



TNC-M24

Four-Axis CNC Mill Controller

Standalone control of X, Y, Z and a fourth axis, with probing, tool-length measurement and power-loss recovery.

OPERATION MANUAL

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THIS MANUAL CONTAINS INFORMATION FOR INSTALLING AND OPERATING THE FOLLOWING PRODUCT: TNC-M24, FOUR-AXIS CNC MILL CONTROLLER.

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Contents

Contents	i
Revision History	iii
Chapter 1 — Safety Information.....	1
1.1 Warning Levels.....	1
1.2 Electrical Safety.....	1
1.3 Motion Safety	1
1.4 General Safety Rules	2
Chapter 2 — Product Overview	3
2.1 Key Features	3
Chapter 3 — Installation and Wiring.....	4
3.1 Input Functions	4
3.2 Output Functions	5
3.3 Bring-Up Order	5
Chapter 4 — Quick Start.....	6
Chapter 5 — Technical Specifications	7
5.1 What This Product Does Not Have	7
Chapter 6 — Controls and Display	9
6.1 Jog.....	9
6.2 Shifted Keys	9
6.3 Screens	10
6.4 Power-Loss Recovery	11
Chapter 7 — Work Offsets and Touch-Up.....	12
7.1 Where the Datum Lives	12
7.2 Offsets Persist.....	12
7.3 The Two Zero Keys Are Deliberately Asymmetric	12
7.4 Touch Up — Correcting the Datum by Jogging	12
7.5 Store Location	13
7.6 Z-Inhibit — Running the Path in the Air.....	13
Chapter 8 — Diagnostics	15
Chapter 9 — Tool Changes and Tool Length.....	16
Chapter 10 — G-code Reference	17
10.1 Supported	17
10.2 Accepted but Ignored	17
10.3 Refused — the Program Will Not Run	18
10.4 Not Supported — the Line Is Skipped.....	18
10.5 File Names	18
Chapter 11 — Settings Reference.....	19
11.1 How the Menu Is Organised.....	19
11.2 Navigation and Editing	20
11.3 The Numeric Keypad.....	20
11.4 Exit: Save or Discard.....	21
11.5 MOTION and Per-Axis Settings	21

11.6 HOMING.....	22
11.7 LIMITS.....	23
11.8 SPINDLE.....	23
11.9 TOOL ZERO.....	23
11.10 GENERAL.....	24
11.11 RATES and DISPLAY.....	24
Chapter 12 — I/O Mapping	26
Chapter 13 — Messages and Alarms	27
Chapter 14 — Warranty and Support	28
14.1 Warranty.....	28
14.2 Exclusions.....	28
14.3 Returns.....	28
14.4 Support.....	28
Appendix A — Connection Diagram.....	29
Appendix B — Integrator Technical Specifications.....	30
B.1 Step Rate Ceiling.....	30
B.2 Direction Setup Time.....	30
Appendix C — Complete Settings Menu Tree.....	31
Appendix D — Quick Reference Card	33
D.1 Three Keys to Learn First.....	33
D.2 Shifted Keys.....	33
D.3 Before the First Run.....	33
D.4 Three Things That Bite.....	33

Revision History

Revision	Date	Timestamp	Sections affected	Summary of change
R1.0	September 2026	2026-09-11	All	First issue under the family documentation standard.

Chapter 1 — Safety Information

Read this chapter before wiring, configuring or running a machine built on the TNC-M24. It applies to every installation regardless of what the controller drives.

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

Esc stops the machine from anywhere — ahead of every screen, every menu, every prompt. If the machine is moving, Esc stops it and does nothing else; press it again to navigate.

CAUTION

No output does anything until it is assigned on the I/O mapping page (Chapter 12, I/O Mapping). An output driving a relay can energise unexpectedly once assigned — confirm what is wired to a terminal before assigning a function to 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, and only apply while it stays referenced. An unreferenced machine will happily drive past its travel bounds.

CAUTION

Arm the hard limit kill only after watching every switch on the Diagnostics inputs page. It ships off for exactly this reason.

WARNING

Z-Inhibit still moves the machine — X, Y and the 4th axis run the program at programmed rate with Z held where it stands. It is a toolpath preview by motion, not a mode where nothing moves (Chapter 7, Work Offsets and Touch-Up).

1.4 General Safety Rules

- Only trained personnel may install, configure or operate this controller.
- Watch every input on the Diagnostics page, and test every relay, before arming the hard limit kill.
- Prove jog on a freshly commissioned machine before homing, probing or running a program — everything after it reads a position, so a wrong position poisons all of it.
- Home one axis at a time on a new machine, with a hand near Esc.
- Never bypass a limit switch to finish a job.
- Never leave a running program unattended.
- Keep this manual with the machine.

Chapter 2 — Product Overview

The TNC-M24 is a standalone four-axis CNC mill controller. It drives X, Y, Z and a configurable fourth axis as step-and-direction outputs, and is operated from a pendant carrying a 128 × 64 monochrome display and a 24-key pad, connected to the mainboard by one cable. The mainboard draws every pixel and reads every key; the pendant has no independent intelligence.

Everything here is what the firmware actually does — where a value has a range, that range is the one the settings editor enforces.

