travel protection until homing or in-place referencing completes (Chapter 8, Referencing and Homing).

On Start, the machine plans from the file's own first Z, not from work zero, and Z lifts before the other axes traverse. Jog clear before pressing Start on a program never run before (section 11.1, Start, Hold, Stop).

## Chapter 5 — Technical Specifications

|                  |                                    |                                        |                              |
|------------------|------------------------------------|----------------------------------------|------------------------------|
| AXES<br><b>4</b> | DISPLAY<br><b>7-in (800 × 480)</b> | MAX STEP RATE<br><b>100 kHz / axis</b> | SUPPLY<br><b>24 V DC 1 A</b> |
|------------------|------------------------------------|----------------------------------------|------------------------------|

| Parameter               | Specification / Value                                                                  |
|-------------------------|----------------------------------------------------------------------------------------|
| Processor               | 32-Bit Dual-core ARM processor                                                         |
| Axes                    | Four — X, Y, Z linear, plus configurable 4th (rotary or linear)                        |
| Motor output type       | Differential Pulse & Direction (8 differential outputs)                                |
| Max step frequency      | 100 kHz per axis                                                                       |
| Display                 | 7-inch graphic colour TFT (800 × 480 pixels), three fixed zones                        |
| Supply voltage          | 24 V DC (1 A nominal)                                                                  |
| Digital inputs          | 16 opto-coupled NPN inputs (24 V)                                                      |
| Digital outputs         | 14 open-collector outputs (24 V, 200 mA each) + 4 relay outputs (dry contact)          |
| Spindle control         | Isolated 0–10 V analog speed reference (externally referenced), switchable to PWM      |
| MPG pendant             | Handheld pendant with LCD display, handwheel, and 1/10/100/1000 µm scale (RS-485 link) |
| Operator keypad         | 36-key built-in tactile keypad plus 6 function softkeys (F1–F6)                        |
| Removable storage       | USB flash drive (host port) and internal microSD card                                  |
| Work coordinate systems | Six — G54 to G59                                                                       |
| Coordinate range        | ±16,777.216 mm, single-precision IEEE 754 representation                               |
| Step pulse width        | 1 to 100 µs, default 3 µs                                                              |
| Direction setup time    | 0 (auto) to 100 µs                                                                     |
| Steps per unit          | 1 to 100,000 steps/mm linear; 0.01 to 100,000 steps/deg on 4th axis                    |
| Maximum rate            | 1 to 200,000 mm/min linear; 1 to 10,000,000 deg/min on 4th axis                        |
| Acceleration            | 1 to 200,000 mm/s <sup>2</sup> linear; 1 to 10,000,000 deg/s <sup>2</sup> on 4th axis  |
| Macro capacity          | 48 variables per macro, expressions, flow control, no length limit                     |

### NOTE

Appendix B, Integrator Technical Specifications, gives the derived limits that follow from the settings above — the step-pulse clamp and the coordinate precision ceiling.

## 5.1 What This Product Does Not Have

---

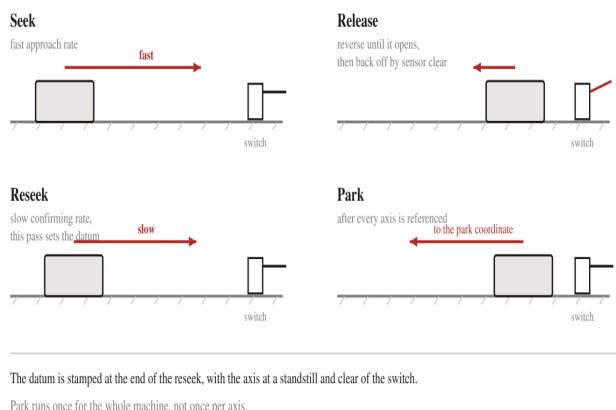
Named because their absence is a stated current limitation, not an omission left to be discovered:

- On a 0-10V or PWM spindle, G84, G86 and G88 move but do not touch the spindle: there is no spindle feedback, so treat them as assisted manual operations. A STEP spindle is the exception — it turns G84 and G74 into real rigid tapping (section 14.12, MACHINE → SPINDLE).
- Cutter compensation, scaling, rotation, polar coordinates and feed-per-revolution are not supported. A program using them is refused at load, naming the code and line.
- G76 and G87 canned cycles are not supported and are refused the same way. So is G74, unless the spindle is in STEP mode.
- G38 probing is available from MDI and from a macro, not inside a running program.
- A Pendant V1 is not detected. Only Pendant V2 is supported.

## Chapter 6 — Controls and Display

The controller is operated from the panel, which carries the display and the keypad, and from the pendant, which carries a smaller display, jog and zero keys, and a handwheel.

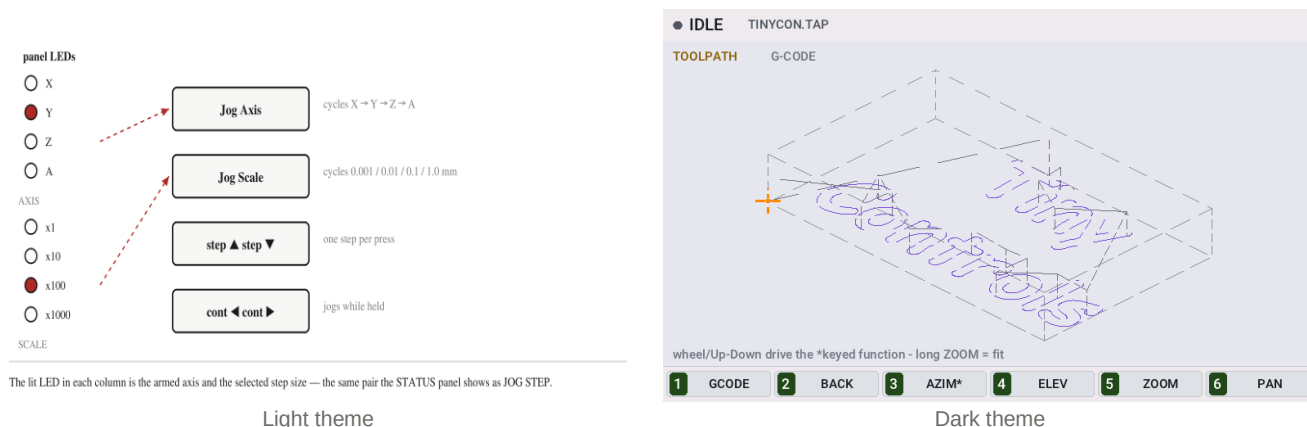
**Figure 6.1 — Panel and Pendant**



### 6.1 Screen Layout

The display is divided into three fixed zones. The main-screen softkeys are F1 MENU, F2 VIEW, F3 assignable, F4 JOG V, F5 MDI and F6 JOG — JOG sits at F6 so it falls next to the JOG Axis and JOG Scale keys. Every other screen relabels the same six chips for itself.

**Figure 6.2 — The Main Screen**



Both captures show the same idle machine with TINYCON.TAP loaded. Along the top are the run-state dot and word, then the loaded file. Down the left are the axis cards, one per axis, carrying the position in the coordinate system currently displayed. To their right, STATUS holds the values that change as a job runs: tool, feed, spindle, rapid, jog velocity and step, line count, and elapsed time against estimate. Beside it, STATE holds the modal G-codes in force. The EXEC strip below them shows the block being executed, and is where a typed MDI line appears. The softkey row labels F1 to F6 for whatever screen is open.

#### NOTE

Theme is a display setting and changes nothing the machine does. Every screen in this manual is shown in both themes; the layout, the wording and the softkeys are identical in each (section 14.2, CONTROLLER → INTERFACE).

| Zone        | Contents                                                                               |
|-------------|----------------------------------------------------------------------------------------|
| Top bar     | Run-state dot and name, loaded file, active work system, alarm text.                   |
| Body        | The active screen — main position display, toolpath view, files, menus, configuration. |
| Softkey row | Six chips labelling F1–F6 for the current screen.                                      |

STATUS lists TOOL, FEED, SPIN, RAPID, JOG VEL, JOG STEP, LINE and TIME. On a machine whose 4th axis is continuous or rolls over, a ninth row joins them and the others close up slightly to fit it:

| Row     | Contents                                                                                                                                                   |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A TURNS | Turns since the 4th axis was last zeroed — B or C to match the configured letter. This is the number a winding job is watched by (section 18.5, 4th Axis). |

Both jog numbers sit together in STATUS. JOG VEL is the continuous-jog velocity in units per minute; JOG STEP is the step distance, shown as the multiplier and the millimetres together — X100 0.100. The multiplier is the same name the panel LEDs and the pendant chips carry, so all three read alike (section 6.4, The Panel LEDs). JOG STEP turns accent-coloured while an axis is armed, matching the border on the armed axis's card: the highlighted card and the highlighted step are one statement — this axis, this distance. The step shows whether or not jogging is armed, because it is a standing setting that cycles either way.

The run-state dot and word are the fastest read on the panel.

| State | Meaning                                            |
|-------|----------------------------------------------------|
| IDLE  | Nothing running; all actions allowed.              |
| RUN   | A program or MDI block is executing.               |
| HOLD  | Feed hold — motion paused, program position kept.  |
| REV   | Reversing back along the toolpath from a hold.     |
| ALARM | A fault is latched; clear it before anything else. |
| JOG   | A jog is in progress.                              |

#### NOTE

A greyed-out softkey chip means that key does nothing on this screen. An unassigned function shows as a dead chip rather than a live-looking label.

## 6.2 Keypad

| Key          | Short press                             | Long press                       |
|--------------|-----------------------------------------|----------------------------------|
| F1...F6      | The action on the softkey chip above    | Screen-specific                  |
| X/Y/Z/A-Zero | Zero the work offset for that axis here | Open numeric entry for that axis |
| Jog Axis     | Cycle the jog axis X → Y → Z → A        | —                                |

| Key                     | Short press                                                              | Long press                                    |
|-------------------------|--------------------------------------------------------------------------|-----------------------------------------------|
| Jog Scale               | Cycle the step size 0.001 / 0.01 / 0.1 / 1.0 mm                          | —                                             |
| cont ← / cont →         | Continuous jog, negative / positive                                      | —                                             |
| step ▲ / step ▼         | Step jog by the current scale; also list navigation                      | —                                             |
| Homing                  | Run the homing cycle                                                     | Arm in-situ reference; press again to confirm |
| Go-zero                 | Rapid to work zero                                                       | Assignable (section 6.3, Assignable Keys)     |
| WCS                     | Open the work-coordinate picker                                          | —                                             |
| WCS-T                   | Toggle the display between work and machine coordinates                  | —                                             |
| Spin-T                  | Toggle the spindle                                                       | —                                             |
| Rapid-O, Feed-O, Spin-O | Open numeric entry for that override                                     | —                                             |
| Limit-O                 | Suspend limit protection (section 1.2, Electrical Safety)                | —                                             |
| Z-Inhbt                 | Inhibit Z motion (section 11.4, Z-Inhibit — Running the Path in the Air) | —                                             |
| File                    | Open the program browser                                                 | —                                             |
| Start                   | Cycle start / resume                                                     | Start from a line number                      |
| Pause                   | Feed hold                                                                | —                                             |
| Stop                    | Abort the program                                                        | —                                             |
| OK                      | Confirm / open / apply                                                   | Context-specific                              |
| ESC                     | Back / cancel / abort                                                    | —                                             |
| Shift                   | Shift for the next key                                                   | Shift lock (sticky) until pressed again       |

**NOTE**

The encoder wheel duplicates step up and step down everywhere, including menus and lists. During any numeric or text entry, the machine-action keys become digits and do not fire their machine action on release; only shift-lock stays live while typing.

## 6.2a Editing a Line: the Cursor

The two long text fields — MDI, and the G-code line editor — carry a cursor, so a line can be corrected in place instead of retyped from the mistake onwards. A thin vertical bar marks it; it does not blink.

| Key                    | In MDI and the line editor              |
|------------------------|-----------------------------------------|
| cont LEFT              | Move the cursor one character left.     |
| cont RIGHT             | Move the cursor one character right.    |
| Shift + Space, or File | Delete the character before the cursor. |
| Any character key      | Insert at the cursor.                   |

All four auto-repeat when held past about half a second, so running the cursor into the middle of a long block is one held key rather than one press per character. To change X50 to X60 in G1 X50 Y30 F600: hold cont LEFT until the bar sits just after the 5, delete, then type 6 — three key actions. Both fields open with the cursor at the end of the line, as does a recalled MDI line, so typing a fresh line is unchanged.

#### NOTE

The cursor keys are the jog keys. While either field is open the continuous jog is suppressed, so moving the cursor cannot move an axis. The same suppression covers the other pop-up entries on the main screen — axis value, the override dialogs, and GOTO.

Numeric fields — configuration rows, overrides, axis values, the PIN — have no cursor. They are short enough that retyping costs less than arrowing, and they show a trailing underscore instead.

## 6.3 Assignable Keys

Five keys have no fixed job on the main screen, carrying seven assignment slots between them. They are assigned in CONTROLLER CONFIG → KEYS, and each can run an internal function or any macro on the card (section 14.4, CONTROLLER → KEYS).

| Panel key                 | Assigned by                                                                                   |
|---------------------------|-----------------------------------------------------------------------------------------------|
| F3                        | Its own short list.                                                                           |
| Space, Space long-press   | Two independent choosers.                                                                     |
| Resume, Resume long-press | Two independent choosers. Start is always the resume key — Resume carries no built-in action. |
| Go-zero long-press        | One chooser (short press stays Go Zero).                                                      |
| DryRun                    | One chooser, which the key no longer fires — see below.                                       |

#### NOTE

F3 is taken over by REVERSE whenever the machine is in HOLD, so reversing out of a hold never depends on how F3 was configured.

#### NOTE

Pressing DryRun does nothing. It prints DRY-RUN retired - reserved for TEACH and returns. Its chooser is still on the KEYS page and still stores what is set there, so six of the seven slots act; use one of those for anything that must run from a key.

## 6.4 The Panel LEDs

Eight LEDs sit beside the screen in two columns of four. The lower column is the SCALE column, silkscreened x1, x10, x100 and x1000; the upper is the AXIS column, silkscreened X, Y, Z and A. The SCALE column shows the jog step multiplier currently selected — the same x1 to x1000 naming that JOG STEP carries in STATUS and that the pendant chips use, so the panel, the screen and the pendant never disagree about the step size. JOG Scale cycles it (section 6.2, Keypad).

The AXIS column shows the armed jog axis. It says the same thing as the border on that axis's card and the JOG chip on F6, so the two columns read together as one statement — this axis, this distance — without looking at the screen at all.

Each column has its own brightness setting, so the two can be balanced against the screen independently (section 14.3, CONTROLLER → DISPLAY).

### NOTE

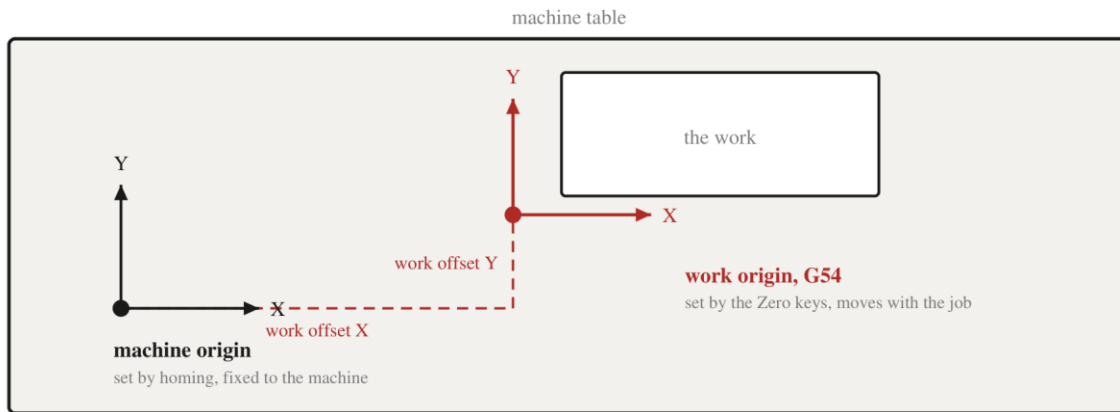
During a controller firmware update the eight LEDs stop showing jog state and become the update's progress display (section 20.1, Controller Firmware). This is the only time they mean anything else.

# Chapter 7 — Coordinates and Work Offsets

A program is written in coordinates that mean nothing until the machine knows where the work sits. This chapter covers the two coordinate systems the controller keeps, how to tell it where the work is, and how tool length is accounted for. Read it before cutting anything; the rest of the manual assumes it.

## 7.1 The Two Coordinate Systems

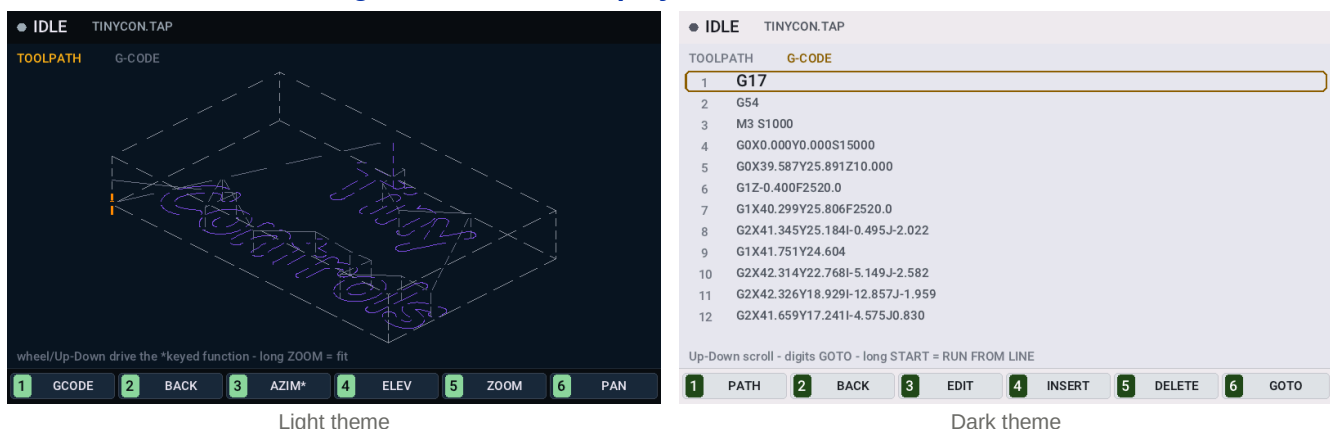
**Figure 7.1 — Machine Origin and Work Origin**



A program is written in work coordinates. The controller adds the work offset to reach machine coordinates.

Machine coordinates are fixed to the machine and only mean anything after the axis is referenced. Work coordinates are what the program is written in. WCS-T toggles the display between them; it always shows which one is displayed.

**Figure 7.2 — The Display in Machine Coordinates**



WCS-T has been pressed here, so the axis cards read machine coordinates rather than work. The MACH badge at the top right is the only difference on the screen, and it is there because the two readings are indistinguishable by their numbers alone — a datum set while the display reads machine coordinates lands somewhere the program was never written for. Check the badge before touching off. The displayed work coordinate is the machine coordinate minus the active work offset, and nothing else:

$$\text{work coordinate} = \text{machine coordinate} - \text{G54..G59 offset}$$

The parser applies further frame shifts to a program or MDI line as it commands a move — not to the displayed position:

```
commanded position = word + G54..G59 offset
                      + G92 offset
                      + G52 local offset
                      + tool length offset (G43, Z only)
```

Both frames agree whenever G92, G52 and G43 are clear, which is the normal case. When one is active they do not: the display keeps reading against the work offset alone while the program cuts at the shifted position. That matters most for touch-off — probe the work datum with G49 in force (section 15.1, Probing — G38).

#### CAUTION

Coordinate range is  $\pm 16,777.216$  mm. Positions are held in single precision: three decimals are exact out to that figure, and beyond it the third decimal is what goes. A typed datum past the limit is clamped, with the limit shown, rather than silently rounding to a value that reads back differently (Appendix B, B.5, Coordinate Precision).

## 7.2 Work Offsets G54–G59

Press WCS to open the picker. The active system is filled, the selection is ringed. OK selects the system; a long press on OK selects it and rapids to its zero.

#### NOTE

Changing the work system re-parses a loaded program that names its own G54–G59. A file's coordinates are resolved into the frame that was active when it was loaded, so switching frames afterwards would leave that shift stale — the file is re-read instead. A file that names no frame is unaffected.

The offsets live on the SD card and survive power-off.

## 7.3 Setting Work Zero

With the tool where zero should be, press the axis's Zero key. That axis's work offset is set so the display reads zero at the current position. Long-press the same key instead to type an exact value — the short zero is then skipped, so a long press never does both.

## 7.4 Tool Offsets

G43 Hn applies tool n's length offset to Z; G49 cancels it. The tool table lives in offsets.cfg on the card (section 2.2, Files on the Card). It is written three ways: by G10 L1 P<h> Z<v>, by hand on the TOOLING page, or by a probing macro's TOOLLEN verb (Appendix D, Macro Programming Reference).

#### NOTE

G43 shifts what the parser commands, not what the display shows (section 7.1, The Two Coordinate Systems). A work-zero probe run with G43 in force refuses, rather than file a number the display agrees with and the program does not.

## 7.5 Reset

MENU → SYSTEM → RESET offers two resets, each shown with its consequences before arming, and each needing a second confirmation.

| Reset                | Does                                                                                                                                                                                            |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RESET COORDINATES    | Declares the current position machine zero and clears G54–G59. Tool table, settings and PIN are kept. For a machine with no home switches, where there is no other way to get a defined origin. |
| RESET ALL TO FACTORY | Returns every setting to shipped defaults — axes, homing, I/O map, key assignments, tool table, stock — wipes coordinates and the stored reference point, and resets the menu PIN to 123456.    |

### CAUTION

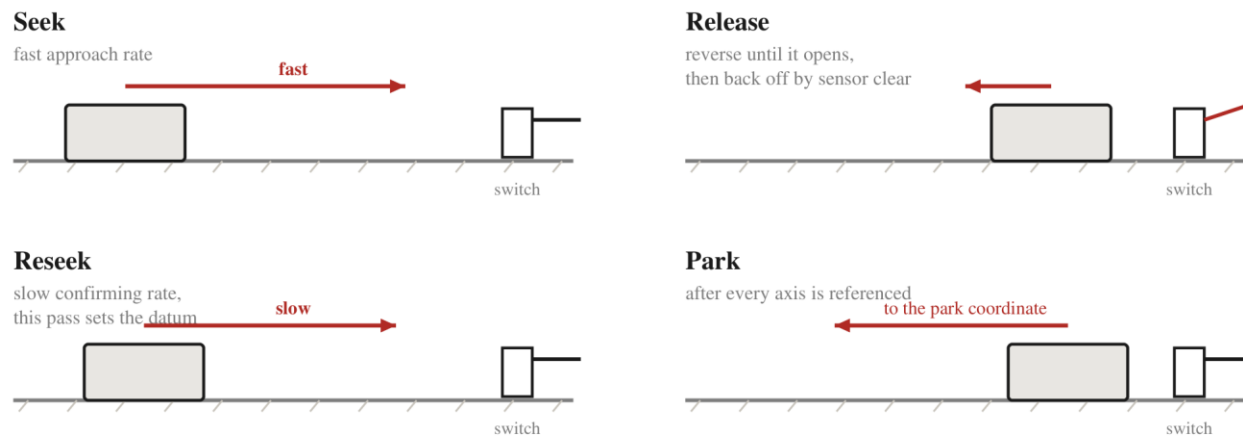
Re-home after a factory reset. The machine's idea of its own geometry is back to the defaults.

## Chapter 8 — Referencing and Homing

Referencing is how the machine learns where it is. Until an axis is referenced its position readout is a guess and its soft limits do not exist, so this is the first thing done after every power-up. The chapter covers the homing cycle, what each setting in it does, machines without switches, and the reference point.