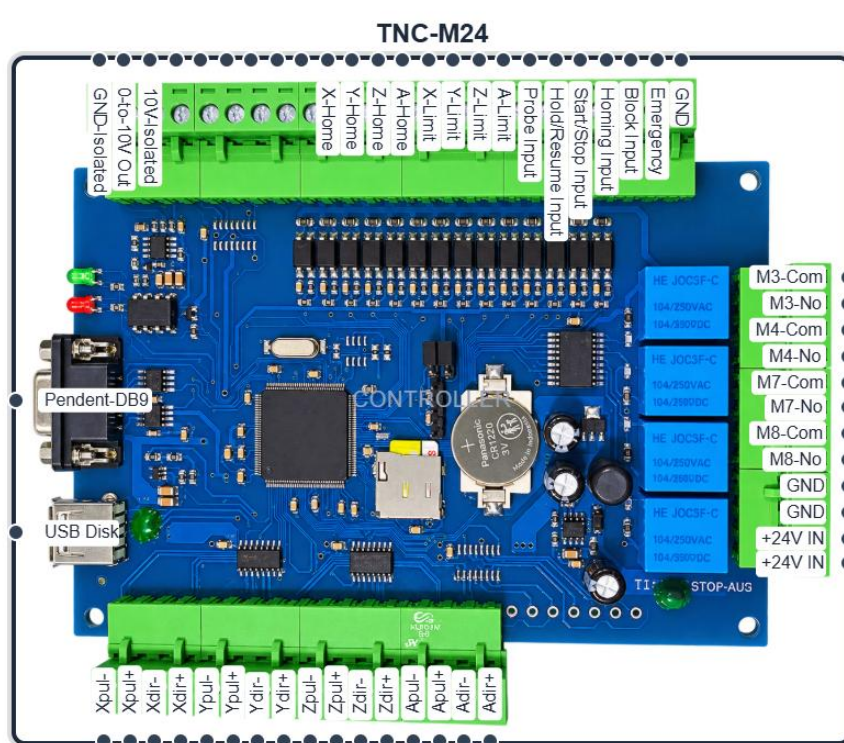
2.1 Key Features

- Four axes — X, Y, Z and a configurable 4th, rotary or linear — each with independent steps per unit, rate, acceleration, travel and backlash.
- Six work coordinate systems, with the active offset and frame persisting across a power cut.
- Guided power-loss recovery: reference, reload, restore outputs, then resume, in that order so nothing irreversible happens early.
- A tool length that is measured, not typed — probed once and applied automatically as a difference at every subsequent tool change.
- Work-datum correction by jogging (Touch Up), for correcting a shallow or deep cut without knowing the exact number in advance.
- A stored machine-coordinate reference point, kept in battery-backed memory, for re-anchoring after a power loss.
- Z-Inhibit, running a program in the horizontal plane only, as a toolpath preview on a controller with no 3D render.
- Canned drilling, boring and tapping cycles that emit real motion.
- Configuration held as plain-text files on the SD card, editable on the panel.

Chapter 3 — Installation and Wiring

Every input and output function is assigned to a pin on the I/O mapping page — nothing is wired by function until that assignment is made (Chapter 12, I/O Mapping).

Figure 3.1 — TNC-M24 Terminal Layout



3.1 Input Functions

Function	Notes
HOME X / Y / Z / 4TH	Homing switches. May share one pin — all four home one at a time rather than together.
LIMIT X / Y / Z / 4TH	Limit switches — the kill, gated by the hard-limit setting.
PROBE	The probe input, used by both probing cycles (section 6.3, Screens and section 7.1, Where the Datum Lives).
EXT E-STOP	External emergency-stop chain.
CYCLE START	Physical start button — starts only, never resumes.
FEED HOLD	Physical hold button.
STOP	Physical abort.
BLOCK RUN	Single-block mode switch, not a step button.

NOTE

This board carries fourteen inputs. The E-Stop input is served by a hardware interrupt rather than the ordinary scan, so a kill on that input does not wait for a scan period. E-Stop may be moved to another terminal and will still work — it falls back to the scan, costing one debounce period on the input where latency matters most. If any other function shares that terminal, both the terminal's row and the function's row warn: whenever that input activates, the machine stops.

3.2 Output Functions

Function	Notes
SPINDLE EN	M3.
SPINDLE DIR	M4.
COOLANT (FLOOD)	M8.
MIST	M7.

This board carries four relay outputs. Each input has a normally-open or normally-closed polarity row, and each output an active-high or active-low row. All inputs are pulled up and switched to ground, so a plain normally-open switch reads active-low — the editor calls this NO. New assignments default to NO.

3.3 Bring-Up Order

In order, because each step depends on the one before.

1. Set the machine table — steps per unit, rates, accelerations, travel. The shipped values are deliberately slow placeholders and will be wrong for your machine.
2. Watch the inputs (Chapter 8, Diagnostics) before arming the hard limit kill. Every switch should show active when pressed and nothing at rest.
3. Test the relays on the outputs page — four distinct clicks.
4. Check the emergency-stop input on the inputs page.
5. Prove jog, including a single-axis check: move one axis and confirm the other three are unchanged.
6. Set homing — direction, switch coordinate, park coordinate, rates — then home one axis at a time, with a hand near Esc.
7. Then probing, which needs a referenced axis.
8. Then a tool change, which needs probing.
9. Then a program, and only then a mid-program touch-up.

NOTE

Esc stops the machine at any point in all of this. A saved configuration file keeps its own values — changing a shipped default does not reach a board that already has settings saved; edit the row directly, or clear the saved file and let it re-default.

Chapter 4 — Quick Start

This chapter takes a new controller, out of the box, to a first program run. It assumes the bring-up order in Chapter 3 has already been followed.

1. **Watch every input** on the diagnostics page before arming hard limits — each switch should read ON when pressed and nothing at rest (Chapter 8, Diagnostics).
2. **Test the relay outputs** on the same page — four distinct clicks (Chapter 8, Diagnostics).
3. **Set the machine table** — steps per unit, rates, accelerations and travel — before trusting any motion; the shipped values are placeholders, not a tuning for your machine (Chapter 11, Settings Reference).
4. **Jog each axis** and confirm it moves the expected distance in the expected direction (Chapter 6, Controls and Display).
5. **Home the machine**, one axis at a time, with a hand near Esc (Chapter 6, Controls and Display).
6. **Set the work offset** by touching off, or by probing (Chapter 7, Work Offsets and Touch-Up).
7. **Load a program** from the file browser (Chapter 6, Controls and Display).
8. **Press Start.**

NOTE

What new operators get wrong: the shipped machine-table values are deliberately slow placeholders, not defaults tuned to any real machine, so running with them unedited moves at the wrong speed or over-travels. Editing a setting in firmware does not reach a board that already saved its own machine.cfg — change the value on the panel, or delete 0:/CONFIG/machine.cfg and let it re-default. Homing does not need to be repeated to keep a work offset — it only settles the machine datum, so an offset already set survives it.

Chapter 5 — Technical Specifications

AXES 4 (X, Y, Z, 4th)	DISPLAY 128 × 64 Mono	STEP CEILING 125 kHz / axis	SUPPLY 24 V DC 1 A
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Parameter	Specification / Value
Supply voltage	24 V DC $\pm 10\%$ (1 A nominal), reverse-polarity protected
Controlled axes	Four axes: X, Y, Z, plus a configurable 4th (rotary A/B/C or linear)
Command interface	Differential Step & Direction (5 V RS-422 line drivers)
Maximum step frequency	125 kHz ceiling per axis (8 μ s fixed step-interrupt period)
Step pulse width	1 to 100 μ s programmable, default 5 μ s
Direction setup time	0 to 100 μ s programmable, default 10 μ s
Steps per unit	1 to 100,000 steps/mm (linear) or steps/deg (rotary) per axis
Maximum velocity	1 to 200,000 mm/min (linear) or deg/min (rotary) per axis
Acceleration	1 to 200,000 mm/s ² (linear) or deg/s ² (rotary) per axis
Digital inputs	14 opto-isolated inputs, 24 V logic, pulled up and switched to ground (sinking, 5 mA)
Relay outputs	4 SPST dry contact relays (SPINDLE EN, SPINDLE DIR, COOLANT/M8, MIST/M7 rated 250 VAC / 30 VDC, 5 A)
Spindle speed command	0–10 V DC analog output or PWM (1 Hz to 1 MHz configurable)
Display & interface	Handheld pendant with 128 × 64 monochrome LCD and 24-key tactile keypad (DB9 link)
Work coordinate systems	Six independent work coordinate systems (G54 through G59)
Program storage	SD card slot and USB flash drive host port
Memory retention	Battery-backed non-volatile RAM; offsets, parameters, and positions survive power cut
Operating temperature	0°C to 50°C (32°F to 122°F)
Operating humidity	10% to 90% RH, non-condensing

NOTE

Appendix B gives the derived step-rate ceiling that the 8 μ s step-interrupt period imposes, with the settings that govern it.