### 8.1 The Homing Cycle

**Figure 8.1 — The Homing Cycle**



The datum is stamped at the end of the reseek, with the axis at a standstill and clear of the switch.

Park runs once for the whole machine, not once per axis.

Per axis, in homing-sequence order — axes sharing a sequence number run as a group:

1. Pre-check. The switch is read before any motion. If already made, the axis releases it first rather than seeking.
2. Seek toward the switch at the fast approach rate.
3. Release — reverse until the switch actually opens, then back off by the sensor-clear margin.
4. Reseek at the slower confirming rate.
5. Release again, then stop. The datum is stamped once the axis is at a standstill, clear of the switch.
6. Park, after the whole cycle, not per axis. Once every axis in the sequence is referenced, X, Y and the 4th axis travel to their park coordinates together in one referenced rapid, and Z parks last, alone, since its park is the one that can bring the tool back down into the work envelope.

#### NOTE

Soft limits are suspended for the whole homing cycle — switches legitimately sit at or beyond the soft travel range. The cycle's own overtravel guards bound the motion instead, and soft limits re-engage the moment the cycle ends.

## 8.2 Homing Settings

| Setting                  | Meaning                                                                             |
|--------------------------|-------------------------------------------------------------------------------------|
| Home axis in cycle       | Enables that axis for the homing cycle.                                             |
| Seek direction           | Direction, not switch polarity — polarity is set on the MAPPING page.               |
| Switch coordinate        | Machine coordinate the axis reads when the cycle datums it.                         |
| Park coordinate          | Machine coordinate the axis moves to once every axis in its sequence is referenced. |
| Homing sequence          | Ascending 1–4; equal numbers group and home together.                               |
| Approach rate (fast)     | The first seek.                                                                     |
| Confirm rate (slow)      | The reseek and every release.                                                       |
| Sensor clear             | Back-off margin after release, all axes.                                            |
| Z safe                   | Work-frame height to lift Z to before homing X/Y, capped to the Z ceiling (below).  |
| Lift Z before homing X/Y | Splices the Z-safe lift in immediately after Z's own homing step.                   |
| GZ lift enable           | Go Zero lifts to Z-safe first.                                                      |
| Abort retract            | On Stop, rapid Z to safe height.                                                    |

### CAUTION

The Z-safe lift is only inserted immediately after Z's own homing entry. It does nothing when another axis is sequenced before Z, when Z shares its sequence number with another axis, when nothing is sequenced after Z, or when Z homing is disabled entirely. The fix is almost always to give Z the lowest sequence number.

### NOTE

Z safe is read in the active work system, not machine coordinates — it means "this far above work zero". The converted target is then clamped to the Z ceiling: the axis's configured top of travel, and, when Z seeks toward the switch from above, one sensor-clear margin below the switch. An axis is never commanded back through the switch that referenced it.

## 8.3 Referencing Without Switches

Long-press Homing to arm in-situ reference for every axis, then press Homing again to confirm. Every axis is declared referenced where it stands. Use this on a machine with no switches, or to re-establish reference after a recovery where the machine has been positioned by hand.

Axes with homing disabled are referenced in place automatically at the start of a homing cycle, so a mixed machine — switches on some axes, none on others — works without extra steps.

## 8.4 Overtravel

---

Between the switch tripping and the axis stopping there is latency, debounce, queued motion and deceleration. At the shipped 2000 mm/min first seek expect roughly 6 mm of overtravel; the fine reseek at 500 mm/min is around 1 mm, and that is the pass that sets the datum. If the first hit is hard enough to skip steps, lower the approach rate — deceleration distance scales with the square of velocity.

## 8.5 Shared Switches

---

If two axes are mapped to the same physical input, they are homed one at a time rather than as a group, regardless of their sequence numbers — otherwise each would see the other's trip.

## 8.6 Global Reference Point

---

Available on F3 when assigned to REF POINT:

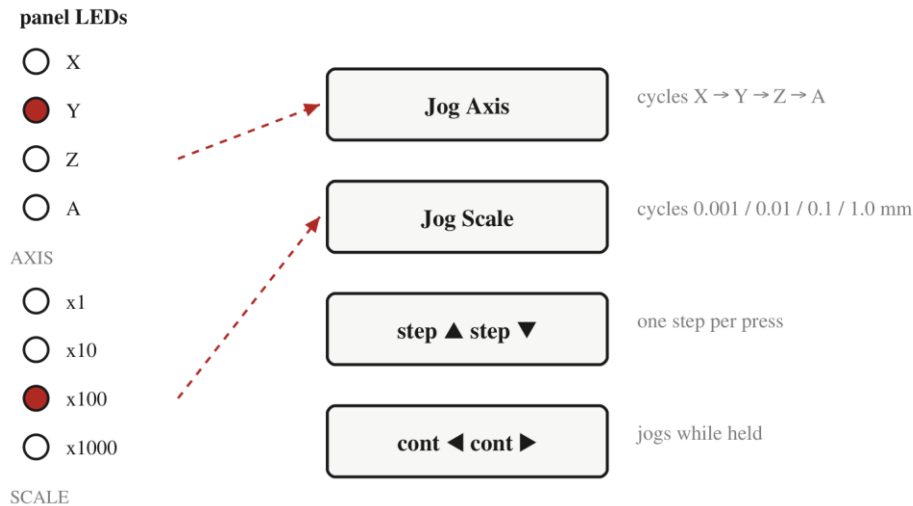
- SET REFERENCE HERE — store the current machine position.
- GO TO REFERENCE — rapid back to it, lifting to safe Z first.
- CLEAR REFERENCE.

The point survives power-off. It is the intended way to mark a known position before an operation that might lose reference.

## Chapter 9 — Jogging

Moving an axis by hand, from the panel keys or the handwheel. Jogging puts the tool where zero should be before you press a Zero key, and backs an axis off a tripped switch. It is also how you confirm an axis moves the distance and direction you expect.

**Figure 9.1 — The Jog Keys**



The lit LED in each column is the armed axis and the selected step size — the same pair the STATUS panel shows as JOG STEP.

1. Press JOG or Jog Axis to arm jogging. The softkey shows it is armed, and the last axis used is remembered.
2. Jog Axis cycles  $X \rightarrow Y \rightarrow Z \rightarrow A$ .
3. Jog Scale cycles 0.001 / 0.01 / 0.1 / 1.0 mm per step.
4. Step up / step down, or the encoder wheel, moves one step.
5. Continuous left / right jogs continuously while held.
6. F4 sets the continuous jog velocity in units per minute. It is also shown in the status line.

### NOTE

Continuous jog velocity is capped by the axis's own maximum rate, so asking for more than the axis can do gives the axis maximum, not an error.

### NOTE

The handwheel follows the crank rate directly rather than sprinting and braking per detent: a steady crank rolls the axis at exactly the crank rate, and stopping the wheel decays speed to an exact landing. The feel is adjustable in CONTROLLER config — smaller values feel tighter, larger values feel smoother.

## Chapter 10 — Files

Press File, or Menu and navigate, to reach the file browser. It is a two-pane view: SD on the left, USB on the right.

| Key             | Action                             |
|-----------------|------------------------------------|
| cont ← / cont → | Move between the SD and USB panes. |
| F3              | Copy SD → USB.                     |
| F4              | Copy USB → SD.                     |
| F5              | Delete (press again to confirm).   |
| OK              | Load the selected program.         |
| Up/Down, wheel  | Navigate.                          |

### NOTE

Long file names are supported to 96 characters. A file that cannot be opened is never listed — if it is visible, it can be opened. Copying a large file shows a progress bar and keeps the panel responsive.

### 10.1 Loading a Program

Loading jumps straight to the toolpath preview. For a file that is not runnable, the view opens on the text tab instead.

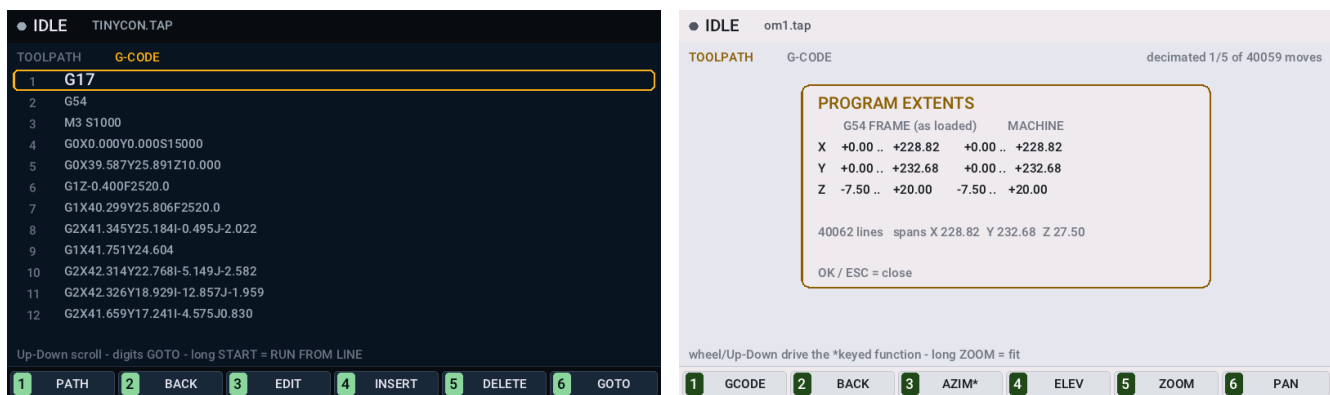
### NOTE

Very large programs load in reduced tiers, dropping editing and then modal-state detail as size demands, down to a scan-only tier that still gives a toolpath and line count. The tier in use is shown during the load.

### 10.2 Viewing and Editing

The view screen has two tabs. Toolpath is a 3D preview — F5 zooms, a long press on F5 fits the whole path, and the camera is nudged with the wheel. Text shows the program source, with an editor when the load tier allows it, and F6 arms a jump to a line number.

**Figure 10.1 — The Toolpath Tab**

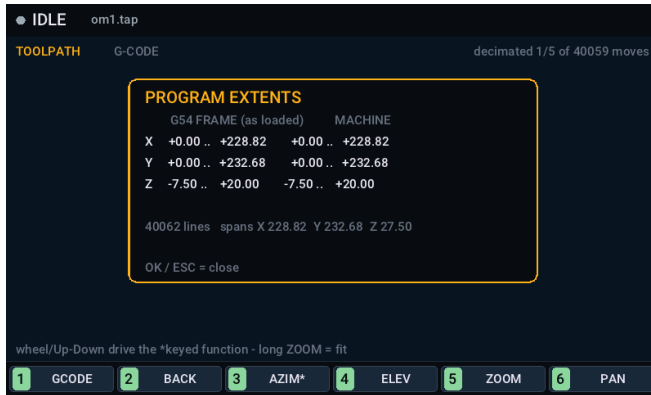


Light theme

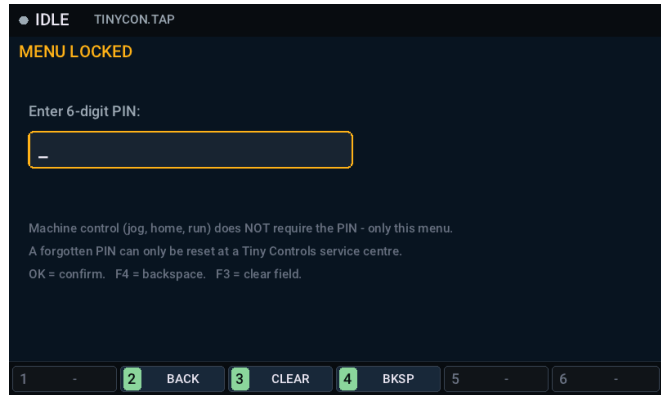
Dark theme

The path is drawn inside a wireframe box standing for the stock, so a program that overruns the material is visible before anything moves. Cutting moves and rapids are drawn differently, which is what makes a missing retract obvious at a glance. The cross marks the tool, drawn large and in a contrasting colour so it stays findable in a dense path. The softkeys select what the wheel adjusts — azimuth, elevation, zoom, pan — and the asterisk marks the one it is driving now.

**Figure 10.2 — The G-Code Tab**



Light theme



Dark theme

The same program as text, numbered by line, with the centred line boxed. F3 edits that line, F4 inserts a blank one after it, F5 deletes it, and F6 jumps to a line number — becoming SAVE once anything has changed.

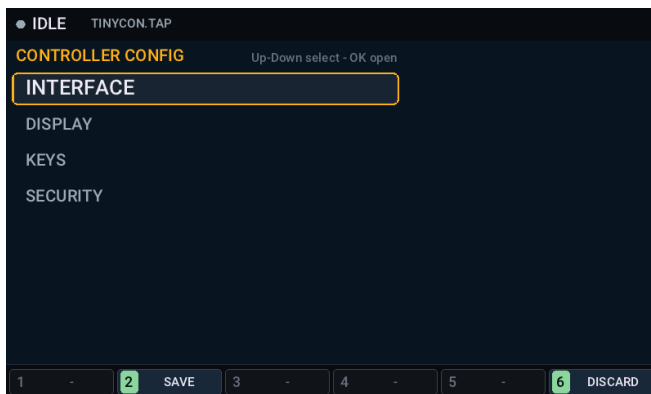
#### CAUTION

Starting mid-program takes the modal state — tool, spindle, offsets, plane — from a scan of every line above the start point, not from having executed them. The panel warns and waits for a confirmation before it will go (section 11.3, Run From Line).

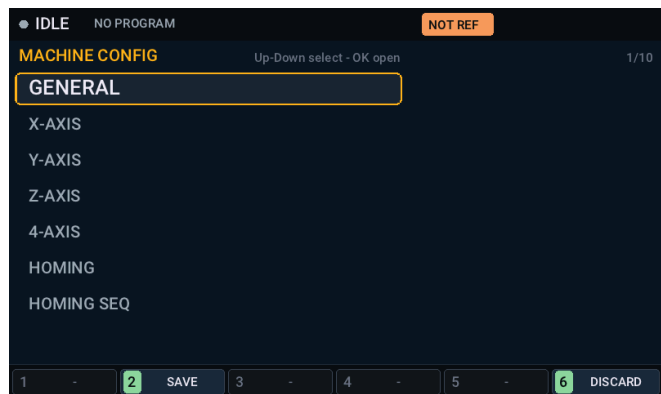
## 10.3 Program Extents

From the toolpath tab, the extents panel reports how far the loaded program actually reaches.

**Figure 10.3 — Program Extents**



Light theme



Dark theme

Minimum and maximum are given per axis in two frames side by side: the G54 frame the file was loaded against, and the machine frame the axes actually move in. Below them is the line count and the span in each axis. Reading the machine column against the travel set in MACHINE is the check worth doing before a first run — a program that fits the table in the work frame can still reach past a soft limit once the work offset is applied.

**NOTE**

The extents are those of the program as loaded. Changing the work offset afterwards moves where the program will actually cut without changing the G54 column.

## Chapter 11 — Running a Program

Starting, holding and stopping a run, and the controls that change one already in progress. Load the file and set the work offset first; Chapter 10 and Chapter 7 cover those.

**Figure 11.1 — A Program Running**

● IDLE NO PROGRAM NOT REF

**MACHINE CONFIG** OK edit - digits type 1/8

| X-AXIS | Steps per mm       | 200    |
|--------|--------------------|--------|
|        | Max rate mm/min    | 3000   |
|        | Accel mm/s2        | 300    |
|        | Travel min mm      | 0      |
|        | Travel max mm      | 300    |
|        | Invert direction   | NORMAL |
|        | Flip jog direction | NORMAL |
|        | Backlash mm        | 0      |

range 1 .. 100000

1 - 2 SAVE 3 - 4 - 5 - 6 DISCARD

Running, the screen keeps the same layout it has when idle. The state word reads RUN and the positions track the motion. STATUS fills in: FEED shows the commanded rate against the programmed one, with the override percentage beside it. SPIN does the same for the spindle. LINE counts through the file, and TIME gives elapsed against estimate. The EXEC strip carries the block currently executing.

### 11.1 Start, Hold, Stop

| Key             | Action                                                                                        |
|-----------------|-----------------------------------------------------------------------------------------------|
| Start           | Begin the loaded program, or resume from hold.                                                |
| Pause           | Feed hold — decelerate and stop, keeping program position.                                    |
| Stop            | Abort — decelerates first (below); rapids Z to safe height afterwards if abort retract is on. |
| F3 (while HOLD) | Reverse back along the toolpath.                                                              |

### WARNING

Every stop from Stop or ESC decelerates the machine at its configured acceleration before it aborts. An instant stop from feed or rapid would ask the motors to go from full speed to nothing in one step pulse — they cannot follow that, so they slip, and the position readout would stay confident while the machine no longer is where it says it is. The only instant stops are E-STOP and a limit trip (section 1.3, Motion Safety).

On Start the machine travels from wherever it stands to the program's first point, in a fixed and safe order. Z lifts first. Then X, Y and the 4th axis traverse. Z comes down last, at the first move's own rapid or feed and never faster.

The height Z lifts to is taken from the file itself: its highest programmed Z, never below where Z already is, and clamped at machine zero. The plan begins at the file's first commanded coordinates rather than at work zero, and an axis the program never mentions does not move at all.

### CAUTION

Two kinds of file keep the older, more conservative Z behaviour: one whose very first Z action is a downward cut with no clearance move above it, and one whose first Z appears inside a helix. For those, command a clearance height as the file's first Z move — which good post-processors do anyway.

The approach belongs to Start alone. MDI lines, macro moves and the calibration move are always literal: G0 Z-5 goes to Z-5 and nothing else, from wherever the machine stands. Run-from-line has its own identical entry sequence (section 11.3, Run From Line).

## 11.1a Single-Block Mode

Block run makes the program stop at the end of every source line. One Start runs one line, then the machine holds; the next Start runs the next line. It is the mode for proving out a new program or fixture at the machine.

- Turn it on in MACHINE CONFIG → GENERAL, from an assignable key, or from a mapped input — all three set the same mode.
- Start is the step key; there is no separate step key or input.

An amber BLK RUN chip appears in the STATE panel while the mode is on, so a program that stops every line never looks like a machine that keeps stalling.

One line means one line, however many moves it expands into: an arc's segments and the Start approach legs belong to their own line and run as one step. A line with no motion — an M-code or a comment — is not a step of its own. It takes effect with the next moving line.

### CAUTION

Every line boundary becomes an exact stop while the mode is on, so the tool stops on each line's end point rather than carrying speed through it. A contoured path run this way is stopped at every one of its points — expect witness marks if it is done in the cut. Switching the mode on mid-run is legitimate; the machine decelerates into the first boundary it reaches, and may pass a few tenths beyond it because that corner was planned to carry speed.

## 11.2 Overrides

Feed-O, Rapid-O and Spin-O each open a numeric entry and OK applies it. The values are percentages; ESC closes the entry without applying anything. They work from the toolpath view as well, which is exactly when trimming feed is wanted. Pressing one there switches the panel to the main screen to show the entry, because the number pad lives there.

**NOTE**

Fixed feed and fixed rapid are not overrides. A non-zero value replaces the programmed rate outright rather than scaling it — they are forces, not ceilings (section 14.2, CONTROLLER → INTERFACE). Useful while proving a machine; left set, they present as a program cutting at the wrong speed with no bad number in the G-code.

## 11.3 Run From Line

A long press on Start opens the line-number entry. Type the line number and press OK to arm running from it. The panel warns and waits for confirmation, because starting mid-program means the modal state — tool, spindle, offsets, plane — is taken from a scan of everything above that line rather than from having actually executed it. Press Start to go.

## 11.4 Z-Inhibit — Running the Path in the Air

The program runs without moving Z. Z is held where it stands; X, Y and the 4th axis follow the program at programmed rate.

**CAUTION**

Z is held at whatever height it is at when the run starts. Raise Z clear of the work first; the machine will otherwise trace the entire program at that height.

## 11.5 Optional Stop and Tool Change

When optional stop is on, M1 stops the program. Tool change (M6) behaves per setting: ignore, pause and wait for Start, or run the tool-change macro.

## Chapter 12 — MDI

F5 on the main screen opens MDI. Type a G-code block and press OK to execute it. MDI blocks are modal in the same way a program is.

MDI is refused unless the machine is idle.

### WARNING

A feed move needs a feed. G1, G2, G3 and canned-cycle points with no F in effect are refused rather than run — the planner treats F=0 as no feed limit, so such a move would execute at the axis's full rapid rate. The same rule applies at program load and inside macros.

### NOTE

MDI's modal state is separate from a macro's. A macro runs in its own modal context, re-initialised on every run: a hand-typed F, G91 or tool offset survives any macro untouched, and nothing a macro sets leaks back.

## Chapter 13 — Menus

Menu (F1 from the main screen) opens the settings tree. If a menu PIN is enabled (section 13.2, The Menu PIN and the SECURITY Page) the PIN prompt appears first; once entered, the menu stays unlocked until the next power-up.

**Figure 13.1 — The Menu**

● IDLE NO PROGRAM NOT REF

**MACHINE CONFIG** OK edit - digits type 1/8

| Y-AXIS | Steps per mm       | 200    |
|--------|--------------------|--------|
|        | Max rate mm/min    | 3000   |
|        | Accel mm/s²        | 300    |
|        | Travel min mm      | 0      |
|        | Travel max mm      | 200    |
|        | Invert direction   | NORMAL |
|        | Flip jog direction | NORMAL |
|        | Backlash mm        | 0      |

range 1 .. 100000

1 - 2 SAVE 3 - 4 - 5 - 6 DISCARD

Five entries, in the order the panel lists them. CONTROLLER and MACHINE hold the settings; MACROS runs a script from the card; MAPPING assigns the I/O; SYSTEM carries the information and service pages. What each one covers is in section 14.1, How the Menu Is Organised.

### 13.1 Navigation and Editing

Wheel or Up/Down to select, OK to open, ESC to go back one level, F6 to close to the main screen.

- Numeric values open an entry box. Type, then OK.
- Boolean and small enum values toggle on OK with meaningful labels, rather than a bare 0 or 1.
- Edits are held in memory until the page is saved. ESC or F2 walks back page, then group, then menu, saving on the way out.

#### NOTE

A machine action taken without passing through that save chain uses the live values but leaves the card unchanged, so the next reboot reloads the old file. Settings that do not apply to the current configuration are hidden rather than greyed out.

## 13.2 The Menu PIN and the SECURITY Page

The menu can be protected by a six-digit PIN, default 123456. Machine control — jog, home, run, MDI — never requires the PIN; it gates settings only, so a forgotten PIN is a service call, not a stopped machine.

### NOTE

A forgotten PIN can only be reset at a Tiny Controls service centre — record the PIN before changing it. Five wrong attempts lock the prompt for 60 seconds, doubling on repeat.

**Figure 13.2 — The PIN Prompt**

● IDLE NO PROGRAM NOT REF

**MACHINE CONFIG** OK edit - digits type 1/8

| Z-AXIS             | Steps per mm | 200    |
|--------------------|--------------|--------|
| Max rate mm/min    |              | 1500   |
| Accel mm/s2        |              | 150    |
| Travel min mm      |              | -100   |
| Travel max mm      |              | 0      |
| Invert direction   |              | NORMAL |
| Flip jog direction |              | NORMAL |
| Backlash mm        |              | 0      |

range 1 .. 100000

1 - 2 SAVE 3 - 4 - 5 - 6 DISCARD

The prompt states its own limits, so an operator who meets it locked out is told there and then why machine control still works.

CONTROLLER → SECURITY carries two things. CHANGE PIN, on F3, takes the new PIN twice — OK confirms, F4 backspaces, F3 clears the field. Below it is this controller's device ID, in the form XXXX-XXXX-C: a short, check-summed identifier for the unit. Quote it when contacting Tiny Controls support. It appears on the ABOUT page as well.

### NOTE

Nothing on this controller is licensed or time-limited. There is no licence code, no expiry and no clock to set, and the controller never refuses to run a program for a commercial reason — a program is refused only for machine reasons: not referenced, a file that is not a program, a move past the soft limits.

## 13.3 Settings Are Idle-Only

A setting commits into the running machine the moment it is confirmed, so editing is refused unless the machine is idle. Reading any page, and everything under System — diagnostics, live pins, limit override, about, help — is never blocked, because those are what is needed while something is wrong.

### NOTE

Display settings — brightness and contrast — are the one editable exception, since none of it can move an axis. Settings that only take effect at parse time, such as motion mode, re-parse a loaded program when they change, because being idle is not enough when the program in memory was parsed with the old value.

# Chapter 14 — Settings Reference

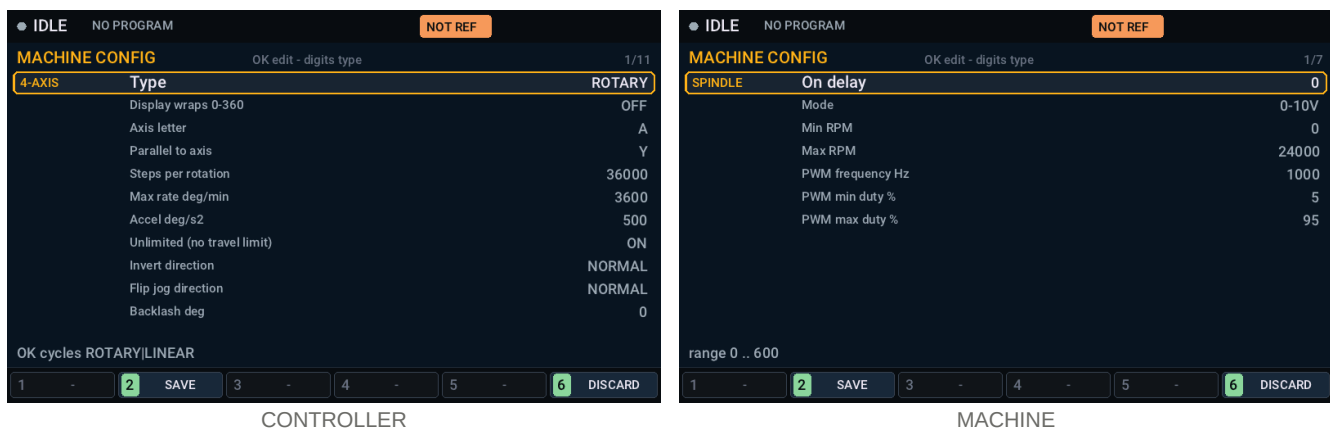
Ranges are enforced by the controller — a value outside the range shown in Appendix C, Complete Settings Menu Tree, is refused, not clamped, at the point of entry unless stated otherwise.

## 14.1 How the Menu Is Organised

MENU is PIN-gated and holds five entries. Two of them, CONTROLLER and MACHINE, hold the settings, in groups; the other three are not settings at all. A hundred and fifteen fields are settable in all — twenty-one under CONTROLLER and ninety-four under MACHINE — plus the I/O assignments under MAPPING, which vary with how many functions are in use.

| Entry      | What it holds                                                                                                                                                                | Groups |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| CONTROLLER | How this unit behaves — screen, pendant and the assignable keys, plus the security page. Nothing here depends on the machine it drives.                                      | 4      |
| MACHINE    | What the machine is — axis scaling and travel, homing, limits, spindle and tool zero. Every field is a fact about the mechanics, and a wrong one is a wrong part or a crash. | 8      |
| MACROS     | A picker for the .mac files on the card. No settings.                                                                                                                        | —      |
| MAPPING    | Which pin each input and output function sits on, and its polarity — two rows per function, not a fixed list.                                                                | —      |
| SYSTEM     | Information and service pages: versions, help, diagnostics, the tuning wizards, pendant update and reset.                                                                    | —      |

**Figure 14.1 — The Two Settings Branches**



CONTROLLER holds four pages. Three carry settings; SECURITY carries the menu PIN and this controller's device ID rather than configurable values, and is described in section 13.2, The Menu PIN and the SECURITY Page.

| Group     | Covers                                                                                                                              | Fields |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------|--------|
| INTERFACE | Theme and accent, optional stop, tool-change behaviour, the fixed feed and rapid overrides, jog velocity and handwheel follow time. | 8      |
| DISPLAY   | Panel and pendant backlight, pendant contrast and ratio, and the axis                                                               | 6      |

| Group    | Covers                                                                                                                      | Fields |
|----------|-----------------------------------------------------------------------------------------------------------------------------|--------|
|          | and scale LED brightness.                                                                                                   |        |
| KEYS     | What each assignable key does. F3 chooses from its own list; the rest choose from the shared list or any macro on the card. | 7      |
| SECURITY | The menu PIN and the device ID. No configurable values.                                                                     | —      |

MACHINE holds eight groups:

| Group          | Covers                                                                                                                                                                                    | Fields |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| GENERAL        | Step pulse and direction timing, corner and arc tolerance, acceleration smoothing, the starting motion mode and single-block.                                                             | 7      |
| X / Y / Z-AXIS | One page per linear axis, identical rows: scaling, rate, acceleration, travel bounds, direction invert, jog flip, backlash.                                                               | 24     |
| 4-AXIS         | The same rows as a linear axis, plus the rotary or linear choice, its letter, the axis it parallels, rollover, continuous rotation and how F is measured.                                 | 14     |
| HOMING         | Per axis: whether it homes, which way it seeks, and its switch and park coordinates. Then the rates, debounce, sensor clearance and the Z-safe and retract behaviour shared by the cycle. | 25     |
| HOMING SEQ     | The order the axes home in; equal numbers home together.                                                                                                                                  | 4      |
| LIMITS         | Whether hard limits and soft limits are armed.                                                                                                                                            | 2      |
| SPINDLE        | Spin-up delay, the drive mode, the RPM range, the PWM frequency and duty span it maps onto, and the two rows a STEP spindle adds.                                                         | 9      |
| TOOL ZERO      | The sensor height, the approach and retract distances and rates, and the optional fixed setter position.                                                                                  | 9      |

The rest of this chapter walks the menu as the panel presents it: one section per page, in menu order, with every field on that page and what it does. Ranges and shipped values are not repeated here — they are in Appendix C, Complete Settings Menu Tree, which is the page to consult at the machine.

#### NOTE

Fields are named here exactly as the panel labels them, so that a row in this chapter and a row on the screen read the same. Appendix C lists the same fields by their configuration-file key instead, because that is what appears in the files on the card. The order is identical in both, so a field is found in one from its position in the other.

## 14.2 CONTROLLER → INTERFACE

Figure 14.2 — CONTROLLER → INTERFACE

● IDLE
NO PROGRAM
NOT REF

MACHINE CONFIG
OK edit - digits type
1/9

|           |                            |     |
|-----------|----------------------------|-----|
| TOOL ZERO | Sensor height              | 20  |
|           | Back-off between passes mm | 2   |
|           | Max probe travel mm        | 50  |
|           | Approach FAST mm/min       | 100 |
|           | Confirm SLOW mm/min        | 20  |
|           | Final retract mm           | 50  |
|           | Use pos                    | OFF |
|           | Setter x                   | 0   |
|           | Setter y                   | 0   |

range -100000 .. 100000

1 -
2 SAVE
3 -
4 -
5 -
6 DISCARD

| Field                | What it does                                                                                                      |
|----------------------|-------------------------------------------------------------------------------------------------------------------|
| Theme                | Dark or light screen. Display appearance only.                                                                    |
| Accent color         | Highlight colour used for the active selection and the run state.                                                 |
| M1 optional stop     | Whether M1 is honoured (section 11.5, Optional Stop and Tool Change).                                             |
| M6 tool change       | What M6 does: ignore it, pause for a manual change, or run a macro.                                               |
| Fixed feed mm/min    | Forces every feed move to this rate, overriding the programmed one. 0 is off.                                     |
| Fixed rapid mm/min   | Forces rapid velocity the same way. 0 is off.                                                                     |
| Key jog speed mm/min | Speed of a held-key continuous jog. A step jog uses the jog scale instead.                                        |
| Wheel follow time s  | How long the machine keeps following the handwheel after it stops turning — the feel of the wheel, not its scale. |

## 14.3 CONTROLLER → DISPLAY

Figure 14.3 — CONTROLLER → DISPLAY

● IDLE NO PROGRAM NOT REF

MACROS - SD:/macros

toolchange.mac

park.mac

safecheck.mac

airblast.mac

atc6.mac

toolzero.mac

workzero.mac

refset.mac

OK runs (IDLE) - Start resumes prompts - ESC aborts

1 - 2 BACK 3 - 4 - 5 - 6 CLOSE

| Field                  | What it does                                                                                                                               |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| LCD backlight %        | Panel backlight.                                                                                                                           |
| Pendant backlight %    | Pendant backlight.                                                                                                                         |
| Pend contrast          | Pendant contrast. Pendant V2 only, and -1 leaves the pendant's own default — the safe value, since a wrong contrast can blank the display. |
| Pend ratio             | Pendant contrast ratio. Pendant V2 only, and read only when contrast is set.                                                               |
| Axis LED brightness %  | Brightness of the axis LEDs.                                                                                                               |
| Scale LED brightness % | Brightness of the jog-scale LEDs.                                                                                                          |

## 14.4 CONTROLLER → KEYS

Figure 14.4 — CONTROLLER → KEYS

| ● IDLE NO PROGRAM                                                           |           | NOT REF                                        |     |
|-----------------------------------------------------------------------------|-----------|------------------------------------------------|-----|
| <b>I/O MAPPING</b>                                                          |           | Up-Down cell - OK edit - F3 or -1 clears a pin |     |
| 1/26                                                                        |           |                                                |     |
| FUNCTION                                                                    | SAVED     | PIN                                            | POL |
| IN HOME X                                                                   | IN7       | IN7                                            | NO  |
| IN HOME Y                                                                   | IN8       | IN8                                            | NO  |
| IN HOME Z                                                                   | IN9       | IN9                                            | NO  |
| IN HOME 4TH                                                                 | IN10      | IN10                                           | NO  |
| IN LIMIT X                                                                  | IN11      | IN11                                           | NO  |
| IN LIMIT Y                                                                  | IN11      | IN11                                           | NO  |
| IN LIMIT Z                                                                  | IN11      | IN11                                           | NO  |
| IN LIMIT 4TH                                                                | IN11      | IN11                                           | NO  |
| IN PROBE                                                                    | IN13      | IN13                                           | NO  |
| IN EXT E-STOP                                                               | IN12      | IN12                                           | NO  |
| IN CYCLE START                                                              | IN14      | IN14                                           | NO  |
| AMBER rows share a pin with another row - may be intentional, worth a look. |           |                                                |     |
| 1 -                                                                         | 2 SAVE    | 3 CLEAR                                        | 4 - |
| 5 -                                                                         | 6 DISCARD |                                                |     |

Seven slots are assigned here, across five keys that have no fixed job on the main screen: F3, Space and its long press, Resume and its long press, the Go-zero long press, and DryRun. Each cycles through the internal functions plus every .mac file on the card, shown by filename so a script and a built-in function stay visually distinct. The internal functions: NONE, OPT STOP (toggle M1), GO REF / SET REF (the reference point), RUN MAC (open the macro picker without the menu PIN), BLOCK RUN (toggle single-block mode).

| Field              | Fires on                                                                                                                                                                                |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| F3 key action      | F3. Chooses from its own list — NONE, OPT STOP, PARK, AIRBLAST, SAFECHECK, REF POINT, RUN MAC — and takes no macro directly; reach one through RUN MAC.                                 |
| Space key          | A Space press.                                                                                                                                                                          |
| Space long-press   | Space held past the long-press threshold.                                                                                                                                               |
| Resume key         | A Resume press. Start has always resumed from hold, so this key is free.                                                                                                                |
| Resume long-press  | Resume held.                                                                                                                                                                            |
| Go-zero long-press | Go-zero held. A short press stays the built-in GO ZERO.                                                                                                                                 |
| DryRun key         | Nothing. The key is retired — a press prints DRY-RUN retired - reserved for TEACH and returns, whatever this row is set to. The row is kept so existing configuration files still load. |

**NOTE**

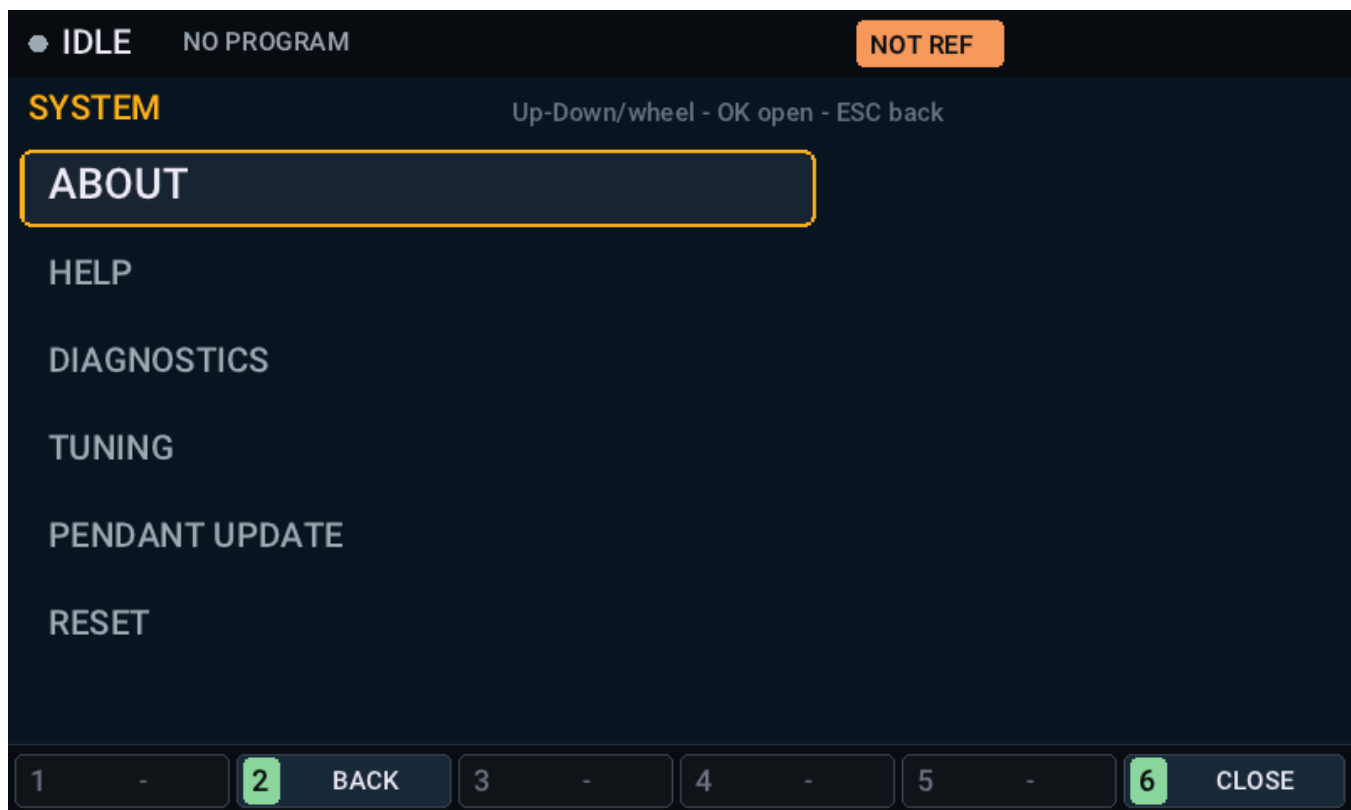
An assignment is stored by filename, never by position in the list, so adding or deleting macros cannot silently re-point a key. A key naming a file that is no longer on the card behaves as NONE until the file returns.

**NOTE**

An unassigned long-press falls back to the short press's action, so a press held slightly too long never becomes a dead key.

## 14.5 CONTROLLER → SECURITY

**Figure 14.5 — CONTROLLER → SECURITY**



The menu PIN and this controller's device ID. No configurable values (section 13.2, The Menu PIN and the SECURITY Page).

## 14.6 MACHINE → GENERAL

Figure 14.6 — MACHINE → GENERAL

● IDLE NO PROGRAM
NOT REF

### ABOUT

## TNC-M34 CNC CONTROLLER v1.0

Tiny Controls Private Limited

BUILD Sep 11 2026 10:54:07

PENDANT: NONE (ENCODER-ONLY IS OK)

CONFIG 4 Axes + 16 IN + 16 OUT

HARDWARE v1.3 (Pendant)

DEVICE 3MH5-XHBD-K

1 -

2 BACK

3 -

4 -

5 -

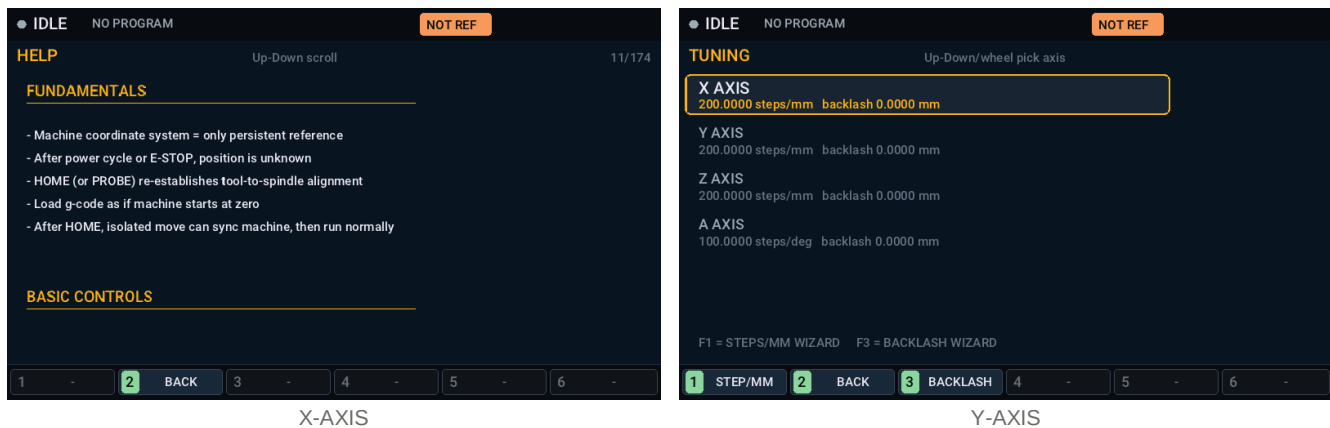
6 -

| Field                 | What it does                                                                                                                                                                                 |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step pulse width us   | Step pulse width. Clamped to half the shortest step period the axes can demand, so a wide pulse on a fast machine is narrowed rather than obeyed (Appendix B, B.3, Step Pulse Width).        |
| Dir setup us (0=auto) | Direction setup time — how long the direction line is stable before the first step. It only acts when it asks for more than the interval already provides, and only on a move that reverses. |
| Corner tolerance mm   | Corner tolerance: how far the path may deviate at a corner to carry speed through it.                                                                                                        |
| Arc tolerance mm      | Arc chord tolerance: how finely an arc is broken into segments.                                                                                                                              |
| Smooth time           | Acceleration ramp time; 0 disables it. Bounding the torque step protects a stepper from stalling on ramp starts and corners, and usually lets the configured acceleration be raised.         |
| Motion mode           | The blending mode a program starts in if it never sets one. A G61 or G64 in the file still wins from the line it appears on.                                                                 |
| Block run             | Single-block mode (section 11.1a, Single-Block Mode).                                                                                                                                        |

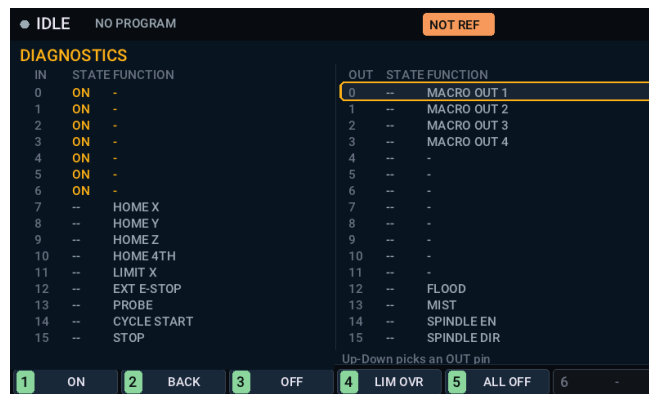
## 14.7 MACHINE → X-AXIS, Y-AXIS, Z-AXIS

Three pages, one per linear axis, carrying identical rows.

**Figure 14.7 — MACHINE → X-AXIS and Y-AXIS**



**Figure 14.7a — MACHINE → Z-AXIS**



| Field              | What it does                                                                                                                                                                                                                                |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Steps per mm       | Scaling: motor steps per millimetre of travel. Calculate it from the motor, driver and drive train (Appendix E, Calculating Steps per mm), set it by measurement, or let the tuning wizard measure it (Chapter 16, Diagnostics and Tuning). |
| Max rate mm/min    | Maximum rate for this axis. What the machine can actually deliver is bounded by the step-rate ceiling (Appendix B, B.1, Step Rate Ceiling).                                                                                                 |
| Accel mm/s2        | Acceleration for this axis.                                                                                                                                                                                                                 |
| Travel min mm      | Lower soft-limit bound, in machine coordinates.                                                                                                                                                                                             |
| Travel max mm      | Upper soft-limit bound, in machine coordinates.                                                                                                                                                                                             |
| Invert direction   | Reverses the direction output for this axis.                                                                                                                                                                                                |
| Flip jog direction | Reverses the jog keys for this axis only, leaving the direction output alone.                                                                                                                                                               |
| Backlash mm        | Lost motion taken up on reversal.                                                                                                                                                                                                           |

### WARNING

Setting Travel max at or below Travel min leaves the axis reading as unconfigured. The safe-Z ceiling then falls back to machine zero, and because every lift is skipped when Z already sits above its target, no lift happens at all — not on abort retract, not on GO ZERO, not on the approach into a program. The tool traverses at cutting depth.

## 14.8 MACHINE → 4-AXIS

Figure 14.8 — MACHINE → 4-AXIS

● IDLE

NO PROGRAM

NOT REF

PENDANT

LINK

NO PENDANT - OR ENCODER-ONLY

PENDANT FW

- (V1 pendants cannot report one)

BUNDLED FW

v2.0 (15432 bytes, in this controller)

F3 sends the bundled firmware to the pendant over RS485 (~20 s).