5.1 What This Product Does Not Have

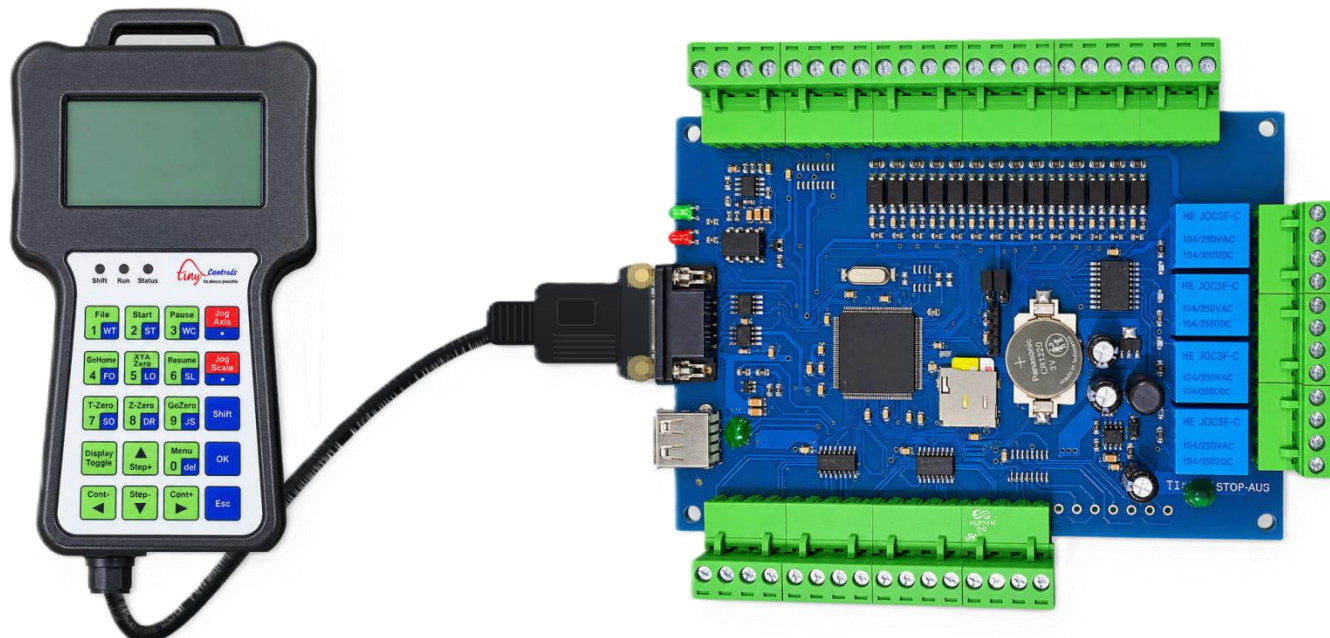
Named because their absence is a design decision or a stated current limitation, not an omission left to be discovered:

- No clock. There is no battery-backed calendar on this board, and offering to set one that cannot survive a power cut would be a lie.
- No editable tool table. Tool length is measured by probing, never typed (Chapter 9, Tool Changes and Tool Length).
- No handwheel. Jogging is by key only.
- No toolpath preview. Z-Inhibit exists as the equivalent — running the path in the horizontal plane while watching it, which is why it is a real motion mode and not a simulation (Chapter 7, Work Offsets and Touch-Up).
- No coolant key on the keypad. Coolant is controlled from the program only, since both relay outputs it could use are already carrying spindle enable and spindle direction on the shipped assignment.
- Pendant contrast and backlight settings do not currently move the panel. The setting is stored and readable, but has no visible effect.

Chapter 6 — Controls and Display

The controller is operated from the board and from the handheld pendant, which carries its own display and keypad and connects over the DB9 port.

Figure 6.1 — Pendant and Controller



Three keys behave differently from the rest and are worth learning first.

Key	Behaviour
Esc	Stops the machine, from anywhere, ahead of every screen, menu or prompt. If the machine is moving, Esc stops it and does nothing else; press it again to navigate.
Shift	A one-shot latch, not a held key. Press it, then press the key it modifies. Pressing it twice cancels.
Long press	Held for 0.6 seconds. Fires while held, not on release, so the cue and the action happen together.

6.1 Jog

Jog is always live on the position display — there is no separate jog mode.

- Jog Axis cycles $X \rightarrow Y \rightarrow Z \rightarrow A$.
- Jog Scale cycles the step: $x1, x10, x100, x1000$, where $x1$ is one micron and $x1000$ is one millimetre.
- Step $+/-$ moves by that increment.
- The left/right jog keys jog continuously while held.

6.2 Shifted Keys

Press Shift, then the key. The overlay prints the shifted meaning beside each key.

Key	Does
WT	WCS Table — view and set the work offsets (section 7.2, Offsets Persist).
WC	Work Coordinate correction — Touch Up (section 7.4, Touch Up — Correcting the Datum by Jogging).
SL	Store Location — Store / Go To / Clear (section 7.5, Store Location).
ST	Spindle toggle.
FO	Feed override.
SO	Spindle override.
LO	Limit override — to jog off a tripped switch.
DR	Z-Inhibit — run the path in the horizontal plane only (section 7.6, Z-Inhibit — Running the Path in the Air).
JS	Jog speed.

NOTE

Keys with no printed shifted legend have no shifted function, deliberately — on a machine with one small screen the overlay is the only reference available.

6.3 Screens

Screen	Reached by	Shows
Position display (home)	Default screen	Active frame, tool, jog scale, selected axis large, the others below, loaded program and state.
Run / Hold	Automatic while a program runs	Pause holds, Resume continues, Esc aborts.
Files	File key	SD and USB panes, newest first, with sizes. OK loads; long-OK copies SD to USB; Delete removes (SD only, with confirmation naming the file).
Homing	Opens automatically when a cycle starts	Each axis as waiting, seeking, or referenced, with the cycle's own message on the last line.
Probe	T-Zero (work Z) or long T-Zero (tool length)	Live Z and the current pass; OK starts.
Store Location	Shift + SL	Store / Go / Clear (section 7.5, Store Location).
Power-loss recovery	Automatic at power-up after an interruption	Section 6.4.
Touch Up	Shift + WC, idle or held	Section 7.4.

Screen	Reached by	Shows
Menu	Menu key	Machine config, controller config, I/O mapping, diagnostics, update pendant, security.