1 -

2 BACK

3 UPDATE

4 -

5 -

6 -

The same rows as a linear axis, read in degrees when the axis is rotary and in millimetres when it is linear, plus six of its own.

| Field               | What it does                                                                                                                                                                                                         |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Type                | Rotary or linear. Decides the units every other row on this page is read in.                                                                                                                                         |
| Display wraps 0-360 | Wraps the displayed position at 360 degrees. The underlying position is not reset mid-program, so a program winding through many turns is undisturbed.                                                               |
| Axis letter         | The word the axis answers to — A, B or C.                                                                                                                                                                            |
| Parallel to axis    | Which linear axis it runs parallel to, when it is linear.                                                                                                                                                            |
| Steps per rotation  | Scaling. On a rotary axis the panel asks for the steps in one full revolution; on a linear one it reads as steps per millimetre. Appendix C lists the same field by its configuration key, which is held per degree. |
| Max rate deg/min    | Maximum rate.                                                                                                                                                                                                        |

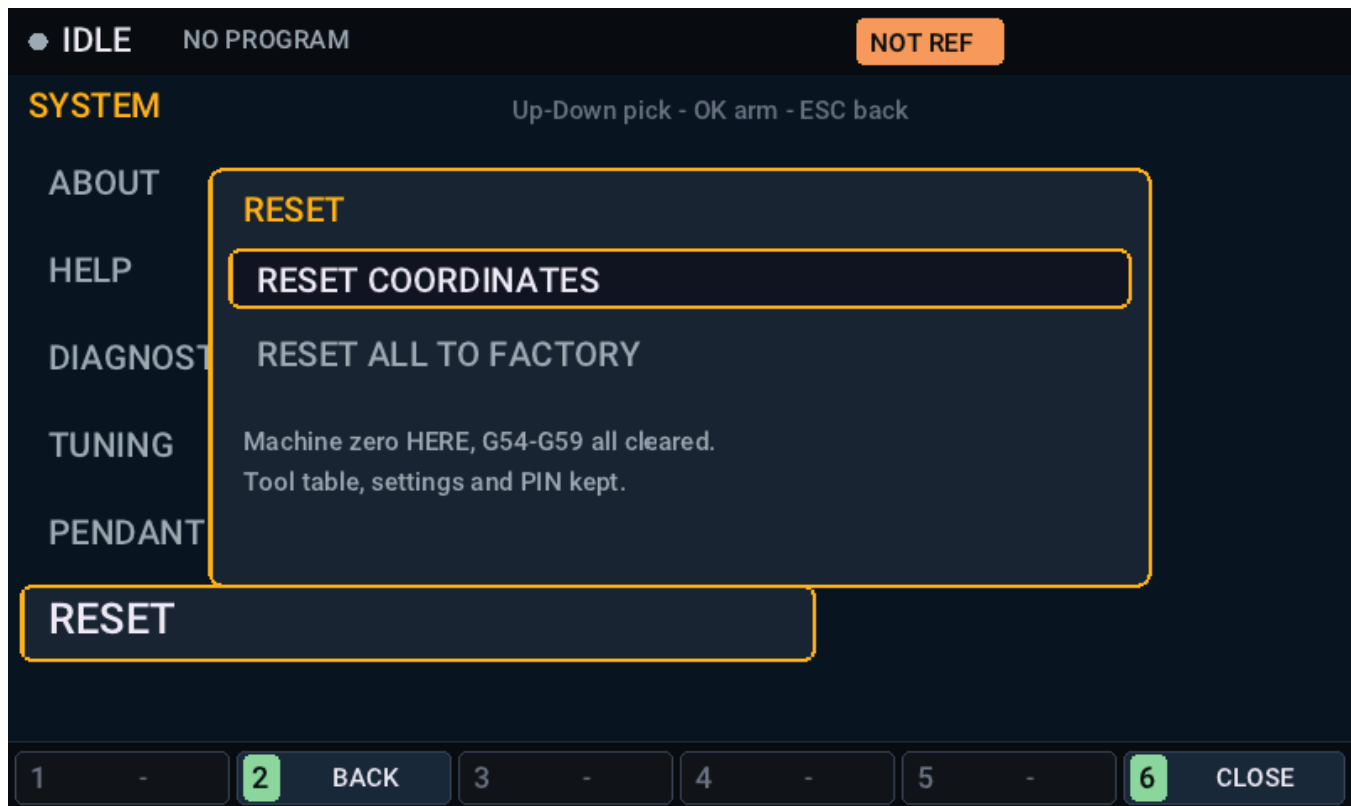
| Field                       | What it does                                                                                                                                                                                                                                                                     |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Accel deg/s <sup>2</sup>    | Acceleration.                                                                                                                                                                                                                                                                    |
| Unlimited (no travel limit) | Unlimited rotation. Soft limits and travel bounds do not apply.                                                                                                                                                                                                                  |
| Travel min deg              | Lower bound. Hidden while the axis rolls over or runs continuously, because it cannot apply.                                                                                                                                                                                     |
| Travel max deg              | Upper bound, on the same condition.                                                                                                                                                                                                                                              |
| Invert direction            | Reverses the direction output.                                                                                                                                                                                                                                                   |
| Flip jog direction          | Reverses the jog keys only.                                                                                                                                                                                                                                                      |
| Backlash deg                | Lost motion taken up on reversal.                                                                                                                                                                                                                                                |
| Feed counts 4th axis        | What F measures on a move that turns the 4th axis and moves X, Y or Z as well. Off, F is the speed along the X/Y/Z path and the 4th axis keeps pace. On, F is the speed along the whole X/Y/Z/4th vector, the degrees counting as length — the convention winding CAM posts for. |

#### NOTE

The difference is large, not cosmetic. Take a hoop pass of 422 mm of X and 100 turns of A at F 12060. With this off it asks for a two-second pass at 2,870 rpm, and the 4th axis maximum rate then caps it. With it on it asks for the three-minute, 33 rpm pass the CAM meant. A move on the 4th axis alone reads the same either way, as does G93 inverse time.

## 14.9 MACHINE → HOMING

Figure 14.9 — MACHINE → HOMING



Four rows for each axis, then nine the whole cycle shares. The per-axis rows repeat for X, Y, Z and the 4th axis.

| Per-axis field                        | What it does                                                                                                                       |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Home X / Y / Z / A in cycle (switch)  | Whether that axis homes in the cycle.                                                                                              |
| X / Y / Z / A seek direction          | Which way the axis seeks its switch. This is direction, not switch polarity — polarity is set in MAPPING (section 14.15, MAPPING). |
| X / Y / Z / A switch coord            | The machine coordinate the axis reads when the cycle datums it.                                                                    |
| X / Y / Z / A park coord (after home) | The machine coordinate the axis moves to once referenced.                                                                          |

### NOTE

No axis parks until every axis is homed. X, Y and the 4th axis then travel to their parks together in one rapid, and Z parks last and alone — its park is the one that can bring the tool back down into the envelope. A park behind the switch, or further out than the axis travel, is refused and named at that axis's own datum.

| Shared field  | What it does                                            |
|---------------|---------------------------------------------------------|
| Search cycles | How many times the cycle seeks and re-seeks the switch. |

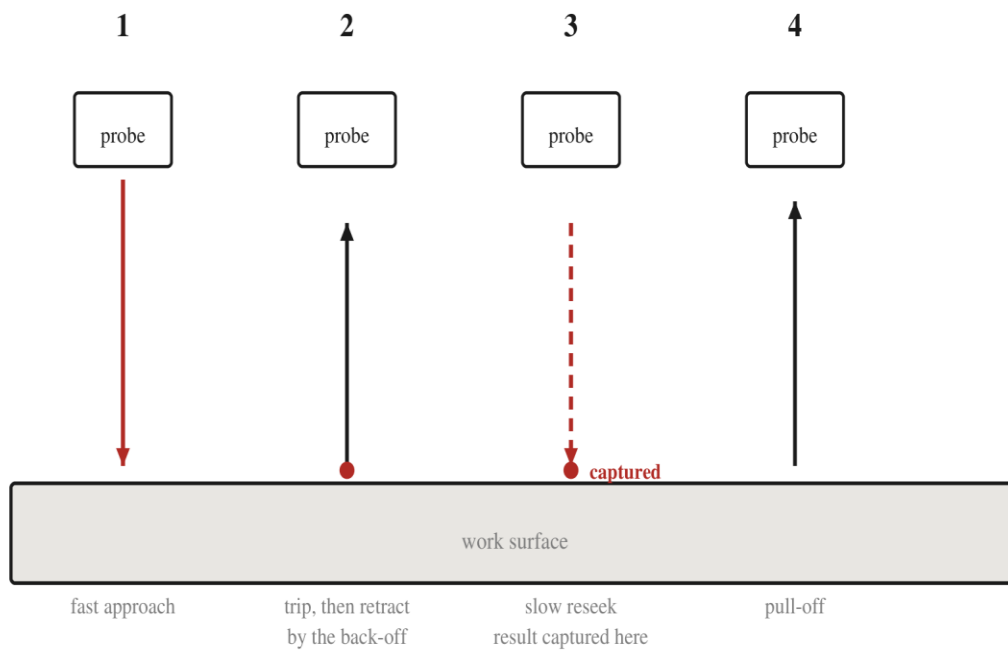
| Shared field             | What it does                                                                                                                      |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Debounce ms              | How long a switch reading must settle before it is believed.                                                                      |
| Sensor clear             | Margin the axis backs off after the switch releases, on every axis.                                                               |
| Approach FAST mm/min     | The FAST first approach, in millimetres per minute.                                                                               |
| Fine seek SLOW mm/min    | The SLOW fine re-seek, and every release. This is the pass that sets the datum.                                                   |
| Z safe                   | The work-frame Z height to lift to before homing X and Y, and for GO ZERO and GO REF. Skipped when Z already sits at or above it. |
| Lift Z before homing X/Y | Whether that lift happens at all.                                                                                                 |
| GZ lift enable           | Whether GO ZERO lifts to the safe height first.                                                                                   |
| Abort retract            | Whether Stop rapids Z to the safe height.                                                                                         |

#### WARNING

The safe-Z lift is spliced in after Z's own homing entry, so that Z is referenced before the height is worked out. It therefore only protects axes sequenced after Z. Give Z the lowest sequence number when the lift is enabled (section 14.10, MACHINE → HOMING SEQ).

## 14.10 MACHINE → HOMING SEQ

Figure 14.10 — MACHINE → HOMING SEQ



Approach FAST is stage 1 and Confirm SLOW is stage 3. The result comes from the slow pass, never the fast one.

| Field                          | What it does                                                                                    |
|--------------------------------|-------------------------------------------------------------------------------------------------|
| X / Y / Z / A homing seq (1-4) | The order the axes home in, taken in ascending order. Axes given the same number home together. |

## 14.11 MACHINE → LIMITS

Figure 14.11 — MACHINE → LIMITS

The screenshot shows the TNC-M34 control interface. At the top, it indicates 'IDLE' and 'NO PROGRAM'. A 'NOT REF' button is visible. The main display shows axis positions: X +00000.000, Y +, Z +, and A +00000.000. A modal dialog titled 'MACHINE POSITION RECOVERY' is open, displaying the following text:

```
0:/gcode/TINYCON.TAP
pos X39.19 Y25.89 Z-0.37 A0.00
referenced: XYZA
```

Below this, it says: **VERIFY the machine still sits at this position!**

OK = restore position + file (no program/spindle)  
ESC = discard - start unreferenced

On the right, a 'STATE' table is visible:

| STATE |     |
|-------|-----|
| G54   | G21 |
| G90   | G17 |
| G0    | G94 |
| G64   | G49 |
| G98   | G80 |

At the bottom, there are function keys: 1 MENU, 2 VIEW, 3 -, 4 JOG V, 5 MDI, 6 JOG. A status bar at the bottom indicates 'F5 = MDI - SHIFT: tap = next ALT key, long = SHIFT LOCK' and 'OK = SEND'.

| Field                  | What it does                                                                                                                   |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Hard limits (switches) | Arms the limit kill: motion stops the moment a pin mapped to LIMIT goes active. E-STOP is separate and is never gated by this. |
| Soft limits (travel)   | Soft travel limits on referenced axes.                                                                                         |

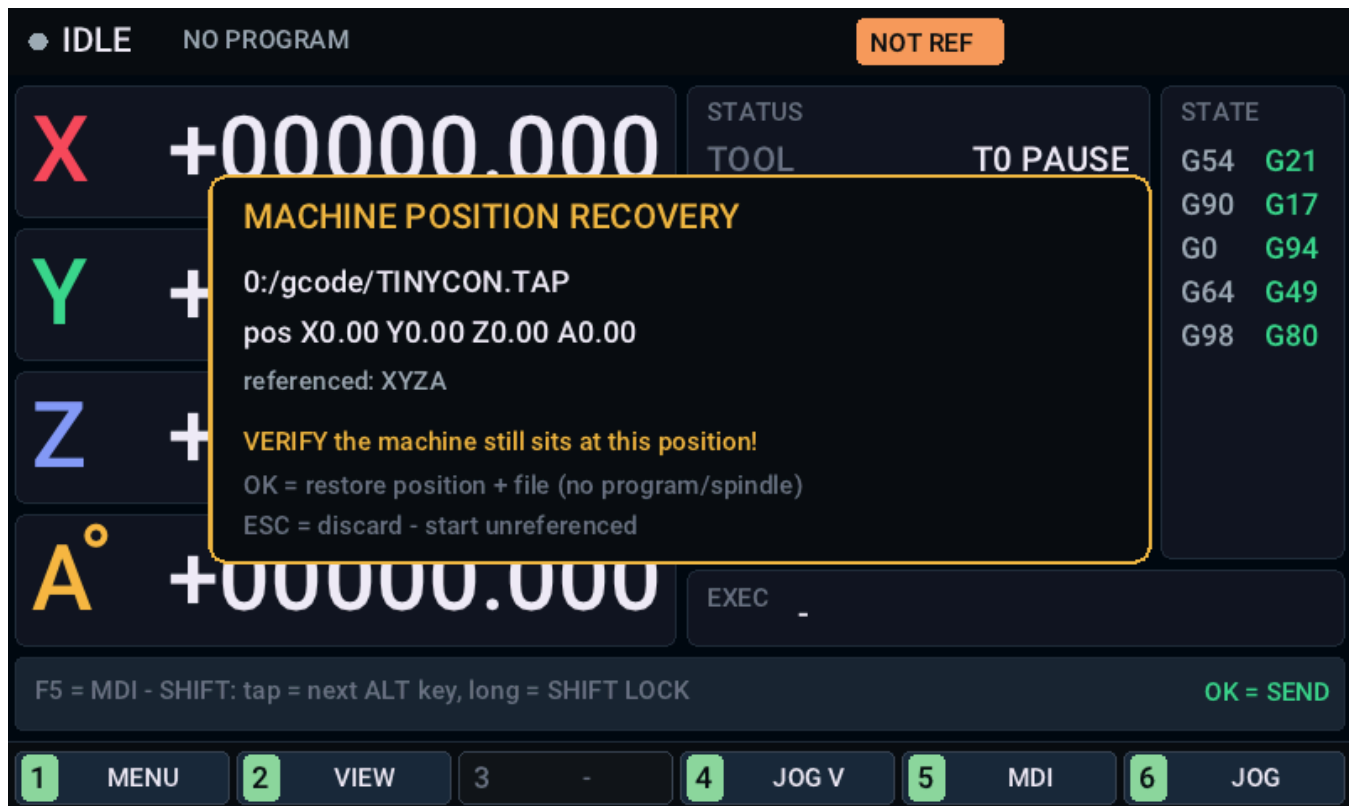
With soft limits armed:

- A jog stops at the travel bound and says SOFT LIMIT.
- A program is refused at Start if its extent exceeds travel.
- Any single commanded move past travel — from MDI, from a macro, from GO ZERO — is refused, with the offending line reported.

Soft limits are suspended during the homing cycle, and a 4th axis that rolls over or runs continuously is exempt from them.

## 14.12 MACHINE → SPINDLE

Figure 14.12 — MACHINE → SPINDLE



| Field            | What it does                                                                                                          |
|------------------|-----------------------------------------------------------------------------------------------------------------------|
| On delay         | Spin-up dwell after M3 or M4 before the first cut. Also paid on a tool-change resume.                                 |
| Mode             | Drive interface: 0-10V, PWM, or STEP. STEP makes the 4th axis the spindle — see below.                                |
| Min RPM          | The speed at minimum duty.                                                                                            |
| Max RPM          | The speed at maximum duty.                                                                                            |
| PWM frequency Hz | PWM carrier frequency.                                                                                                |
| PWM min duty %   | Duty at which the drive reaches minimum RPM.                                                                          |
| PWM max duty %   | Duty at which it reaches maximum RPM. Set both ends to what the drive actually honours; the RPM mapping follows them. |
| Steps per rev    | STEP mode only. The drive's pulses per spindle revolution, after any electronic gearing.                              |
| Accel rpm/s      | STEP mode only. How fast the pulse train ramps between speeds.                                                        |

On delay applies to a 0-10V or PWM spindle only; a STEP spindle waits for its ramp instead, computed from the rpm it is actually at, so a spindle already up to speed costs nothing.

## 14.12a STEP Mode — the 4th Axis Is the Spindle

With Mode set to STEP, a step or servo drive on the 4th-axis terminals turns the spindle motor, and the controller treats that one axis as both things at once.

| As a spindle   | What happens                                                                                                                                                                                 |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M3 / M4 with S | A free-running pulse train, ramped at the configured acceleration. S is a target and the ramp is the slope; a direction change ramps to rest, flips, and ramps back up. Maximum RPM caps it. |
| M5             | Rate zero, with holding torque. The drive's enable output stays on, as it does for every other axis; power is removed by the external chain, not by M5.                                      |
| The SPIN row   | Shows the ramp's rpm, with a tilde while it is still moving. That figure is commanded, not measured — this spindle has no feedback.                                                          |

| As an axis         | What happens                                                                                                                                |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Spindle stopped    | C is an ordinary rotary axis: jog it, home it, run a winding program on it.                                                                 |
| Spindle running    | Any C motion is refused. Jogging and homing say C is the spindle - M5 first, and a C word in a program is refused at load, naming the line. |
| C inside a program | Under STEP, a program's C moves are relative to wherever the spindle was at Start: the axis has no meaningful absolute angle.               |
| C TURNS            | Counts spindle revolutions, in place of the 4th axis turns counter.                                                                         |

### NOTE

The 4-AXIS page's steps, maximum rate, acceleration, type and continuous rows are derived from the spindle rows and hidden while STEP is selected — steps per degree is steps per rev over 360, maximum rate is maximum RPM times 360, acceleration is the spindle acceleration times six. Set the spindle and the axis follows.

### CAUTION

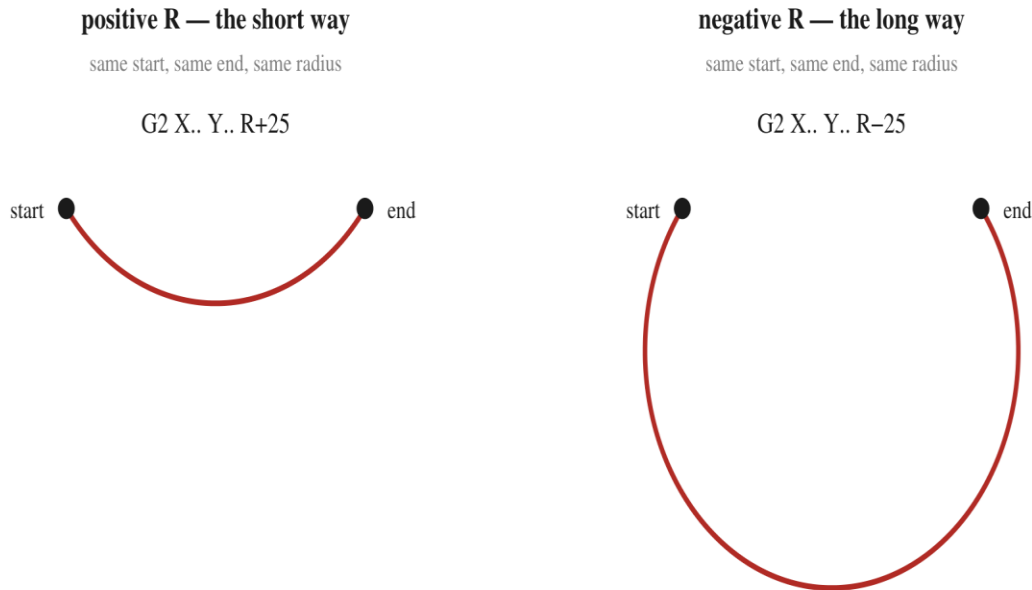
Steps per rev must be the drive's pulses per spindle revolution after any electronic gearing, and the drive's maximum input frequency must cover maximum RPM times steps per rev, divided by 60. Tapping pulses go through the motion engine, so the step-rate ceiling applies (Appendix B, B.1, Step Rate Ceiling). At 1,000 steps per rev that allows tapping up to 6,000 rpm, and at 4,000 steps per rev up to 1,500 — far above any tap.

### WARNING

Switching the mode back to PWM stops the pulse train at once rather than ramping it down, and hands the terminals back to the axis engine. Do not change mode with the spindle turning.

## 14.13 MACHINE → TOOL ZERO

Figure 14.13 — MACHINE → TOOL ZERO



The sign of R chooses which of the two possible arcs is cut. Use I, J and K where the centre matters.

| Field                      | What it does                                                                                                    |
|----------------------------|-----------------------------------------------------------------------------------------------------------------|
| Sensor height              | Height of whatever the tool touches, above the intended Z zero. Set 0 when the tool contacts the work directly. |
| Back-off between passes mm | Retract between the fast and the slow pass.                                                                     |
| Max probe travel mm        | Maximum probe travel before the cycle gives up.                                                                 |
| Approach FAST mm/min       | The FAST approach.                                                                                              |
| Confirm SLOW mm/min        | The SLOW confirming pass.                                                                                       |
| Final retract mm           | Final retract after capture.                                                                                    |
| Use pos                    | Off probes wherever the machine stands; on lifts and traverses to a stored setter position first.               |
| Setter x                   | Machine X of that setter position, read only when Use pos is on.                                                |
| Setter y                   | Machine Y of the same.                                                                                          |

#### NOTE

Sensor height is subtracted on every path — the setter probe and a manual touch-off alike — so the two cannot disagree. It is the pad height for a tool setter, the plate thickness for a touch plate, and zero for a tool touching the work.

## 14.14 MACROS

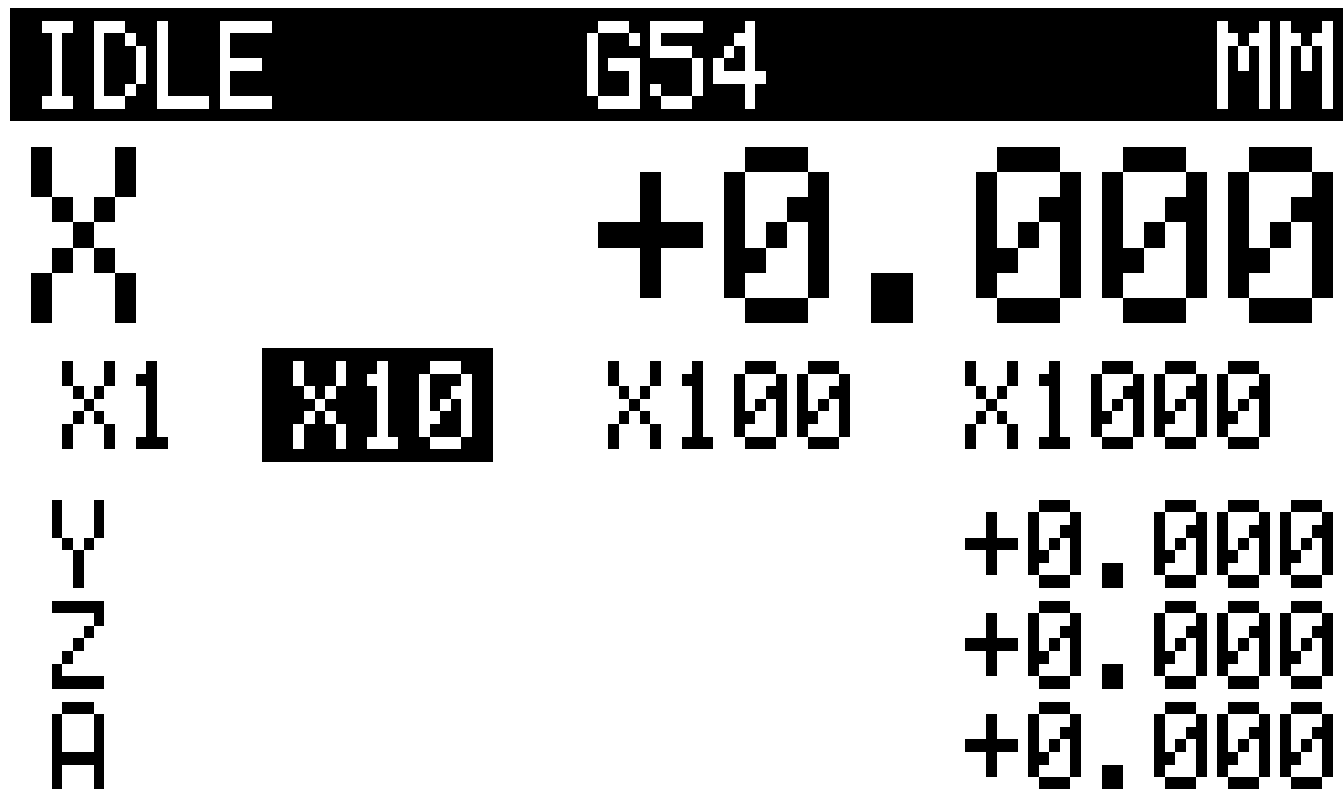
Figure 14.14 — MACROS



A picker listing the .mac files on the card; OK runs the selected one. No settings. It is also reachable without the menu PIN when F3 is assigned to RUN MAC (Appendix D, Macro Programming Reference).