Display Toggle switches the position readout between work and machine coordinates; the frame field reads the machine-frame label in that view.

6.4 Power-Loss Recovery

Offered automatically at power-up when a program was interrupted. Five steps, in an order chosen so nothing irreversible happens early.

Step	What it does	Moves?
Ask	Shows the job, the line, the position.	No
Reload	Re-parses the program.	No
Reference	Settles the datum by jogging or homing.	No
Outputs	Choose which come back.	No
Resume	Re-enters the program.	Yes

NOTE

Esc leaves without discarding — the recovery is still offered next time. Only Delete discards it. Reference settles the machine datum only; work offsets need no settling, since they were saved on the last change and are already restored by the time the wizard appears (Chapter 7, Work Offsets and Touch-Up) — so a resumed program computes from the same origin it was cutting to. On Resume the machine lifts to safe height, traverses, and only then plunges, because the tool may still be down in the part.

Chapter 7 — Work Offsets and Touch-Up

Telling the controller where the work sits, and correcting that answer without losing it. A datum set here survives a power cut, so most of this chapter is done once per job rather than once per shift.

7.1 Where the Datum Lives

Three ways to set a work offset, suiting different moments.

XYA Zero / Z-Zero	This position is zero — a declaration, no motion.
T-Zero	Probe down and set Z zero from the contact (section 6.3, Screens).
Shift + WC	Correct an existing datum by jogging (section 7.4, Touch Up — Correcting the Datum by Jogging).

Shift + WT shows the whole offset table, chooses the active frame, and lets a value be typed directly.

7.2 Offsets Persist

All work systems, and which one is active, are written to the card and to battery-backed memory on every change — a set command, a zero key, the offset table, a touch-up. The card copy is the durable one; the battery-backed copy is the one that survives a power cut which did not wait for the card write, and it wins at startup because it cannot be the older of the two.

NOTE

That matters most for recovery: after a power cut the machine restores its position, its active frame and its offsets, so a resumed program computes from the right origin.

7.3 The Two Zero Keys Are Deliberately Asymmetric

XYA Zero acts on whichever axis Jog Axis currently selects, and only if that is X, Y or A. Z-Zero acts on Z, always, whatever the jog selection is.

The asymmetry follows the work: X, Y and A are zeroed once when a job is set up, so routing them through the jog selection costs nothing. Z is re-zeroed at every tool change, far more often, and usually while some other axis is still selected, so making it wait on a selection change would be friction on the most repeated action in the job.

NOTE

XYA Zero while Z is the selected axis is ignored — no axis is zeroed. It never falls through to Z.

7.4 Touch Up — Correcting the Datum by Jogging

Available idle or held. The answer to "this cut is too shallow" when the number needed is not known — because it usually is not. Jog until it looks right and the control absorbs the difference.

Key	Does
Step +/-	Nudge the selected axis.

Key	Does
← / →	Select the axis — they do not move it here.
Jog Scale	Step size.
Resume	Apply the correction, and continue if a program was held.
Esc	Put the tool back, and discard.

NOTE

The screen shows only the deltas — the numbers being decided about — because that is what is being decided, not the absolute position. Continuous jog is deliberately unavailable: a correction is a few hundredths, and one long press of a velocity key would put metres into a datum.

What it actually does: the jogged distance is added to the active work offset, so the tool keeps the work coordinate it already had and every remaining move inherits the correction. That is also what makes it safe mid-program — a resume replans from the hold point in the work frame, so without the offset shift the first resumed move would drag the tool back onto the old path.

Typical use: a program is cutting air because the blank was not flat. Pause, Shift + WC, nudge Z down until the cutter bites, Resume. The rest of the job runs at the corrected depth.

WARNING

Esc puts the tool back rather than merely discarding the number — abandoning with the tool moved would leave exactly the hazard the correction exists to fix. The correction is written through the normal offset path, so a completed one reaches the card and outlives the job.

7.5 Store Location

Shift + SL. A machine-coordinate point parked somewhere repeatable — a dowel, a hard stop, a fixture corner — stored in battery-backed memory so it survives a power cut.

Item	Action
Store	Store the current machine position.
Go To	Travel to the stored location.
Clear	Discard it.

NOTE

Go To lifts Z to safe height, then traverses, and arrives above the mark, not on it. Store machine coordinates, not work coordinates, so the location stays meaningful across work-system changes. This is the manual re-anchor available after a power cut when the controller cannot otherwise confirm nothing moved while it was off.

7.6 Z-Inhibit — Running the Path in the Air

Shift + DR. Z is held where it stands; X, Y and the 4th axis run the program at programmed rate. This is not "the machine will not move" — with no toolpath render, watching it trace the path at the horizontal plane is the preview, and the whole point is that it moves.

WARNING

A Z-inhibited start is refused until the tool is at or above the configured safe height, naming the height to raise to. Z genuinely does not move during the pass, so without the refusal the tool would traverse the entire program at whatever height it was at when Start was pressed — sitting on the workpiece after setting Z0, it would rake across the part and every clamp at rapid.

The mode is captured when a run starts, so toggling mid-program changes the banner and nothing else until the next run. Usual order: set Z0, Shift + DR, raise Z clear, Start, watch, Shift + DR off, Start for real.

Chapter 8 — Diagnostics

Inputs shows a live bit row plus every input function decoded through the map. The bit row shows activity, not voltage: dots at rest, a mark when something is active.

Bit row	Function row	Meaning
Active	On	Wiring, mapping and polarity all agree.
Active	Off	The polarity row is set the wrong way.
No change	—	Not wired to the pin the mapping claims.
Active at rest	—	Stuck or shorted input.

Outputs lets each relay be toggled individually — this is also the bring-up test: four presses should give four distinct clicks. Link shows pendant link counters.

Chapter 9 — Tool Changes and Tool Length

There is no tool table that can be edited, and that is deliberate. Tool length is measured, never typed. With tool change set to Pause, an M6 in the program stops the machine and the spindle, and shows the tool number waiting for a change. Change the tool by hand and press Resume. The controller then:

1. re-probes the new tool, lifting and traversing to the setter first if that option is set,
 2. shifts work Z by the difference between this tool and the last,
 3. continues the program.
- The first measurement of a session sets the reference and shifts nothing — there is no previous tool to differ from.
 - A probe that finds nothing does not resume. The new tool is unmeasured, which is exactly what the re-probe exists to prevent.
 - With no probe pin mapped, the hold behaves as a plain pause.

NOTE

The remembered length is lost on a power cut, on purpose: the next probe re-establishes it rather than shifting work zero against a length from before the outage.

Chapter 10 — G-code Reference

Every code this controller reads, in four groups. The ones it acts on, the ones it accepts and ignores, the ones that stop a program loading, and the ones it skips a line for. Consult it when a program is refused or a cycle behaves unexpectedly.

10.1 Supported

Motion: G0, G1, G2, G3 (arcs in all three planes), G4 dwell. Planes and units: G17, G18, G19, G20 inch, G21 mm. Coordinates: G53 machine, G54–G59, G10 L2/L20 set offsets, G52 local offset, G92 set position, G90/G91 absolute/incremental, G90.1/G91.1 arc-centre mode. Feed: G93 inverse time, G94 units per minute. Reference: G28, G30 and their .1 set-position forms.

Code	Cycle
G81	Plain drill.
G82	Drill with dwell at depth.
G83	Peck, full retract to R each peck.
G73	Peck, partial retract (chip break).
G84	Tap — feed in, feed out.
G85	Bore — feed in, feed out.
G86	Bore — feed in, rapid out.
G88	As G86, with dwell.
G89	Bore — feed in with dwell, feed out.

G80 cancels; G98/G99 select the return plane. Q sets the peck increment, P the dwell, R the retract plane.

NOTE

G86 and G88 are specified to stop or reverse the spindle at depth. The motion is exact; the spindle action is not performed, and a one-time console note says so.

Motion mode: G61 exact stop, G64 blended. M-codes: M0, M1, M2, M30, M3, M4, M5 (with S), M7, M8, M9, M13/M14 (spindle and flood in one), M6, M48/M49 override enable, M62–M65 output control, M66 wait on input.

10.2 Accepted but Ignored

Code	Why
G43	Tool length is measured, not typed (Chapter 9, Tool Changes and Tool Length). By the time a program reaches G43 the compensation is already in the coordinate frame, so applying a table entry on top would add a second correction for the same tool. Accepted rather than refused, because ordinary posts emit it.
G49	Cancel — already the default.

Code	Why
G40	Cutter compensation off — already the default.
G15, G50, G69	Polar, scaling and rotation cancel — harmless.
G80	Cancel canned cycle.
G98, G99	Canned-cycle return mode.

10.3 Refused — the Program Will Not Run

These change the meaning of every following line, so running the file with them skipped would cut the wrong shape: G16 polar, G41/G42 cutter compensation, G51 scaling, G68 rotation, G95 feed-per-revolution — and three canned cycles: G74 left-hand tapping, G76 fine boring, G87 back boring.

WARNING

Refused rather than skipped, because a canned cycle is modal — bare coordinate lines after one are further points of that same cycle, so dropping only the defining line would silently omit every hole while still running the moves between them.

10.4 Not Supported — the Line Is Skipped

- G38.x probing inside a program. Probing is a panel cycle here (Chapter 6, Controls and Display and Chapter 9, Tool Changes and Tool Length), not a program instruction.
- Any other M word — warned per occurrence, with the motion on that line still run.
- No scripting or macros, by design on this product.

10.5 File Names

CAM output rarely follows the 8.3 naming convention, and that is fine — long file names work on the card. Only files touched by the bootloader must be strict 8.3.

Chapter 11 — Settings Reference

All settings live in the menu, generated directly from the firmware's own configuration schema — a range printed here is the range the editor enforces, not a separate description that could drift out of step with it.

11.1 How the Menu Is Organised

The menu is three levels deep, and its top level is the set of configuration files on the card rather than a set of topics. MACHINE CONFIG and CONTROLLER CONFIG hold the settings, in groups; I/O MAPPING holds pin assignments; the last three entries hold no settings at all. A hundred and one fields are settable across the two configuration files — ninety-two in machine.cfg and nine in controller.cfg — plus the thirty-six pin and polarity rows under I/O MAPPING.