## 14.15 MAPPING

Figure 14.15 — MAPPING



One row per input and output function rather than a fixed field list. Chapter 3, I/O Functions and Mapping, names the functions; this page sets which pin each one sits on.

| Column   | What it shows                                                                                                                                    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| FUNCTION | The function being mapped, prefixed IN or OUT.                                                                                                   |
| SAVED    | The pin currently written to the card. It does not follow an edit, so it is what the machine will use after the next reboot until F2 is pressed. |
| PIN      | The pin being edited. -1, or F3, clears it; committing an empty value cancels the edit rather than writing pin 0.                                |
| POL      | Polarity. On an input this marks the switch normally closed; on an output it marks the drive active low.                                         |

### NOTE

A row tinted amber shares its pin with another row. That is often deliberate — all four limits on one pin is the shipped arrangement — but the tint is there so it is a decision rather than an accident. Nothing reaches the card until F2.

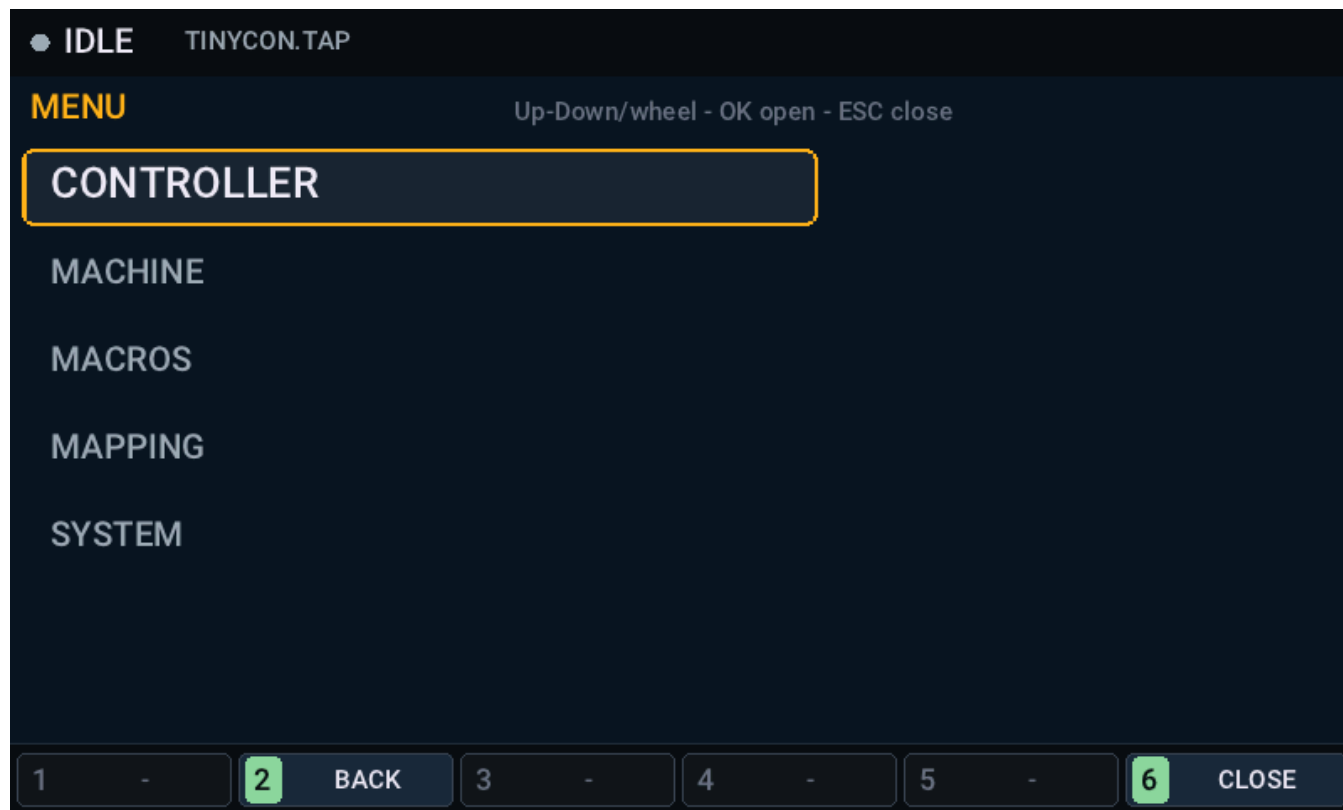
### NOTE

Polarity lives here, not in the homing settings. The homing invert rows set seek direction (section 14.9, MACHINE → HOMING).

## 14.16 SYSTEM

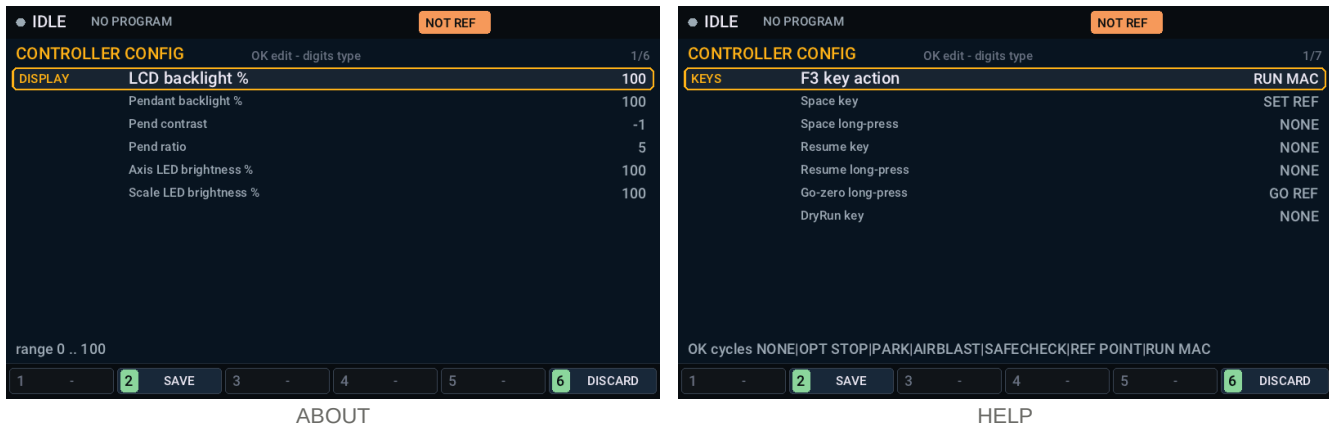
Six information and service pages. None of them holds a setting.

**Figure 14.16 — SYSTEM**



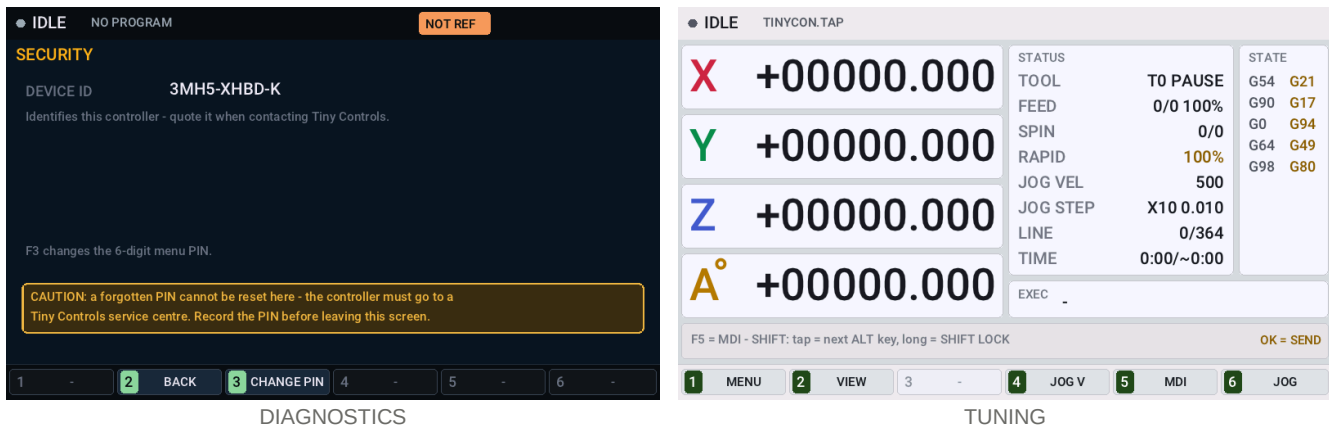
| Page           | What it carries                                                                           |
|----------------|-------------------------------------------------------------------------------------------|
| ABOUT          | Firmware versions, the device ID, and whether a pendant was found.                        |
| HELP           | A scrollable on-panel reference.                                                          |
| DIAGNOSTICS    | Live pin states, forced outputs, and limit override (Chapter 16, Diagnostics and Tuning). |
| TUNING         | The steps-per-unit and backlash wizards.                                                  |
| PENDANT UPDATE | Reflashes a Pendant V2 over the link (Chapter 21, Pendant).                               |
| RESET          | Reset coordinates, or everything to factory defaults.                                     |

**Figure 14.16a — SYSTEM → ABOUT and HELP**



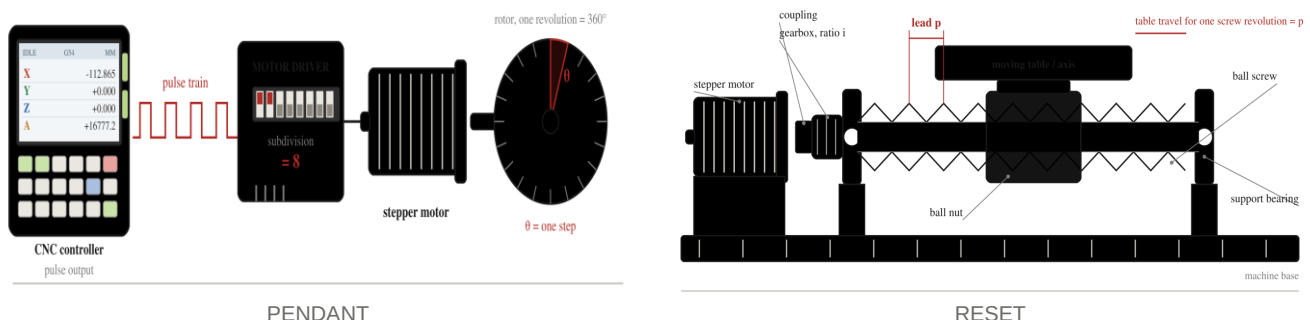
ABOUT is the page to read out on a support call: the firmware build, whether a pendant was found, the axis and I/O count this controller is built for, and the device ID. HELP is a scrollable reference that travels with the machine, so the fundamentals are readable at the panel when this manual is not to hand.

**Figure 14.16b — SYSTEM → DIAGNOSTICS and TUNING**



DIAGNOSTICS lists every input and output pin with its live state and the function mapped to it, which is the fastest way to prove a switch before arming hard limits. F4 is limit override, for driving off a tripped switch. TUNING carries the steps-per-unit and backlash wizards, one row per axis showing what each currently holds.

**Figure 14.16c — SYSTEM → PENDANT and RESET**



The pendant page reports what is on the link and what firmware this controller carries for it, and F3 sends that firmware over. RESET offers the two resets described in section 7.5, Reset, each naming its own consequences before it is armed.

## 14.17 STOCK — Not in the Menu

The stock block drawn behind the toolpath is described by a file on the card rather than by a menu page, so it is edited on the card and not from the panel. It changes nothing the machine cuts — it is there so the preview has something to draw against (section 10.2, Viewing and Editing).

| Field                        | What it does                                                    |
|------------------------------|-----------------------------------------------------------------|
| enable                       | Whether the stock block is drawn at all.                        |
| shape                        | Box or cylinder.                                                |
| mode                         | Automatic, taking the size from the program extents, or manual. |
| zref                         | Whether Z zero sits at the top of the stock or the bottom.      |
| margin                       | Added around the extents when the mode is automatic.            |
| size_x, size_y, size_z       | Block dimensions when the mode is manual.                       |
| origin_x, origin_y, origin_z | Where the block sits.                                           |
| diameter, length             | Cylinder dimensions instead, when the shape is a cylinder.      |
| position                     | Where the cylinder sits along its own axis.                     |

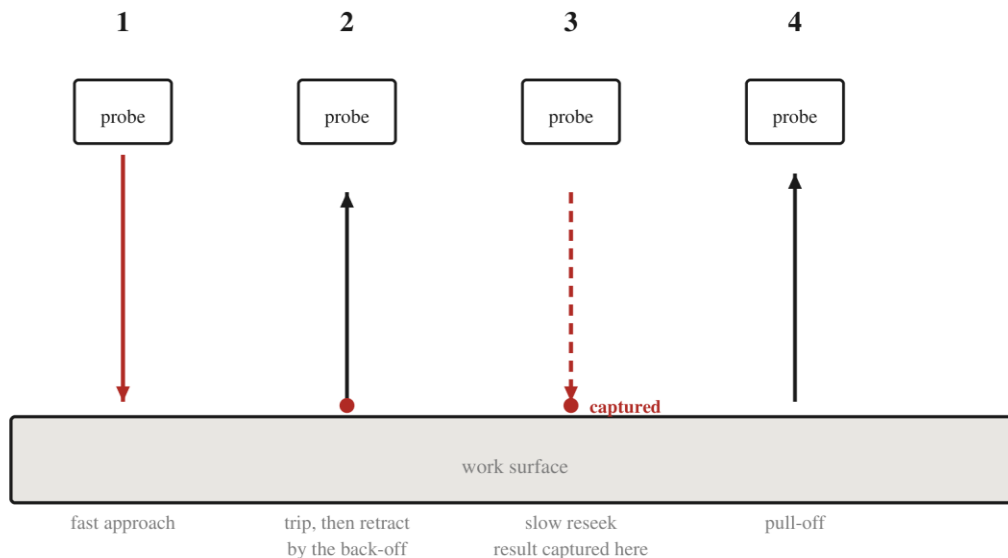
Work offsets and the tool table are not in the menu either, by design. Offsets are written by the zero keys, G10 L2, G92 and the probing macros; the tool table has three routes of its own (section 7.4, Tool Offsets).

## Chapter 15 — Probing and Tool Changes

Both jobs in this chapter measure something and write the result into a datum: a probe finds a surface, a tool change accounts for a different tool length. They share the TOOL ZERO settings and the same probe input.

### 15.1 Probing — G38

Figure 15.1 — The Probe Cycle



Approach FAST is stage 1 and Confirm SLOW is stage 3. The result comes from the slow pass, never the fast one.

A probe is not an ordinary move: its endpoint is unknown until the input fires, and the cycle retracts and re-approaches on its own. It is available from MDI and from a macro; a G38 line in a loaded program is skipped and reported.

| Code  | Direction                       | On no contact                         |
|-------|---------------------------------|---------------------------------------|
| G38.2 | Toward, stop on contact         | Error and retract.                    |
| G38.3 | Toward, stop on contact         | No error; check the probe-hit result. |
| G38.4 | Away, stop when contact is lost | Error and retract.                    |
| G38.5 | Away, stop when contact is lost | No error.                             |

Form: G38.2 Z-30 — one axis, and the number is a relative distance, not a coordinate. Any F word is ignored; speeds come from the tool-zero settings, since those fields are this cycle's parameters.

#### NOTE

The reported result is a machine coordinate, captured at the moment the input fired, and matches what the display shows for that axis at contact.

The cycle always runs a fast pass, retracts by the back-off, then re-probes slowly; the reported result is the capture from the slow pass. The trip is detected, the position captured and the motion stopped on the motion processor itself, so accuracy does not depend on how fast the screen is drawing.

#### CAUTION

Approach FAST is the fast pass and Confirm SLOW the slow one — the opposite way round from the feed and seek naming used by some other controls. Setting them the wrong way round drives the fast pass onto the work (section 14.13, MACHINE → TOOL ZERO).

Both retracts are clamped to the axis travel, and an upward Z retract additionally to the same ceiling every safe-Z move respects, so a large final retract near the top of travel stops at the bound instead of driving into the switch that referenced the axis. If the back-off does not reopen the probe the cycle stops there rather than probing again from a closed one; raise the back-off if that happens.

#### WARNING

The cycle is refused before any motion if the axis is not referenced, no PROBE pin is mapped, the probe is already made, or the PROBE pin is shared with a limit while hard limits are armed — engage limit override first. Stop or ESC ends it at any point, in either pass, whether it was started from MDI or from a macro.

## 15.2 Tool Changes

With tool change set to PAUSE, an M6 in the program stops the machine and the spindle. The tool is changed by hand, and Start resumes the cycle from where it stopped — nothing is re-measured and no offset is applied.

#### CAUTION

Work Z is not corrected for the new tool. A tool of a different length cuts at the old tool's depth from the resume onwards. Set the offset before pressing Start.

## Chapter 16 — Diagnostics and Tuning

MENU → SYSTEM → DIAGNOSTICS shows all 32 pins — 16 in, 16 out — whether or not they are assigned, with live state by colour. This is the screen for checking wiring before trusting a mapping.

| Key            | Action                        |
|----------------|-------------------------------|
| Up/Down, wheel | Select a pin.                 |
| F1             | Force the selected output ON. |
| F3             | Force it OFF.                 |
| F5             | All outputs off.              |
| F2             | Back.                         |

### WARNING

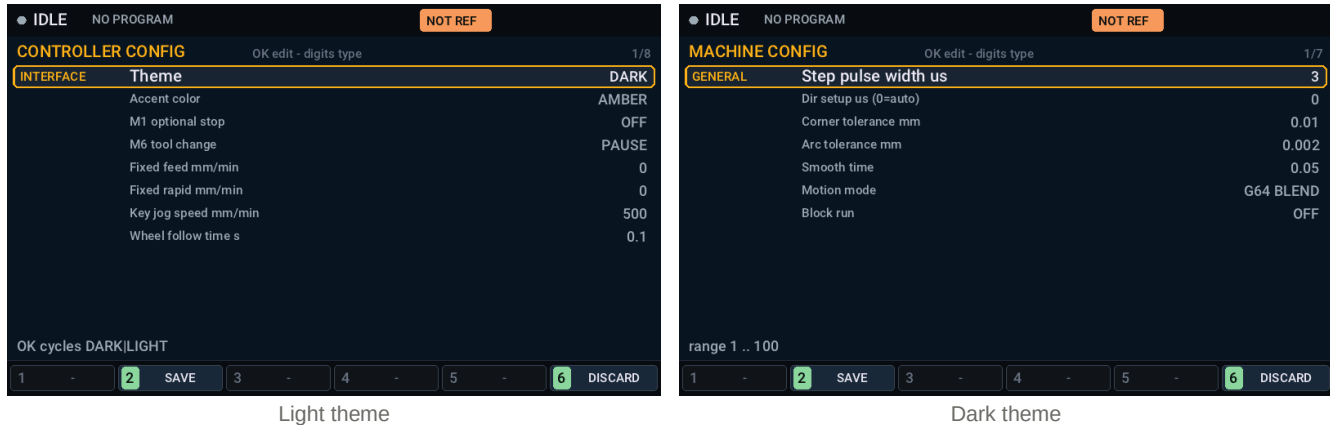
Outputs forced here are forced for real — a forced output drives whatever is wired to it, spindle enable included. Use all-off before leaving the page.

MENU → SYSTEM → TUNING gives a per-axis screen for checking motion quality against real hardware. Select an axis, then a mode; ESC steps back out one level at a time.

# Chapter 17 — Recovery After Power Loss

If the controller loses power mid-program, the next boot offers a guided recovery. Machine state and the loaded file are held through the cut.

**Figure 17.1 — Machine Position Recovery**



The prompt names the file that was loaded, the position held at the moment power was lost, and which axes were referenced. The instruction to verify the machine still sits at that position is the whole point of the screen. The controller knows where it was, not where it is. An axis dropped or moved by hand while the power was off invalidates everything below. NOT REF in the top bar is the reminder that nothing is referenced yet.

The wizard is four steps, and nothing moves until you say so.

| Step          | What happens                                                                                                 |
|---------------|--------------------------------------------------------------------------------------------------------------|
| 1/4 Reference | Home with switches, or jog to a known position — the stored global reference point is the intended aid here. |
| 2/4 State     | The recovered position and the saved line number are shown for confirmation.                                 |
| 3/4 Outputs   | Mark which outputs must be on before motion restarts, honouring spindle spin-up dwell.                       |
| 4/4 Confirm   | Final review, then start.                                                                                    |

## NOTE

At the initial prompt, OK restores position and file without starting the program or the spindle; ESC discards and starts unreferenced. The saved line number is shown explicitly, and is also the line run-from-line will want.

A winding job survives the cut as well. The A TURNS count is held through it to within the last second, and resuming settles the 4th axis's whole turns before the run so the mandrel takes the short way in rather than unwinding (section 18.5, 4th Axis).

## NOTE

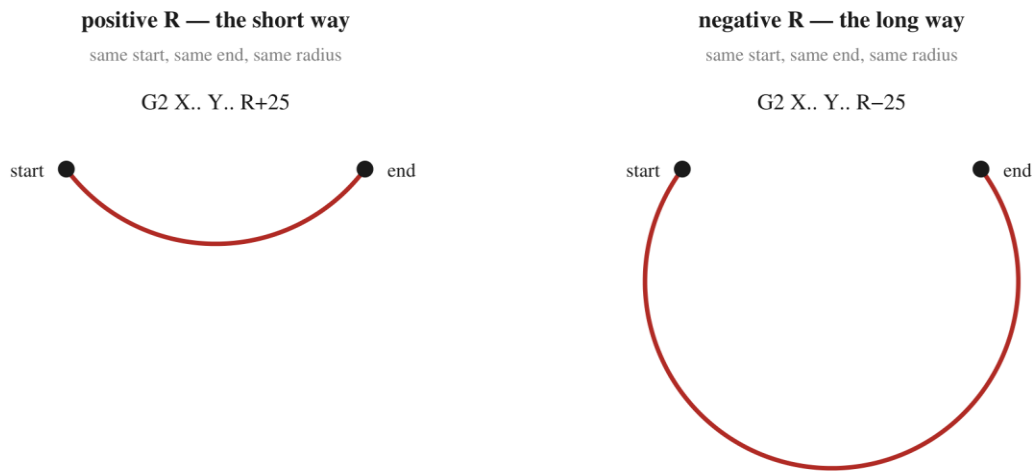
The recovered state and loaded file, the global reference point (section 8.6, Global Reference Point) and the A TURNS count (section 18.5, 4th Axis) are the three things that survive a power cut without being files on the card. They are held by an internal backup cell, which is not user-accessible. If those three stop surviving power-off while settings and offsets still do, it is a service matter.

## Chapter 18 — G-code Reference

What this controller does with each code, and what it does with the codes it does not support. Consult it when a program is refused at load, or when a cycle behaves differently from the machine a program was posted for.

### 18.1 Motion and Modal

Figure 18.1 — The Sign of R



The sign of R chooses which of the two possible arcs is cut. Use I, J and K where the centre matters.

| Code            | Meaning                                                                                                                                                                                                                                                                                                                        |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| G0 / G1         | Rapid / feed linear.                                                                                                                                                                                                                                                                                                           |
| G2 / G3         | Arc CW / CCW — centre by I/J/K, or radius by R. A positive R takes the short way round and a negative R the long way; with the start and end coincident, R cuts a full circle, its centre placed +R along the plane's first axis. Use I/J/K where the centre matters: the R form leaves it ambiguous and the controller picks. |
| G4 Pn           | Dwell, seconds.                                                                                                                                                                                                                                                                                                                |
| G10 L1 Ph Zv    | Write the tool table — set tool length offset h, 0 to 6, the same H number G43 takes.                                                                                                                                                                                                                                          |
| G10 L2 Pn X/Y/Z | Set work coordinate system n (1–6 = G54...G59).                                                                                                                                                                                                                                                                                |
| G17 / G18 / G19 | Plane XY / XZ / YZ.                                                                                                                                                                                                                                                                                                            |
| G20 / G21       | Units inch / mm.                                                                                                                                                                                                                                                                                                               |
| G28, G30        | Go to reference position. .1 forms set it.                                                                                                                                                                                                                                                                                     |
| G40             | Cutter compensation off (the only supported state).                                                                                                                                                                                                                                                                            |
| G43 Hn / G49    | Tool length offset on / off.                                                                                                                                                                                                                                                                                                   |

| Code          | Meaning                                   |
|---------------|-------------------------------------------|
| G52           | Local offset.                             |
| G53           | One-shot machine-coordinate move.         |
| G54...G59     | Work coordinate system.                   |
| G61 / G64     | Exact stop / continuous.                  |
| G90 / G91     | Absolute / incremental.                   |
| G90.1 / G91.1 | Arc centres absolute / incremental.       |
| G92 / G92.1   | Set offset / clear it.                    |
| G93 / G94     | Inverse-time / units-per-minute feed.     |
| G98 / G99     | Canned-cycle retract to initial Z / to R. |

**NOTE**

An R too small to reach between the start and end points refuses the file, naming the line — but only beyond a 0.1 per cent rounding slack, so an R meant as an exact half circle is taken as one rather than rejected.

**NOTE**

Centre words that contradict the active plane are corrected where the pair says which plane was meant — I with K means G18, J with K means G19 — and the correction is named on the console. A single foreign word, a lone K under G17, refuses the file rather than guessing.

## 18.2 Canned Cycles

R sets the retract plane, Q the peck increment, P the dwell in seconds. G98 (the default) returns to the initial Z, G99 to R. G80 cancels an active cycle.

| Code     | Status                                                                                                                                                   |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| G73      | Peck drill, partial retract (chip break). Fully implemented.                                                                                             |
| G81      | Drill. Fully implemented.                                                                                                                                |
| G82      | Drill with dwell at depth. Fully implemented.                                                                                                            |
| G83      | Peck drill, full retract to R each peck. Fully implemented.                                                                                              |
| G85      | Bore, feed in and feed out. Fully implemented.                                                                                                           |
| G89      | Bore, dwell at depth, feed out. Fully implemented.                                                                                                       |
| G84      | Right-hand tap. On a 0-10V or PWM spindle, motion only — it does not reverse the spindle on retract. On a STEP spindle it is a real rigid tap; needs M3. |
| G86, G88 | Bore. Motion only — does not stop the spindle at depth.                                                                                                  |
| G74      | Left-hand tap, on a STEP spindle only; needs M4. Refused at load otherwise.                                                                              |

| Code     | Status                                                                    |
|----------|---------------------------------------------------------------------------|
| G76, G87 | Not supported — the program is refused at load, naming the code and line. |

**WARNING**

Treat G84, G86 and G88 on a 0-10V or PWM spindle as assisted manual operations. G84 there also depends on F being set equal to pitch times RPM. Each such line prints a warning naming itself.

**NOTE**

Under a STEP spindle G84 and G74 move Z and the spindle as one coordinated pass, so no tension holder is needed and the hole is as deep as Z says (section 14.12a, STEP Mode — the 4th Axis Is the Spindle).

## 18.3 M Codes

| Code         | Meaning                                                                                              |
|--------------|------------------------------------------------------------------------------------------------------|
| M0 / M1      | Program stop / optional stop.                                                                        |
| M2 / M30     | Program end.                                                                                         |
| M3 / M4 / M5 | Spindle CW / CCW / off (S sets rpm).                                                                 |
| M6           | Tool change — behaviour set by the tool-change setting.                                              |
| M7 / M8 / M9 | Mist / flood / coolant off.                                                                          |
| M13 / M14    | Spindle on plus flood, clockwise / counter-clockwise. Each decomposes exactly into M3 or M4 plus M8. |
| M48 / M49    | Feed and speed override enable / disable.                                                            |
| M62 / M63    | Set / clear output P, synchronised with motion.                                                      |
| M64 / M65    | Set / clear output P, immediate.                                                                     |
| M66 Pn       | Wait on input n.                                                                                     |

A lone S word retargets a running spindle without needing an M3 or M4 to go with it. P accepts 0 to 15 on the codes that take it.

## 18.4 What Is Refused, Ignored, or Skipped

Handled in three tiers, by how much damage the code could do if it were quietly ignored.

| Code | Why refused at load                                  |
|------|------------------------------------------------------|
| G16  | Polar — X/Y become radius/angle on every later line. |
| G51  | Scaling — every later coordinate is scaled.          |
| G68  | Rotation — the whole coordinate frame is turned.     |

| Code            | Why refused at load                                                                                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| G41 / G42       | Cutter compensation — every path is offset by a tool radius; run on the centreline instead, the tool gouges where it should stay clear. |
| G74 / G76 / G87 | Canned cycles are modal (section 18.2, Canned Cycles).                                                                                  |
| G95             | Feed per revolution — read as mm/min, roughly a thousandfold error.                                                                     |

Accepted and ignored, genuinely harmless: G15, G40, G50 and G69 — the cancel forms, and nothing was ever enabled for them to cancel.

Line skipped, program continues:

- G38.2 to G38.5 inside a program. Probing is MDI or macro only.
- An unrecognised G word with coordinates on the same line, since the controller cannot know whether it repurposes them.
- An unsupported M word. The motion on that line still runs, and the omission is named.

#### WARNING

An axis word this machine cannot consume gates the program — a rotary letter that is not the configured 4th axis, any 4th-axis letter with the 4th axis disabled, and U, V, W or E, which are never axes here. The file still loads, with a warning naming the letter and the first affected line, but Start and run-from-line refuse: the plan in memory is missing motion the file asked for.

An unrecognised G word alone on its line is ignored silently — there are no coordinates on that line for it to have reinterpreted, so nothing can be got wrong by dropping it.

## 18.5 4th Axis

The word letter is configurable — A, B or C. A rotary 4th axis is always in degrees and is not affected by G20; a linear 4th axis scales with the other linear axes. With rollover on, the displayed position wraps to 0–360; the underlying position is not reset mid-program, so a program winding an axis through many turns is not disturbed.

Winding drives the 4th axis to millions of degrees — a relative wind adds a few thousand small moves per layer and never turns back. Positions stay exact to one step up to a limit set by the axis resolution:  $\pm 131,072^\circ$  at 100 steps per degree,  $\pm 16,384^\circ$  at 1,000. Past that, on a continuous or rolling-over axis, the controller keeps the number in range rather than letting precision go:

- The displayed 4th axis jumps back by whole turns each time the program passes the limit — on a 25-layer wind, first in layer 3 and then about every 1.8 layers. The mandrel does not move at the jump: only the number is renumbered, everywhere at the same instant, so it never grows past the limit however long the job runs.
- A TURNS runs smoothly through every jump, counting turns since the axis was last zeroed. It survives a power cut to within the last second, and resets when the 4th axis is zeroed or set.
- Start and run-from-line settle whole turns first. A run from a line before the last jump, a recovery, or a second job started without zeroing turns the mandrel less than half a turn on the way in, never back through the turns in between. The console says 4th axis renumbered by N turn(s).
- Zeroing the 4th axis after a long wind, with machine position past half the limit — 65,536 degrees at 100 steps per degree, which only a wind reaches — first drops the whole turns from machine position so the next job starts from a small number. The mandrel does not move, and the console says so.
- A program that stays inside the limit is not touched at all, and neither is an axis with soft limits — rollover and continuous both off — because it cannot reach that far.

**NOTE**

Set Feed counts 4th axis (section 14.8, MACHINE → 4-AXIS) when the CAM's F is meant along the whole X/Y/Z/4th vector, as winding CAM usually is. The run-time estimate counts the 4th axis maximum rate the way the planner does, so a wind's estimate is not minutes short.

## Chapter 19 — Messages and Alarms

Messages appear in the top bar. They are grouped here by what was happening when they arrived, because that is how a reader meets them. Angle brackets stand for a value the message fills in — an axis letter, a line number, a coordinate.

### 19.1 Homing and Referencing

| Message                                             | Meaning                                                                                                                                            |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| HOME <axis> FAILED: switch not seen                 | Seek ran past the travel span without a trip — wrong direction, or an unwired switch.                                                              |
| HOME <axis> FAILED: switch will not release         | The axis backed off and the switch stayed made — wiring, polarity, or a mechanically stuck switch.                                                 |
| HOME <axis> FAILED: switch re-made during clearance | The switch closed again while backing off — usually bounce or a marginal sensor.                                                                   |
| HOME <axis>: park is behind the switch              | The park coordinate would drive back onto the switch. The axis is referenced; the park move is refused.                                            |
| HOME <axis>: park <n> too far from switch           | The park coordinate is further from the datum than the axis travel — almost always a typo.                                                         |
| HOME <axis>: park short by <n>                      | The park move did not reach its coordinate. The datum is still valid.                                                                              |
| HOMING DONE - <axes> NOT referenced                 | Named axes failed or were skipped; the rest are good.                                                                                              |
| HOMING: switch already made - releasing             | Normal. The pre-check found the switch closed and is clearing it.                                                                                  |
| HOMING: IDLE only                                   | Homing was requested while something else was running.                                                                                             |
| HOMING: Z to safe height                            | Normal. The Z-safe lift before X and Y home.                                                                                                       |
| HOMING: axes to park                                | Normal. The last axis has homed; X, Y and the 4th axis now travel to their parks together.                                                         |
| HOMING: Z to park                                   | Normal, and last. Z descends to its park only once everything else has parked.                                                                     |
| SAFE Z (work <n>) capped - using <n>                | The work-frame safe-Z converts to a machine height past machine zero, travel, or the Z home switch; the lift was clamped to the named figure.      |
| 4th axis renumbered by <n> turn(s)                  | Normal on a winding job. Start or run-from-line settled whole turns before the run so the mandrel takes the short way in (section 18.5, 4th Axis). |

**NOTE**

A failed axis does not abort the whole cycle; the remaining axes still get their turn, and the summary at the end names what is unreferenced. If homing ever appears to hang, press Stop — it aborts the cycle and releases the lock homing holds on jogging, MDI and program start.

Three of the failures above — did not stop after release, clearance move did not finish, park move did not finish — are watchdogs:

| Message                                           | Meaning                                                           |
|---------------------------------------------------|-------------------------------------------------------------------|
| HOME <axis> FAILED: did not stop after release    | The axis never came to a standstill after backing off the switch. |
| HOME <axis> FAILED: clearance move did not finish | The clearance move never completed.                               |
| HOME <axis> FAILED: park move did not finish      | The park move never completed.                                    |

**CAUTION**

Each of those three means a phase waited two minutes for the axis to come to rest and gave up. They should never appear. The cycle ends rather than leaving the panel locked, but treat one as a fault worth reporting, not as a setting to tune.

The safe-Z lift is also announced when it cannot run at all, which is worth knowing before a cycle rather than after (section 14.9, MACHINE → HOMING):

| Message                                             | Meaning                                                                                    |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------|
| SAFE-Z LIFT INACTIVE: Z homing is disabled          | The lift needs Z referenced, and Z is not in the cycle.                                    |
| SAFE-Z LIFT INACTIVE: Z shares this sequence number | Z homes alongside another axis, so it is not referenced before that axis needs the height. |
| SAFE-Z LIFT INACTIVE: nothing is sequenced after Z  | Z homes last, so there is nothing left for the lift to protect.                            |

## 19.2 Motion, Limits and Stopping

| Message                                 | Meaning                                                                                                                                            |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| E-STOP ACTIVE - motion refused          | The external E-stop chain is open. Limit override does not help here, by design.                                                                   |
| LIMIT ACTIVE - LIMIT OVR to move off it | A hard limit is made. The machine stops once and stays stopped; use limit override to drive off the switch. STATE carries an amber LIMIT HIT chip. |
| SOFT LIMIT                              | A jog reached the travel bound on a referenced axis and stopped there (section 14.11, MACHINE → LIMITS).                                           |
| C is the spindle - M5 first             | A jog or homing cycle asked the 4th axis to move while it                                                                                          |

| Message                                     | Meaning                                                                                                                                                                                               |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                             | was running as a STEP spindle (section 14.12a, STEP Mode — the 4th Axis Is the Spindle).                                                                                                              |
| STOPPING (controlled)                       | Stop or ESC was pressed. The machine decelerates at its configured acceleration, then aborts. Pressing Stop again does nothing extra — this is already the fastest controlled stop the axes can make. |
| ABORT: no retract - Z <n> is above safe <n> | Stop was pressed with abort-retract armed, but Z already sat above the safe height, so there was nothing to lift.                                                                                     |
| GO ZERO (no lift - Z already above safe Z)  | The same for GO ZERO: the lift was skipped because it had nothing to do, not because it is switched off.                                                                                              |

## 19.3 Loading and Running a Program

A program is refused for machine reasons only. Each refusal names the line.

| Message                                              | Meaning                                                                                                                                                                            |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UNSUPPORTED G1 WITHOUT F                             | A feed move with no feed rate in effect. Refused rather than run at full axis speed. In a macro this aborts the macro.                                                             |
| UNSUPPORTED G16 POLAR at line <n>                    | Polar coordinate input is not supported.                                                                                                                                           |
| UNSUPPORTED G41 CUTTER COMP at line <n>              | Cutter compensation is not supported — post the compensated path from CAM instead.                                                                                                 |
| UNSUPPORTED G51 SCALING at line <n>                  | Coordinate scaling is not supported.                                                                                                                                               |
| UNSUPPORTED G68 ROTATION at line <n>                 | Coordinate rotation is not supported.                                                                                                                                              |
| UNSUPPORTED G74 CYCLE at line <n>                    | That canned cycle is not supported.                                                                                                                                                |
| UNSUPPORTED G76 CYCLE at line <n>                    | That canned cycle is not supported.                                                                                                                                                |
| UNSUPPORTED G87 CYCLE at line <n>                    | That canned cycle is not supported.                                                                                                                                                |
| UNSUPPORTED G95 FEED/REV at line <n>                 | Feed per revolution is not supported; feed is per minute.                                                                                                                          |
| UNSUPPORTED G2 R<n> TOO SMALL at line <n>            | The radius given cannot reach between the start and end points.                                                                                                                    |
| WARNING: USES B - 4TH AXIS IS A (LINE <n>, x<count>) | The file uses an axis letter this machine cannot consume, named with its first line and how many times it occurs. The file still loads so the toolpath can be inspected, but Start |

| Message              | Meaning                                                                                                                                                                                                              |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | and run-from-line refuse with the same words, and it is not overridable. Fix the post-processor or the 4th-axis letter, whichever is wrong (section 14.8, MACHINE → 4-AXIS). In MDI the line is refused on the spot. |
| RE-PARSE FAILED      | A setting that changes how a program is read was altered and the loaded program could not be re-read. The program is dropped rather than left half-valid; reload it.                                                 |
| BLOCK RUN - LINE <n> | Single-block mode is on and the machine is held between lines. STATE carries an amber BLK RUN chip.                                                                                                                  |

## 19.4 Probing

| Message                              | Meaning                                                                                                                                                                                  |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PROBE: STILL TRIGGERED AFTER BACKOFF | The retract between passes did not reopen the probe, so the cycle stopped rather than probe again from a closed one. Raise Back-off between passes (section 14.13, MACHINE → TOOL ZERO). |
| PROBE ABORTED                        | Stop or ESC ended the cycle. Probe speeds are low, so the stop is controlled and the cycle ends at a standstill.                                                                         |

## 19.5 Coordinates

| Message      | Meaning                                                                                                                   |
|--------------|---------------------------------------------------------------------------------------------------------------------------|
| X LIMIT <n>  | A typed datum sat beyond the coordinate range and was clamped to the limit named (Appendix B, B.5, Coordinate Precision). |
| X SET TO <n> | Follows the clamp, confirming what was actually stored, so the display and the typed value cannot disagree silently.      |

## 19.6 Settings and Configuration

| Message                                     | Meaning                                                                                                                                                  |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| SETTINGS ARE IDLE ONLY - machine is running | A setting was edited while the machine was running, held, reversing, running a macro, or jogging on the wheel (section 13.3, Settings Are Idle-Only).    |
| cfg: REJECTED                               | A configuration file on the card was refused at load and defaults were used instead. Look for this on the console when settings appear to have reverted. |
| DRY-RUN retired - reserved for              | The DryRun key was pressed. The key no longer acts,                                                                                                      |

| Message               | Meaning                                                                                                                                                                                                                                                                                                                                      |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TEACH                 | whatever its slot on the KEYS page is set to (section 14.4, CONTROLLER → KEYS).                                                                                                                                                                                                                                                              |
| C TRAIN <n> rpm TRAIN | On the diagnostics page, a STEP spindle's commanded rpm and its pulse train, with the dropped-pulse count beside it. The trailing word names which side owns the terminals: TRAIN while the spindle path drives them, ENGINE once it is stopped and the axis engine has them back (section 14.12a, STEP Mode — the 4th Axis Is the Spindle). |

## 19.7 Pendant

| Message                            | Meaning                                                                                                                                                                |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PENDANT: NONE (ENCODER-ONLY IS OK) | On ABOUT: no pendant on the link. Not a fault — the panel handwheel is wired directly to the controller and keeps working (Chapter 21, Pendant).                       |
| NO PENDANT - OR ENCODER-ONLY       | The same state, as the pendant page reports it.                                                                                                                        |
| V2 PROTOCOL                        | A Pendant V2 was found and is talking on its own protocol. The page also shows its firmware version.                                                                   |
| NO PENDANT ON THE LINK             | The pendant update page found nothing to update. A Pendant V1 reads this way too: it answers no probe, so it is simply not there as far as this firmware is concerned. |

## 19.8 Firmware Update

A pendant update walks its phases on the panel — entering bootloader, erasing, writing, verifying, promoting, confirming — and ends on one of these (Chapter 20, Firmware Update).

| Message                      | Meaning                                                                                                                                        |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| UPDATE OK                    | The update completed and the pendant is running the new firmware.                                                                              |
| UPDATE FAILED (step <n>)     | The update stopped at the named phase. The pendant reboots into its old firmware, which is left untouched; the update can simply be run again. |
| UPDATE: MACHINE MUST BE IDLE | An update was requested while the machine was doing something. Stop first.                                                                     |

## Chapter 20 — Firmware Update

Two separate updates, each covered below: the controller updates itself from a USB stick at power-on, and a Pendant V2 updates over its own cable from the panel. Neither can be run while the machine is doing anything.

### 20.1 Controller Firmware

1. Copy M34FWUPD.TNC to the root of a FAT-formatted USB stick, without renaming it.
2. Plug it into the USB host port.
3. Switch the machine on.

The bootloader looks for the file for a few seconds after every power-on. If it is not there, the machine boots normally — leaving a stick in the slot permanently is harmless.

The eight panel LEDs (section 6.4, The Panel LEDs) are the progress display, filling upward one per stage. The LED blinking is the stage running now; everything below it is solid.

| LED, bottom to top | Stage                                                |
|--------------------|------------------------------------------------------|
| x1000              | Stick found and mounted.                             |
| x100               | M34FWUPD.TNC opened.                                 |
| x10                | Header accepted — right product, right board.        |
| x1                 | Signature verified. The longest step, a few seconds. |
| A                  | Erasing.                                             |
| Z                  | Writing the main processor.                          |
| Y                  | Writing the motion processor.                        |
| X                  | Reading it all back and checking.                    |

#### NOTE

All eight blinking together means the update finished and the machine is resetting itself; all eight solid means this firmware was already installed.

#### NOTE

Nothing is erased until the signature passes. A file that is corrupted, truncated, or meant for a different product or board revision is refused with the existing firmware untouched. If the update is interrupted by a power cut, the bootloader refuses to start a half-written firmware and waits for a stick instead — plug it back in and it finishes the job.

After an update, check any configuration the update migrated — the panel migrates files automatically, but a migrated homing coordinate is worth confirming by eye (section 8.2, Homing Settings).

### 20.2 Pendant Firmware

A Pendant V2 is updated over the same cable, from MENU → SYSTEM → PENDANT UPDATE. The pendant image travels inside the controller's own firmware, so updating the controller also delivers the pendant firmware it was released with; there is nothing extra to copy.

The page shows the link state, the version the pendant reports, and the version bundled in this controller. F3 starts the update, and the whole run takes about 20 seconds — erasing can take 5 and promoting 10, so a pause on either is normal. The pendant reboots part-way through and its display is blank while it does.

| Phase               | What is happening                                   |
|---------------------|-----------------------------------------------------|
| Entering bootloader | The pendant is asked to reboot into its bootloader. |
| Erasing             | Staging slot cleared.                               |
| Writing             | Image streamed across, progress bar.                |
| Verifying           | The pendant checksums what it received.             |
| Promoting           | Copy into the execution slot.                       |
| Confirming          | New version read back over the link.                |

#### NOTE

The machine must be idle to start, since the pendant reboots during the update. It is safe to interrupt before promoting: everything up to that point writes only to a spare slot, so a failure or a power cut leaves the pendant running its existing firmware. Retry from the same page. If power is lost during promoting, the pendant's own bootloader finishes the job on its next power-up.

If the page reports the pendant sitting in its bootloader, press F3 to re-send. Re-sending the same version is allowed — the update is yours to start, so a re-flash or a deliberate downgrade is a decision the panel does not argue with.

#### NOTE

Re-sending the same version leaves the version readout unchanged, because it was already that version. The pendant's behaviour is the proof the write happened, not the number on the page.

## Chapter 21 — Pendant

A Pendant V2 is detected automatically — there is nothing to configure. At power-on the controller probes for a pendant three times in quick succession, then keeps probing every 2 seconds, so a pendant plugged in later is still picked up within a few seconds.

### NOTE

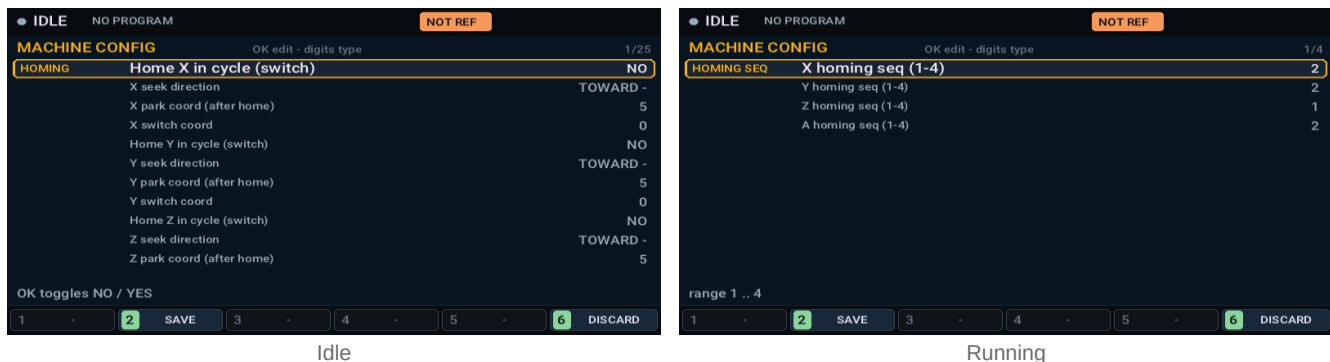
No pendant on the link is not a fault. The panel's own handwheel is wired directly to the controller, not through the pendant link, so it keeps working exactly as before whether or not a pendant is connected. A Pendant V1 left connected reads the same way — it answers no probe, so it is simply not there as far as this firmware is concerned. V1 units are converted at a Tiny Controls service centre.