Entry	What it holds	Groups
MACHINE CONFIG	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. Saved as machine.cfg.	8
CONTROLLER CONFIG	How this unit behaves — the rate overrides and the pendant display. Nothing here depends on the machine it drives, so it need not be copied with the machine file. Saved as controller.cfg.	2
I/O MAPPING	Which pin each of the fourteen input and four output functions sits on, and its polarity — two rows per function. Saved as io.cfg.	—
DIAGNOSTICS	Live input, output and link pages (Chapter 8, Diagnostics). No settings.	—
UPDATE PENDANT	Reflashes the pendant over the link. No settings.	—
SECURITY	Device identity and licence, read-only.	—

NOTE

The split between the two configuration files is the point of it: a second identical machine is set up by copying machine.cfg alone, without carrying the first one's pendant brightness across with it.

MACHINE CONFIG holds eight groups:

Group	Covers	Fields
GENERAL	Optional stop and tool-change behaviour, step pulse and direction timing, corner and arc tolerance, acceleration smoothing, the starting motion mode and single-block.	9
X / Y / Z-AXIS	One page per linear axis, identical rows: scaling, rate, acceleration, travel bounds, direction invert, jog flip, backlash.	24
4TH AXIS	The same rows as a linear axis, plus the rotary or linear choice, its letter,	12

Group	Covers	Fields
	rollover and continuous rotation.	
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 and the PWM frequency and duty span it maps onto.	7
TOOL ZERO	The sensor height, the approach and retract distances and rates, and the optional fixed setter position.	9

CONTROLLER CONFIG holds two groups:

Group	Covers	Fields
RATES	The fixed feed and rapid overrides and the continuous-jog velocity.	3
DISPLAY	Pendant backlight, contrast and ratio, and the Shift, Run and Status LED brightness.	6

11.2 Navigation and Editing

Three levels: sections, then rows, then an exit prompt. A single-section file skips the section level and lands straight on rows.

Key	Does
▲ ▼	Move the cursor.
◀ ▶	Nudge the highlighted value (coarse — ×10 — on floats).
OK	Numeric row opens the keypad; boolean toggles; labelled enum cycles.
Esc	Back one level; from the top, offers Save or Discard if anything changed.

OK on any magnitude opens typed entry on the numeric keypad (section 11.3, The Numeric Keypad); the arrows still nudge for a small correction.

NOTE

A field whose editor wraps at the range ends is cyclic — an enum, or a pin assignment where -1 means unassigned. A magnitude clamps at its ends instead.

11.3 The Numeric Keypad

The top ten keys carry a printed digit for use while a numeric field is open; the digit tier is inactive at every other time so it never shadows the primary function printed above it. The two red jog keys carry

the decimal point and minus sign on their shifted tier, and the menu key carries delete, so a full numeric entry is reachable while editing.

1	2	3
4	5	6
7	8	9
	0	

- The field is seeded with the current value; the first digit typed replaces it.
- Range is clamped on accept, not per keystroke — rejecting digits as they are typed would make the keypad feel broken on the way to a valid number.
- An empty field cancels rather than committing zero. Zero is a legitimate value and can be typed; silently committing it because everything was deleted is how a travel limit becomes 0.000.

11.4 Exit: Save or Discard

Edits are applied to the live configuration immediately, so their effect is visible while they are made. The commit is a separate decision, and the prompt appears only if something actually changed.

Choice	Does
Save	Writes the configuration to the card.
Discard	Restores the snapshot taken on entry.
Esc	Cancels the exit and returns to editing.

11.5 MOTION and Per-Axis Settings

Ranges and defaults for every field below are in Appendix C, Complete Settings Menu Tree, in panel order.

Field	Notes
Steps per unit	
Maximum rate	Per minute.
Acceleration	Per second squared.
Travel min / max	Machine-frame soft-limit bounds. Default X/Y 0...+1000, Z -100...0.
Direction invert	Reverses the direction output.
Jog flip	Reverses the jog keys only, leaving the direction output alone.
Backlash	Millimetres of lost motion, taken up on reversal.

NOTE

Z runs negative-down on this product: machine zero is the top of Z travel and the tool works downward, which is the usual mill convention and the one the rest of the firmware assumes — every retract is capped at the travel maximum, so a Z maximum of 0 means never above the top of travel. The shipped travel numbers have the right shape for this convention; narrow them to the machine rather than flipping the signs.

The 4th axis carries the same rows, plus type (rotary or linear), rollover (wraps the displayed position at 360°), and continuous (unlimited rotation — soft limits do not apply and travel bounds are ignored). A rotary letter is chosen from A, B or C; a file using a different letter for that axis is refused, not silently ignored.

11.6 HOMING

Ranges and defaults for every field below are in Appendix C, Complete Settings Menu Tree, in panel order.