The pendant keys mirror the panel: jog step, XY axis, Z axis, jog axis, start/pause and spindle toggle, gated to machine-idle like MDI.

### NOTE

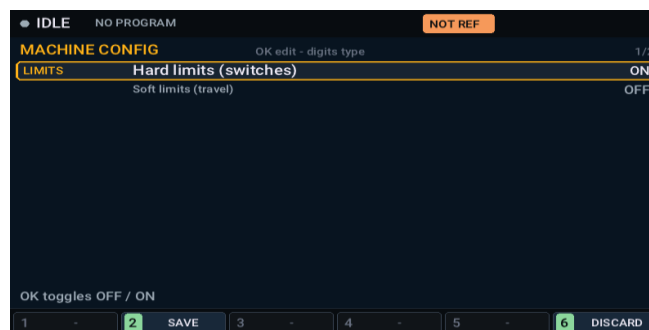
A pendant display that ends up showing mixed or stale content — after its own disconnect screen has raced a reconnect, for instance — corrects itself within ten seconds. The controller re-sends the whole frame periodically, precisely because the pendant sometimes draws screens of its own. Wait rather than reboot.

**Figure 21.1 — The Pendant, Idle and Running**



The pendant display is monochrome and carries only what is worth reading at arm's length from the machine. Idle, it gives the active work system, the units, the axis being jogged in large digits, the jog step with the selected one inverted, and the other three axes in small type. Running, the header changes to the line number, all four axes are listed together, and a bar across the foot tracks progress through the file with feed, override, tool and spindle on the line above it.

**Figure 21.2 — A Tool-Change Prompt on the Pendant**



When a tool change pauses the program, the pendant carries the prompt as well as the panel, so the operator standing at the spindle is told which tool to fit and that Start resumes (section 11.5, Optional Stop and Tool Change).

## Chapter 22 — Warranty and Support

What the warranty covers, what voids it, how to return a unit, and where to reach Tiny Controls. The published Terms of Sale are the contract; this chapter restates them.

### 22.1 Warranty

Tiny Controls warrants the TNC-M34 against defects in materials and workmanship for 12 months from the date of invoice. Cover is repair or replacement at Tiny Controls' option. Products resold rather than manufactured by Tiny Controls carry their original manufacturer's warranty, passed through.

### 22.2 Exclusions

The warranty does not cover:

- incorrect supply voltage or reverse polarity;
- wiring errors;
- water ingress, physical impact, lightning or surge damage;
- unauthorised modification;
- use outside the published ratings.

### 22.3 Returns

Return the unit carriage paid, with the invoice number and a description of the fault. Where the fault is covered, Tiny Controls pays the return carriage.

#### NOTE

Out-of-warranty repair remains available at cost for as long as parts are obtainable.

### 22.4 Support

| Office    | B-17/A, Nishat Park, Kakrola, New Delhi – 110078                                                 |
|-----------|--------------------------------------------------------------------------------------------------|
| Works     | Khewat 863-Killa 103/8/2(1-18), Village Barhana, Tehsil Beri, District Jhajjar, Haryana – 124107 |
| Telephone | Sales and support +91 99111 93212 · Office +91 99111 93210                                       |
| Email     | anil@tinycontrols.com                                                                            |
| Web       | www.tinycontrols.com                                                                             |

#### NOTE

This chapter restates the published Terms of Sale, which are the contract. Where the two differ, the Terms of Sale govern.

## Appendix A — Connection Diagram

A worked wiring reference for a four-axis mill using the safety inputs, homing switches and stepper drivers described in Chapter 3, I/O Functions and Mapping. Terminal names match the board exactly; use that chapter for what each function does.

Figure A.1 — TNC-M34 Connection Diagram

● IDLE

TINYCON.TAP

MACH

X

+00000.000

Y

+00000.000

Z

+00000.000

A°

+00000.000

STATUS

TOOL

FEED

SPIN

RAPID

JOG VEL

JOG STEP

LINE

TIME

TO PAUSE

0/0 100%

0/0

100%

500

X10 0.010

0/364

0:00/~0:00

STATE

G54 G21

G90 G17

G0 G94

G64 G49

G98 G80

EXEC

-

F5 = MDI - SHIFT: tap = next ALT key, long = SHIFT LOCK

OK = SEND

1 MENU

2 VIEW

3 -

4 JOG V

5 MDI

6 JOG

## Appendix B — Integrator Technical Specifications

Reference for integrators: the derived limits, which follow from a combination of settings rather than being set directly, and the terminal markings printed on the board. Each derived limit is stated with the setting that governs it.

### B.1 Step Rate Ceiling

The controller delivers at most 100,000 steps per second on the fastest-moving axis of a move; the other axes take fewer pulses from the same schedule. The ceiling is a clamp, so it bounds every configuration however the axes are set up.

What that ceiling is worth in feed depends entirely on steps per unit, which is why the maximum-rate field accepting a number is not a promise that the machine will deliver it:

| Steps per unit | Maximum feed at the ceiling |
|----------------|-----------------------------|
| 200            | 30,000 mm/min               |
| 400            | 15,000 mm/min               |
| 800            | 7,500 mm/min                |
| 1,600          | 3,750 mm/min                |
| 3,200          | 1,875 mm/min                |

#### NOTE

Microstepping buys resolution and costs top speed, and this is where the bill arrives. A maximum rate set above the line for the steps-per-unit in use cannot be delivered; the axis simply runs slower than the number says.

### B.2 Timing Quantisation

A step period is a whole number of microseconds, so the rates the machine can actually produce are one million divided by that whole number. Near the top of the range the grid is coarse: 10 microseconds is the ceiling itself, and the next period available, 11 microseconds, is about 9 per cent slower with nothing in between. At a tenth of the ceiling the same step is about 1 per cent. The period is truncated rather than rounded, so the delivered rate sits at or just above the commanded one.

#### NOTE

This is a velocity effect only. Step counts are exact, so position never drifts because of it.

### B.3 Step Pulse Width

The step pulse width is held to half the shortest step period the axes can demand — maximum rate multiplied by steps per unit sets that period — so width and speed are in direct competition:

| Step pulse width | Highest demand it can coexist with                   |
|------------------|------------------------------------------------------|
| 1 – 3 $\mu$ s    | Anything up to the ceiling                           |
| 5 $\mu$ s        | The ceiling itself — the first width that reaches it |

| Step pulse width | Highest demand it can coexist with |
|------------------|------------------------------------|
| 10 $\mu$ s       | Half the ceiling                   |
| 20 $\mu$ s       | A quarter of the ceiling           |
| 50 $\mu$ s       | A tenth of the ceiling             |

#### CAUTION

Read that the right way round: the machine is not slowed to protect a wide pulse — the pulse is narrowed to fit the machine. Asking for 10  $\mu$ s on axes configured to demand 80 kHz does not cap the machine at half the ceiling; it silently gives a 6  $\mu$ s pulse instead. Where a driver datasheet needs a particular width, bring the demand down to suit it — a lower maximum rate, or fewer microsteps — so the width survives.

The MACHINE → GENERAL row shows the effective width, which is the one the hardware is programmed with. If it does not read back what was typed, the clamp is why.

#### WARNING

A pulse still high when the next step falls due merges into one long pulse, the axis quietly delivers half its steps, and that is a position error, not a speed error. The clamp exists to prevent it and is applied at configuration save.

## B.4 Direction Setup Time

A direction change happens only at a segment boundary, and the boundary already provides at least 8 microseconds of setup on its own. The direction setup setting does nothing until it asks for more than that, and even then it stretches only the first interval of the segment that reverses — every later interval in that segment runs at the programmed rate. The cost is one late step per reversal, landing exactly where junction speed and backlash already interact.

#### NOTE

Set it above zero only if a driver datasheet demands more than 8 microseconds. It does not lower the sustained step rate (section 14.6, MACHINE → GENERAL).

## B.5 Coordinate Precision

Positions are held in single precision. Every value holds three decimals exactly up to 16,777.216 mm, because 16,777,216 — that figure counted in thousandths of a millimetre — is the largest whole number this representation can count to without gaps. Beyond it the third decimal is what goes: the smallest step the machine can distinguish roughly doubles, to about two microns, and coarsens further the further out the value sits. A typed datum beyond the limit is clamped, with the limit named — X LIMIT 16777.216 — rather than silently rounding to a value that reads back differently.

## B.6 Board Terminal Markings

Every name printed on the board, in the order the terminals sit in Figure 3.1, TNC-M34 Terminal Layout. The markings are printed sideways and small; this table is the searchable copy. Only the relay pairs carry no number on the board, so theirs are given here.

| Block              | Terminals, in board order                                                                                                                        |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Top row, left      | Gnd-in, 24V-in<br>In-U7, In-08, In-09, In-10, In-11, In-12 E, In-13, In-14, In-15<br>Gnd                                                         |
| Top row, centre    | Out-0, Out-1, Out-2, Out-3, Out-4, Out-5<br>Out-6, Out-7, Out-8, Out-9, Out-10, Out-11                                                           |
| Top row, right     | 24V-Out, A-Gnd, A-Out, A-Vdd<br>M3-NO, M3-Com — output 12<br>M4-NO, M4-Com — output 13<br>M7-NO, M7-Com — output 14<br>M8-NO, M8-Com — output 15 |
| Bottom row, left   | In-0, In-1, In-2, In-3, In-4, In-5, In-6<br>Gnd<br>A-Dir+, A-Dir-, A-Pul+, A-Pul-                                                                |
| Bottom row, centre | Z-Dir+, Z-Dir-, Z-Pul+, Z-Pul-<br>Y-Dir+, Y-Dir-, Y-Pul+, Y-Pul-<br>X-Dir+, X-Dir-, X-Pul+, X-Pul-                                               |
| Bottom row, right  | A nine-pin connector. It carries no terminal markings.                                                                                           |

A marking names the terminal, not the job it does. Which function reaches which input or output is set on the MAPPING page and nowhere else (Chapter 3, I/O Functions and Mapping). In-U7 is input 7; the marking is a misprint. Electrical ratings are not in this document (Chapter 5, Technical Specifications).

## Appendix C — Complete Settings Menu Tree

Every settable value on the panel, in menu order, with the range the editor enforces. Chapter 14, Settings Reference, carries the reasoning. Rows the panel hides unconditionally are not listed; rows it hides only while a related field makes them inapplicable are listed, because they are always present in the underlying file.

Shipped values are not listed here. Every setting's current value lives in its config file on the card (section 2.2, Files on the Card), and those files hold the shipped value until something changes it. RESET ALL TO FACTORY (section 7.5, Reset) returns every setting to it.

```

MAIN SCREEN -- MENU (PIN-gated)
|
+- CONTROLLER
|   +- INTERFACE
|   |   theme          DARK / LIGHT
|   |   accent         TEAL / AMBER / VIOLET / GREEN
|   |   opt_stop       OFF / ON
|   |   tool_change    IGNORE / PAUSE / MACRO
|   |   fixed_feed     0 .. 200000 mm/min
|   |   fixed_rapid    0 .. 200000 mm/min
|   |   jog_vel        1 .. 200000 mm/min
|   |   mpg_follow     0.02 .. 0.5 s
|   +- DISPLAY
|   |   lcd_backlight  0 .. 100 %
|   |   pendant_backlight 0 .. 100 %
|   |   pend_contrast  -1 .. 63
|   |   pend_ratio     0 .. 7
|   |   led_axis_bright 0 .. 100 %
|   |   led_scale_bright 0 .. 100 %
|   +- KEYS
|   |   f3_fn .....   NONE / OPT STOP / PARK / AIRBLAST /
|   |   |               SAFECHECK / REF POINT / RUN MAC
|   |   space_key, space_hold, resume_key, resume_hold,
|   |   gozero_hold, dryrun_key ..
|   |   |               NONE / OPT STOP / GO REF / SET REF /
|   |   |               RUN MAC / BLOCK RUN /
|   |   |               any .mac on the card
|   +- SECURITY -- menu PIN and device ID, no settable values
|
+- MACHINE
|   +- GENERAL
|   |   step_pulse_us  1 .. 100 us
|   |   step_delay_us  0 .. 100 us
|   |   junction_dev    0.0001 .. 10 mm
|   |   arc_tol         0.0001 .. 10 mm
|   |   smooth_time     0 .. 0.5 s
|   |   motion_mode     G64 BLEND / G61 EXACT
|   |   block_run       OFF / ON
|   +- X-AXIS / Y-AXIS / Z-AXIS (identical rows, one page each)
|   |   steps_per_mm    1 .. 100000 steps/mm
|   |   max_rate        1 .. 200000 mm/min
|   |   accel           1 .. 200000 mm/s2
|   |   travel_min      -100000 .. 100000 mm
|   |   travel_max      -100000 .. 100000 mm
|   |   invert          NORMAL / REVERSED
|   |   flip_jog        NORMAL / FLIPPED
|   |   backlash        0 .. 100 mm
|   +- 4-AXIS
|   |   type            ROTARY / LINEAR
|   |   rollover        OFF / ON
|   |   letter          A / B / C
|   |   parallel        X / Y / Z
|   |   steps_per_deg   0.01 .. 100000 steps/deg (per mm if LINEAR)
|   |   max_rate        1 .. 10000000 deg/min (mm/min if LINEAR)
|   |   accel           1 .. 10000000 deg/s2 (mm/s2 if LINEAR)
|   |   continuous      OFF / ON

```

```

| | vector_feed      OFF / ON
| | travel_min      -100000 .. 100000 deg (mm if LINEAR)
| | travel_max      -100000 .. 100000 deg (mm if LINEAR)
| | invert          NORMAL / REVERSED
| | flip_jog        NORMAL / FLIPPED
| | backlash        0 .. 100 deg (mm if LINEAR)
+- HOMING
| | enable_x y z a   NO / YES (4 rows)
| | invert_x y z a   TOWARD - / TOWARD + (4 rows)
| | park_x y z a     -100000 .. 100000 mm (4 rows)
| | pos x y z a      -100000 .. 100000 mm (4 rows)
| | search_cycles    1 .. 10
| | debounce_ms      0 .. 1000 ms
| | sensor_clear      0 .. 1000 mm
| | feedrate         1 .. 200000 mm/min
| | seekrate         1 .. 200000 mm/min
| | z_safe           -100000 .. 100000 mm
| | z_safe_enable     OFF / ON
| | gz_lift_enable    OFF / ON
| | abort_retract     OFF / ON
+- HOMING SEQ
| | seq_x y z a      1 .. 4 (4 rows)
+- LIMITS
| | hard OFF / ON
| | soft OFF / ON
+- SPINDLE
| | on delay         0 .. 600 s (0-10V/PWM only)
| | mode             0-10V / PWM / STEP
| | steps_per_rev    100 .. 20000 steps/rev
| | accel            10 .. 20000 rpm/s
| | min_rpm          0 .. 300000 rpm
| | max_rpm          0 .. 300000 rpm
| | pwm_freq         1 .. 1000000 Hz
| | pwm_min_duty     0 .. 100 %
| | pwm_max_duty     0 .. 100 %
+- TOOL ZERO
| | sensor_height    -100000 .. 100000 mm
| | backoff          -100000 .. 100000 mm
| | distance         -100000 .. 100000 mm
| | feed             1 .. 200000 mm/min
| | seek             1 .. 200000 mm/min
| | pulloff          -100000 .. 100000 mm
| | use_pos          OFF / ON
| | setter_x         -100000 .. 100000 mm
| | setter_y         -100000 .. 100000 mm
+- MACROS -- 0:/macros/*.mac, select, OK runs
| | also PIN-free via F3 = RUN MAC
+- MAPPING
| | two rows per function: PIN then POLARITY
| | in <function>     -1 .. 15 (-1 = unassigned)
| | in <function>_nc   OFF / ON (ON = normally closed)
| | out <function>     -1 .. 15 (-1 = unassigned)
| | out <function>_lo  OFF / ON (ON = active low)
+- SYSTEM
| | ABOUT             versions, DEVICE ID, pendant found
| | HELP              scrollable on-panel reference
| | DIAGNOSTICS       live pins, force outputs, LIM OVR
| | TUNING            steps/mm + backlash wizards
| | PENDANT UPDATE    Pendant V2 over RS-485
| | RESET             coordinates, or ALL to factory

NOT IN THE MENU -- STOCK, edited on the card:
| | enable OFF / ON shape BOX / CYLINDER
| | mode AUTO / MANUAL zref TOP / BOTTOM
| | margin 0 .. 10000 mm

```

|                  |                   |    |
|------------------|-------------------|----|
| size_x/y/z       | -100000 .. 100000 | mm |
| origin x/y/z     | -100000 .. 100000 | mm |
| diameter, length | 0 .. 100000       | mm |
| position         | -100000 .. 100000 | mm |

#### NOTE

Work offsets and the tool table are not in this tree. Neither is a menu setting: both live in offsets.cfg and are written from the panel, from G-code or from a macro (section 7.4, Tool Offsets).

## Appendix D — Macro Programming Reference

Macros are short scripts that drive the machine's own motion and I/O primitives with a little logic on top. They are used for tool changes, probing routines, parking, safety interlocks, and automatic tool changers. A macro is not a G-code program: it issues moves and M-codes one statement at a time, and can pause, branch, loop, wait on inputs, and prompt.

### D.1 Where Macros Live and How to Run Them

- Plain text files with a .mac extension in 0:/macros/ on the SD card. Edit them on a PC, or on the panel through Files — anything outside 0:/gcode opens view/edit, never runnable.
- Run from Menu → Macros (OK runs), from an assignable F3 without the menu PIN, or bind one directly to a physical key.
- A macro named toolchange.mac runs automatically on an M6 line when tool change is set to MACRO. The requested and current tool numbers arrive as #treq and #tcur (section D.7, Variables).

#### NOTE

While a macro runs it owns the machine: jog, MDI and program-start are locked out. At a prompt or confirm pause you may jog — positioning for a manual step is the point of the pause — and resume with Start. Changing a datum, work system or homing stays blocked, because those move the coordinates the macro is working from.

### D.2 Program Structure

One statement per line. A line is a verb and its arguments, a label (:name) as a jump target, or a comment starting with a semicolon.

#### NOTE

Comments use a semicolon, not parentheses. Unlike G-code, parentheses are expression grouping: MPOS X[(#a-1)\*2] is arithmetic, not a comment. A line whose very first character is ( is tolerated as a whole-line comment for G-code familiarity, but never use ( ) mid-line for one.

A macro ends at END or at end of file. No length limit; variables are capped at 48 per macro.

### D.3 Motion Verbs

Each blocks until the move finishes. All motion is metric; coordinates are X Y Z A words and may contain variables and expressions.

| Verb              | Frame             | Use                                                                                                                                                  |
|-------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| RAPID X.. Y.. Z.. | Absolute, work    | Fast move in the active work system.                                                                                                                 |
| MOVE X.. F..      | Absolute, work    | Feed move — F is required on the first MOVE/MOVER of a macro. A MOVE with no feed in effect aborts the macro rather than running at full axis speed. |
| MPOS X.. Y.. Z..  | Absolute, machine | Fixed machine position — change spot, park.                                                                                                          |
| RAPIDR X.. Y..    | Relative          | Rapid by a delta.                                                                                                                                    |

| Verb          | Frame    | Use              |
|---------------|----------|------------------|
| MOVER X.. F.. | Relative | Feed by a delta. |

**CAUTION**

Use MPOS for anything that must land in the same physical place regardless of the current work system — tool-change positions, park corners, changer pockets. The safe-Z work setting is a work height, while MPOS takes machine coordinates; only the built-in Go Reference and Go Zero paths do that frame conversion and the machine-zero and travel clamps. A macro's own MPOS retract should target a fixed machine coordinate, not the safe-Z setting directly.

## D.4 Spindle, Coolant and Digital Outputs

These act immediately — they are not motion-synced.

| Verb                      | Notes                                               |
|---------------------------|-----------------------------------------------------|
| SPINDLE CW / CCW [S<rpm>] | Rpm optional.                                       |
| SPINDLE OFF               | Stop.                                               |
| COOLANT ON / OFF          | Flood.                                              |
| MIST ON / OFF             | Mist.                                               |
| OUT <name> ON / OFF       | Digital output, by mapped function name or raw pin. |

<name> is either a mapped function from MENU → MAPPING — FLOOD, SPINDLE\_EN, MACRO\_OUT1 — or a raw pin. Pins are zero-based and spelled identically for inputs and outputs, IN0 to IN15 and OUT0 to OUT15, matching the board labelling and the diagnostics page (Chapter 16, Diagnostics and Tuning).

**NOTE**

Prefer mapped function names over raw pin numbers. A name survives rewiring; a pin number has to be found and edited in every macro that used it. Matching ignores case, spaces and underscores, so MACRO\_OUT1, macro out 1 and MacroOut1 are the same function.

**NOTE**

The flood output is labelled FLOOD and also answers to COOLANT. Both names reach the same relay.

## D.5 Timing and Inputs

| Verb                            | Meaning                                                                                                                                             |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| DWELL <seconds>                 | Pause for N seconds.                                                                                                                                |
| WAITIN <name> HIGH LOW [T<sec>] | Wait until an input reaches a level. T<sec> sets the timeout, default 10 s; on timeout the macro aborts with a message rather than waiting forever. |

To test an input without blocking, read it as a variable instead — `#in_<NAME>` or `#in<n>` (section D.7, Variables) — and branch on it.

## D.6 Operator Interaction and Flow Control

| Verb                  | Meaning                                 |
|-----------------------|-----------------------------------------|
| MSG "text"            | Transient status line.                  |
| PROMPT "text"         | Pause; Start continues.                 |
| CONFIRM "text"        | Pause; Start proceeds, ESC/Stop aborts. |
| ALARM "text"          | Abort the macro with this reason.       |
| SET #var = <expr>     | Assign a variable.                      |
| IF <expr> GOTO :label | Jump when the expression is non-zero.   |
| GOTO :label           | Unconditional jump.                     |
| END                   | Finish successfully.                    |

Messages embed variables with a percent sign, for example %name.

## D.7 Variables

A variable is `#name`, case-insensitive. System variables are read-only, with two exceptions: SET `#tcur` and SET `#treq` write the real tool registers, which is how a tool-change macro records a completed swap. Every other system variable refuses a SET at parse time, so a macro cannot fake a probe result or rewrite the machine's configuration as a side effect.

| System variable                                                    | Value                                                                                                                                                                                                                                        |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| #treq · #tcur · #tool                                              | Requested and current tool number. #tool is a read-only alias of #tcur.                                                                                                                                                                      |
| #x #y #z #a                                                        | Live machine position.                                                                                                                                                                                                                       |
| #in0 ... #in15 · #in_<NAME>                                        | Input level, by pin number or mapped function name.                                                                                                                                                                                          |
| #probe_hit                                                         | 1 if the last probe touched, else 0.                                                                                                                                                                                                         |
| #probe_x #probe_y #probe_z<br>#probe_a                             | Machine position captured at the trip of the last probe on that axis.                                                                                                                                                                        |
| #ref_valid · #ref_x #ref_y #ref_z<br>#ref_a                        | The stored global reference point (section 8.6, Global Reference Point).                                                                                                                                                                     |
| #tz_sensor #tz_dist #tz_pulloff<br>#tz_zsafe #tz_fixed #tz_x #tz_y | The TOOL ZERO settings (section 14.13, MACHINE → TOOL ZERO), so a probe macro can do its own arithmetic from them.                                                                                                                           |
| #tlo                                                               | Tool length offset in force — what G43 applied, 0 under G49. Read from your own context, not the macro's: the parser adds this to every commanded Z while the display does not, so a datum probed with it live shifts what the program cuts. |

| System variable | Value                                                                                         |
|-----------------|-----------------------------------------------------------------------------------------------|
| #tool_ofs       | The tool table entry for #tool — what a G43 H<tool> would apply, whether or not it is active. |

User variables — any other name — are created on first use, hold a number, default zero, up to 48 per macro. Probe results persist after the macro ends, so a follow-up macro or an MDI check can still read them.

## D.8 Expressions and Substitution

Float arithmetic with the usual precedence: + - \* /, unary - and !, the comparisons < > <= >= == !=, and logical & and |. Group with ( ) or [ ] — the two are interchangeable everywhere. There are no built-in functions: no sin, no sqrt.

| Where               | Form                                                                                                                                 |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| In move coordinates | [expr] evaluates to a number; a bare #var is inlined. MPOS X[(#a-1)*2], MOVE Z#depth F200.                                           |
| In messages         | %name is replaced by the value — a whole number prints as an integer, anything else to three decimals. MSG "Tool %tcur at %probe_z". |

### NOTE

Arguments are evaluated when the statement runs, not when the file is read. That matters for storing a tool measurement against a tool number that was reassigned earlier in the same macro — a parse-time destination would file it against whichever tool was fitted when the file was opened.

## D.9 Execution Model and Errors

- Statements run top to bottom. Motion, probing, dwell and wait-on-input block until complete; prompt and confirm block until you act.
- A parse error — unknown verb, bad assignment, missing label, unknown pin name — refuses to start the macro and names the line. Nothing moves.
- An alarm, a wait timeout, a confirm cancel, a refused move, or Stop aborts the macro; the machine returns to idle.
- As the M6 handler, a macro reaching END hands control back: the controller restores spindle and coolant and re-enters the program at the tool-change line with a safe-Z approach.

## D.10 Probing — Use PROBE, Never MOVE Plus WAITIN

PROBE <axis><dist> [NOERR] [AWAY] runs the firmware's probe cycle: fast approach, retract, slow confirming pass, final pull-off. The trip decision, the position capture and the stop all happen on the motion processor, so the measurement does not depend on the display frame rate. NOERR reports no-contact rather than aborting; AWAY trips when contact is lost instead of made.

### WARNING

Do not build a probe with MOVE plus WAITIN. Waiting on an input is polled once per display frame, so the tool keeps travelling between polls — the number recorded is the stopping distance as much as the surface, and a probe that never trips leaves the move running to its full depth with nothing retracting.

Store results with TOOLLEN <h> = <expr> (the tool table, what G43 Hn reads) or WORKZERO <axis> = <expr> (the active work offset). Both persist to the card, and both report what they wrote on the macro status line — G54 Z OFS = -95.855, TOOL 1 LEN = 42.300. WORKZERO names the work system it landed in, because which one was active is exactly what makes a correct write look like a missing one.

## D.11 Reference Point From a Macro

REFSET stores the current machine position, REFCLEAR forgets it, and the stored point can be read back as variables. There is deliberately no verb to travel back to it from a macro — that needs a travel-capped safe-Z lift first, which only the firmware's own path can compute. Use the panel's Go Reference instead, or assign it to a key.

## D.12 Quick Reference

| Category           | Verbs                                                                         |
|--------------------|-------------------------------------------------------------------------------|
| Motion (blocking)  | RAPID · MOVE · MPOS · RAPIDR · MOVER                                          |
| Probing (blocking) | PROBE <axis><dist> [NOERR] [AWAY]                                             |
| Store a result     | TOOLLEN <h> = <expr> · WORKZERO <axis> = <expr> · REFSET · REFCLEAR           |
| Spindle / I/O      | SPINDLE CW CCW OFF · COOLANT ON OFF · MIST ON OFF · OUT <n> ON OFF            |
| Timing / input     | DWELL <s> · WAITIN <n> HIGH LOW [T<s>]                                        |
| Operator / flow    | MSG · PROMPT · CONFIRM · ALARM · SET · IF..GOTO · GOTO · END                  |
| Labels / comments  | :label · ; comment                                                            |
| System variables   | #treq #tcur #tool · #x #y #z #a · #in0..#in15 · #in_<NAME> · #tlo · #tool_ofs |
| Probe results      | #probe_hit · #probe_x #probe_y #probe_z #probe_a                              |
| Reference point    | #ref_valid · #ref_x #ref_y #ref_z #ref_a                                      |
| Tool-zero settings | #tz_sensor #tz_x #tz_y #tz_fixed #tz_pulloff #tz_zsafe #tz_dist               |
| Pin naming         | IN0..IN15 · OUT0..OUT15 (zero-based), or a mapped function name               |
| Substitution       | [expr] or #var in coordinates · %var in messages                              |

## D.13 Shipped Macros

Provisioned to the card at boot, write-if-missing — edits are never overwritten. None names a raw pin: every I/O reference goes through the map, so they keep working when the wiring changes.

### NOTE

Deleting one of these files does not remove it: the next boot writes it back, because the card no longer has a copy. To retire a shipped macro for good, empty the file down to a single END line instead — that is an edit, and edits stand.

| File           | What it does                                                                                        |
|----------------|-----------------------------------------------------------------------------------------------------|
| toolchange.mac | The M6 handler for MACRO mode: retract, fixed change position, prompt, record the new tool.         |
| toolzero.mac   | Measure the fitted tool against a setter and store its length.                                      |
| workzero.mac   | Probe through a touch plate and set work Z0 on the surface.                                         |
| refset.mac     | Store the reference point, confirming over the old one.                                             |
| park.mac       | End-of-job: everything off, retract, park corner.                                                   |
| safecheck.mac  | Guard-interlock retry loop, as a template.                                                          |
| airblast.mac   | Counted output pulses, as a template.                                                               |
| atc6.mac       | A full six-pocket linear-cassette tool changer, with pocket position computed from the tool number. |

## Appendix E — Calculating Steps per mm

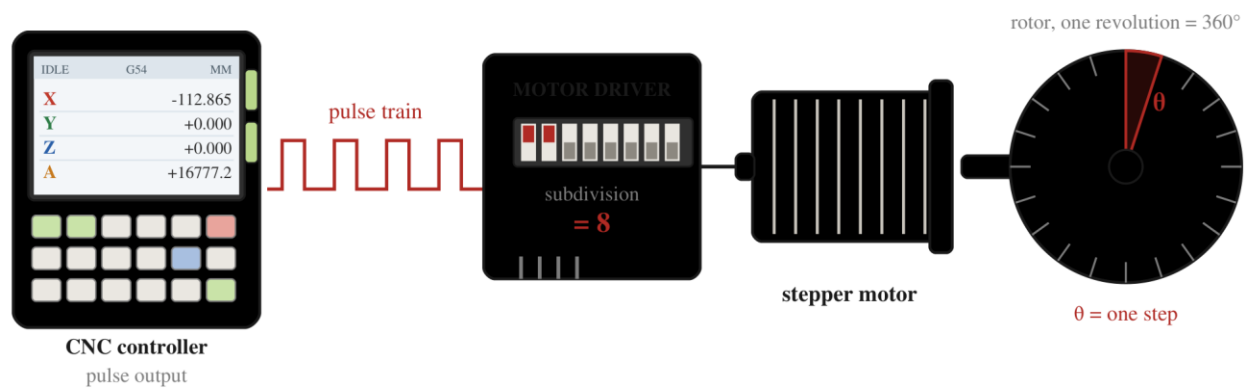
Steps per mm tells the controller how many steps to send for every millimetre an axis moves (section 14.7, MACHINE → X-AXIS, Y-AXIS, Z-AXIS). Get it wrong and every dimension the machine cuts is wrong by the same proportion — a part programmed at 100 mm comes out at 98, or at 125.

The whole calculation is one division: steps per revolution, which is electrical, over distance per revolution, which is mechanical. Work the two halves out separately, then divide. Everything below is metric; an axis configured in inches is outside this appendix.

$$\text{Steps per mm} = \frac{\text{steps per revolution (electrical)}}{\text{distance per revolution (mechanical)}}$$

### E.1 Steps per Revolution — Stepper Motor

Figure E.1 — From Controller to Rotor



One step from the controller turns the rotor by one step, or one micro-step where the driver subdivides. How far that turns the shaft depends on the motor's step angle and the driver's subdivision setting.

$$\text{steps per revolution} = (360 / \text{step angle}) \times \text{driver subdivision}$$

- Step angle is a motor property, printed on the nameplate. Almost all CNC stepper motors are 1.8 degrees, giving 200 full steps per revolution; some are 0.9 degrees, giving 400.
- Driver subdivision — microstepping — is set on the driver, usually by DIP switches with a table printed on its case. It is the number the driver multiplies each full step by.

#### NOTE

Many drivers label their DIP table in steps per revolution rather than in subdivision. Where the table already reads 1600, 3200 or 6400, that figure is the steps per revolution — do not multiply it again.

| Step angle | Subdivision   | Steps per revolution |
|------------|---------------|----------------------|
| 1.8°       | 1 (full step) | 200                  |

| Step angle | Subdivision | Steps per revolution |
|------------|-------------|----------------------|
| 1.8°       | 4           | 800                  |
| 1.8°       | 8           | 1,600                |
| 1.8°       | 16          | 3,200                |
| 0.9°       | 8           | 3,200                |

## E.2 Steps per Revolution — Servo Drive

A servo drive has no fixed step. The steps per revolution are chosen by setting the drive's electronic gear ratio, and the drive scales the controller's steps up to its own encoder resolution. The controller still sends step and direction, so nothing in Chapter 3 or section 14.7 changes.

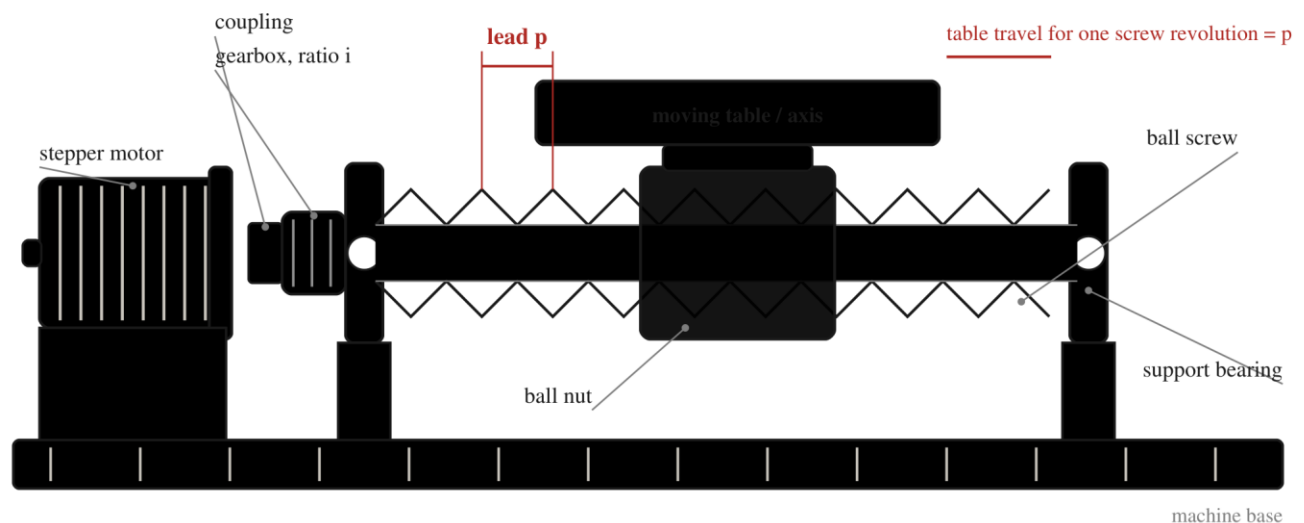
$$\text{electronic gear ratio} = \frac{\text{encoder counts per revolution}}{\text{steps per revolution you want to use}}$$

Pick the steps per mm first, then work backwards to the ratio. Section E.5 is a worked example.

## E.3 Distance per Revolution

How far the axis physically moves for one turn of the motor shaft. Two mechanisms cover nearly every machine.

**Figure E.2 — Screw Drive**



One screw revolution moves the table by one lead. The screw drawn is single-start, so its lead equals its crest-to-crest pitch.

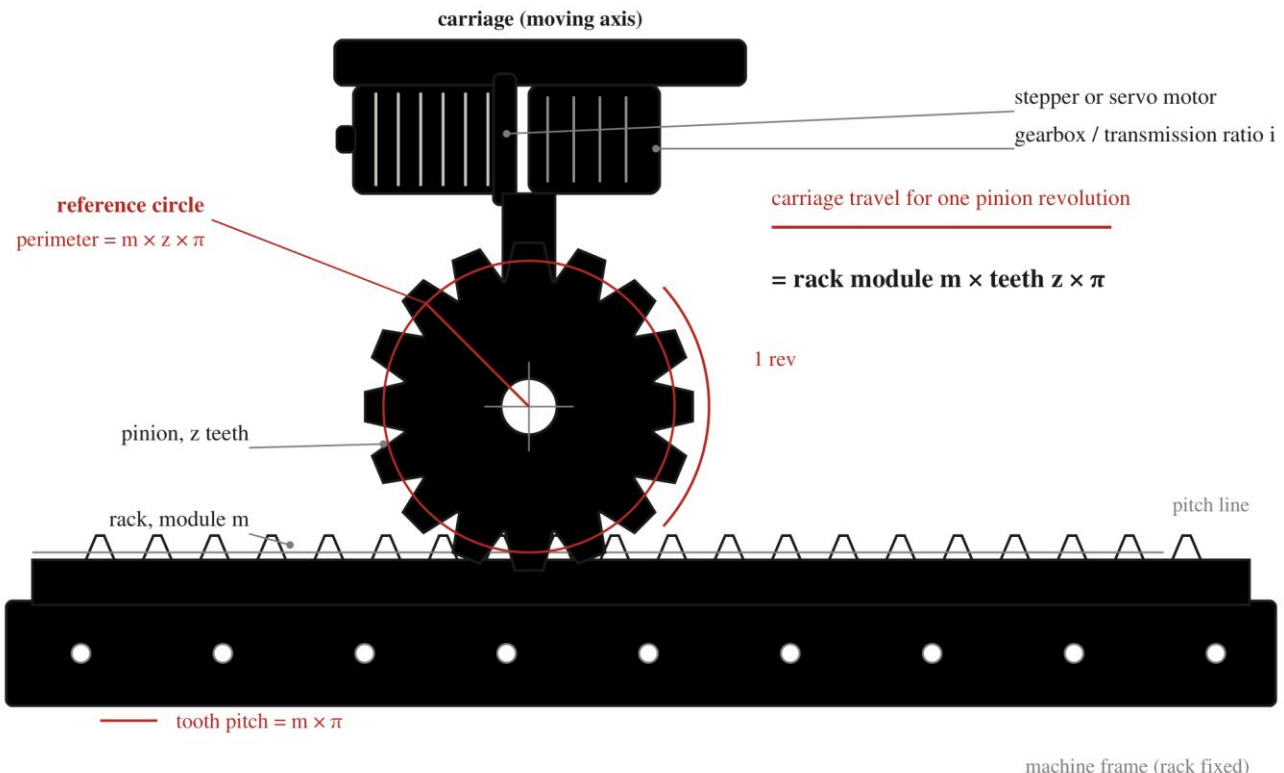
$$\text{distance per revolution} = \text{screw lead} \times \text{transmission ratio}$$

### CAUTION

Lead is not pitch. Pitch is the distance between adjacent threads; lead is the travel per turn, and lead = pitch x number of starts. On a single-start screw the two are equal, which is why the terms get used interchangeably. On a four-start screw they differ by a factor of four, and using pitch there makes every dimension four times too small.

Common ball screws are 5 mm or 10 mm lead. A screw marked 1610 is usually 10 mm lead on a 16 mm shaft. To be certain: mark the nut, turn the screw exactly ten turns, measure the travel and divide by ten.

**Figure E.3 — Rack Drive**



One pinion revolution advances the carriage by the perimeter of the pinion's reference circle.

$$\text{distance per revolution} = \text{module} \times \text{pinion teeth} \times \pi \times \text{transmission ratio}$$

Module is the rack's tooth size in millimetres — module 1.5 and module 2 are common on gantry routers. Pinion teeth is a count.

## E.4 Transmission Ratio — the Common Error

Define it this way round, every time:

$$\text{transmission ratio } i = \frac{\text{revolutions of the screw or pinion}}{\text{divided by revolutions of the motor}}$$

| Arrangement                                          | i     |
|------------------------------------------------------|-------|
| Motor coupled directly to the screw or pinion        | 1     |
| 5:1 reduction gearbox                                | 0.2   |
| 3:1 reduction gearbox                                | 0.333 |
| Belt, 20-tooth motor pulley to 40-tooth screw pulley | 0.5   |

#### NOTE

This is the reciprocal of the way gearboxes are labelled: a box marked 5:1 gives  $i = 0.2$ , not 5. A reduction always makes  $i$  less than 1, so the axis moves less per motor revolution and steps per mm goes up. If the figure moved the wrong way when a gearbox was added,  $i$  is inverted.

## E.5 Worked Examples

A — ball screw, direct coupled. Motor  $1.8^\circ$ , subdivision 8, 5 mm lead, no gearbox.

```

steps per revolution    = (360 / 1.8) x 8 = 200 x 8 = 1600
distance per revolution = 5 x 1          = 5 mm
Steps per mm           = 1600 / 5         = 320

```

B — the same motor and driver through a 2:1 belt reduction, on a 10 mm lead screw: a 20-tooth motor pulley driving a 40-tooth screw pulley, so  $i = 0.5$ .

```

steps per revolution    = 1600
distance per revolution = 10 x 0.5 = 5 mm
Steps per mm           = 1600 / 5 = 320

```

The coarser screw and the reduction cancel, giving the same figure as A.

C — rack and pinion. Motor  $1.8^\circ$ , subdivision 16, module 1.5 rack, 20-tooth pinion, 5:1 gearbox, so  $i = 0.2$ .

```

steps per revolution    = (360 / 1.8) x 16 = 3200
distance per revolution = 1.5 x 20 x pi x 0.2 = 18.850 mm
Steps per mm           = 3200 / 18.850    = 169.765

```

Rack drives rarely give round numbers. Enter the decimals the field accepts — rounding 169.765 to 170 introduces about 0.14 mm of error per 100 mm of travel.

D — servo, working backwards. A drive with a 10,000 count encoder on a 5 mm lead screw, direct coupled, and you want to keep 400 steps per mm. At 400 the controller sends 2,000 steps to move 5 mm, which is one screw revolution, so the drive must turn once — 10,000 encoder counts — for every 2,000 steps in.

```

electronic gear ratio = 10000 / 2000 = 5 / 1

in general: ratio = encoder counts per revolution /
                  Steps per mm x distance per rev

```

## E.6 Check It on the Machine

Never trust the arithmetic alone: it cannot know about a mislabelled gearbox or a driver whose DIP table does not match its case. The TUNING wizard (Chapter 16, Diagnostics and Tuning) walks this measurement and writes the result. To do it by hand:

1. Clamp a dial gauge or a steel rule to the axis and note the start position.
2. Command a move of 100 mm — long enough that measurement error stays small.
3. Measure the actual travel.
4. Correct the value proportionally, then re-measure.

$$\text{new value} = \text{old value} \times \frac{\text{commanded distance}}{\text{actual distance}}$$

Set to 320 and commanded 100 mm, an axis that travels 98.4 mm needs  $320 \times (100 / 98.4) = 325.2$ . Two rounds normally gets within a few hundredths of a millimetre per 100 mm.

### NOTE

A measured travel out by a factor close to 2, 4, 5 or 10 rather than by a few tenths of a per cent is not a calibration error. Recheck the subdivision setting, the gearbox ratio, or the screw lead.

## E.7 Before You Finish

A high steps-per-mm figure limits how fast the axis can run, because the controller delivers at most 100,000 steps per second:

$$\text{step rate (steps/s)} = \text{Steps per mm} \times \text{feed (mm/min)} / 60$$

At 320 steps per mm and 6,000 mm/min that is 32,000 steps per second, comfortably inside the ceiling. Appendix B, B.1, Step Rate Ceiling gives the feed each steps-per-mm figure can actually reach; a maximum rate set above that line cannot be delivered whatever the field says.

- Set every axis. X, Y and Z are separate values, and Z very often differs because it uses a different screw.
- Keep a record of the final figures and the step angle, subdivision, lead and ratio they came from. Anyone changing a motor or driver later needs those numbers.

|                         | Stepper                                               | Servo                            |
|-------------------------|-------------------------------------------------------|----------------------------------|
| Steps per revolution    | $(360 / \text{step angle}) \times \text{subdivision}$ | set by the electronic gear ratio |
| Screw, distance per rev | lead x i                                              | lead x i                         |
| Rack, distance per rev  | module x teeth x pi x i                               | module x teeth x pi x i          |
| Steps per mm            | steps per rev / distance per rev                      | chosen, drive scaled to match    |

## Appendix F — Quick Reference Card

| Want to...                       | Do this                                                                                        |
|----------------------------------|------------------------------------------------------------------------------------------------|
| Home the machine                 | Homing                                                                                         |
| Reference without switches       | Long-press Homing, then Homing                                                                 |
| Set work zero on an axis         | That axis's Zero key                                                                           |
| Type an exact work coordinate    | Long-press the axis Zero key (max $\pm 16,777.216$ )                                           |
| Change work system               | WCS, then OK — a long OK also goes there                                                       |
| See machine coordinates          | WCS-T                                                                                          |
| Load a program                   | File, select, OK                                                                               |
| Preview the toolpath             | F2, long-press F5 to fit                                                                       |
| Run                              | Start                                                                                          |
| Pause / resume                   | Pause, then Start                                                                              |
| Back out of a cut                | Pause, then F3 (Reverse)                                                                       |
| Abort                            | Stop                                                                                           |
| Run one line at a time           | Block Run on — assignable key, mapped input, or Menu → Machine → General — then Start per line |
| Start mid-program                | Long-press Start, type the line number, OK, confirm, Start                                     |
| Change feed                      | Feed-O, type, OK                                                                               |
| Set jog speed                    | F4 on the main screen                                                                          |
| Jog off a tripped limit          | Limit-O, jog clear, release it                                                                 |
| Check wiring                     | Menu → System → Diagnostics                                                                    |
| Run a macro                      | Menu → Macros, select, OK                                                                      |
| Probe / touch off Z              | MDI G38.2 Z-30, or run workzero.mac                                                            |
| Measure a tool length            | Run toolzero.mac                                                                               |
| Update pendant firmware          | Menu → System → Pendant Update, F3                                                             |
| Run a macro without the menu PIN | Set the F3 key action to RUN MAC, then press F3                                                |
| Write a tool length by hand      | MDI: G10 L1 P<tool> Z<value>                                                                   |
| Change the menu PIN              | Menu → Controller → Security, F3                                                               |
| Find this controller's device ID | The Security page, or About                                                                    |
| See which pendant is connected   | About, or the Pendant Update page                                                              |

| Want to...                              | Do this                                                                                              |
|-----------------------------------------|------------------------------------------------------------------------------------------------------|
| Count turns wound on the 4th axis       | A TURNS, the last STATUS row — continuous or rollover rotary only. Zero it with that axis's Zero key |
| Use the 4th axis as a step spindle      | Menu → Machine → Spindle → Mode = STEP, set Steps per rev and Accel, then M3 S... runs it            |
| Rigid-tap a hole                        | On a STEP spindle: M3 S500, then G84 X... Y... Z-15 R2 K1.5                                          |
| Make F count the 4th axis (winding CAM) | Menu → Machine → 4-Axis → Feed counts 4th axis = ON                                                  |

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