Field	Notes
Home axis in cycle	
Seek direction	Direction, not switch polarity — polarity is set in I/O mapping.
Switch coordinate	Machine coordinate the axis reads when the cycle datums it.
Park coordinate	Machine coordinate to move to once referenced.
Homing sequence	Ascending; equal numbers group and home together.
Search cycles	
Debounce	
Sensor clear	Back-off margin after release.
Approach rate (fast)	First seek.
Confirm rate (slow)	Reseek and every release.
Z safe	Work-frame height to lift to before homing X/Y and for Go Zero / Go To. Skipped when Z is already above it.
Lift Z before homing X/Y	Spliced in immediately after Z's own homing entry — only protects axes sequenced after Z.
GZ lift enable	Go Zero lifts to Z-safe first.
Abort retract	On Stop, rapid Z to safe height.

WARNING

A switch mapped as both a home input and a limit input is refused when homing is requested, naming the axis — homing drives deliberately into the switch, so the limit kill would fire at the moment the cycle succeeded. Use limit override if that is genuinely intended.

Two behaviours worth knowing: axes sharing one switch pin are homed one at a time, not together, even on the same sequence number; and a park coordinate that is behind the switch or further than the axis travel is refused rather than driven to.

11.7 LIMITS

Field	Meaning
Hard	Arms the limit kill. Off by default until every switch has been watched on the diagnostics page.
Soft	Refuses moves outside travel bounds; only applies to referenced axes.

11.8 SPINDLE

Ranges and defaults for every field below are in Appendix C, Complete Settings Menu Tree, in panel order.

Field	Notes
On delay	Spin-up dwell after M3/M4 before the first cut. Also paid on a tool-change resume.
Mode	
Min / max RPM	The speed at minimum / maximum duty.
PWM frequency	
PWM min / max duty	Set to the ends the drive actually honours; the RPM mapping follows.

11.9 TOOL ZERO

Ranges and defaults for every field below are in Appendix C, Complete Settings Menu Tree, in panel order.

Field	Notes
Sensor height	Height of whatever the tool touches, above intended Z0. Set 0 when the tool contacts the work directly.
Backoff	Retract between the fast and slow pass.
Distance	Maximum probe travel before no-contact.
Feed / seek	Fast approach / slow confirming pass.
Pulloff	Final retract after capture.
Use fixed position	OFF probes where the machine stands; ON lifts and traverses to a stored setter position first.
Setter X / Y	Machine coordinates, read only when the fixed position is used.

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.

11.10 GENERAL

Ranges and defaults for every field below are in Appendix C, Complete Settings Menu Tree, in panel order.

Field	Notes
Optional stop	
Tool change	M6 behaviour (Chapter 9, Tool Changes and Tool Length).
Step pulse width	Raise it if a driver misses steps.
Direction setup	How long the direction line must be stable before the first pulse.
Junction deviation	Corner tolerance.
Arc tolerance	Arc chord tolerance.
Smooth time	Acceleration smoothing; 0 is off.
Motion mode	
Block run	Single-block mode.

WARNING

The step interrupt has a fixed ceiling (Appendix B, Integrator Technical Specifications). If maximum rate multiplied by steps per unit exceeds it, the axis simply runs slower than the number says, and the page warns on both the rate rows and the pulse-width row.

11.11 RATES and DISPLAY

Ranges and defaults for every field below are in Appendix C, Complete Settings Menu Tree, in panel order.

Field	Notes
Fixed feed	Non-zero replaces every programmed feed. 0 is off.
Fixed rapid	Non-zero caps rapid velocity. 0 is off.
Jog velocity	Continuous-jog speed, also set from Shift + JS.
Pendant backlight	
Pendant contrast	-1 leaves the pendant's own default.
Pendant contrast ratio	

Field	Notes
Shift / Run / Status LED	Indicator brightness, not panel illumination.

NOTE

A non-zero fixed rate overrides every programmed rate in the file. Useful while proving a machine; left set, it presents as a program cutting at the wrong speed with no bad number in the G-code. Continuous jog velocity set from Shift + JS is clamped to the slowest enabled axis's maximum rate, since the axis being jogged can change with a single keypress; the same field edited directly in the menu is bounded only by its own range.

Chapter 12 — I/O Mapping

Two rows per function: the pin and its polarity. Functions are assigned to pins, never the other way round.

Group	Functions
Inputs (14, NC/NO polarity)	Home X/Y/Z/4th, Limit X/Y/Z/4th, Probe, Ext E-Stop, Cycle Start, Feed Hold, Stop, Block Run.
Outputs (4, HI/LO polarity)	Spindle Enable, Spindle Direction, Coolant, Mist.

NOTE

All fourteen inputs are pulled up and switched to ground, so a plain normally-open switch reads active-low, which the editor calls NO. New assignments default to NO. For outputs, LO means active-low drive.

Chapter 13 — Messages and Alarms

Message	Meaning
NO AXIS SET TO HOME	Homing was requested with no axis enabled for the cycle.
<axis> FAILED: not seen	The seek ran past its travel cap without a trip — wrong direction, or an unwired switch.
HOMED - REFERENCED	The axis has stamped its datum and the cycle has moved on.
<axis> HOME IS A LIMIT	That axis's home input is also mapped as a limit, and the hard-limit kill is armed. Homing is refused until limit override is used, or the mapping is corrected.
AXIS NOT REFERENCED	A probing cycle was requested on an axis that has not been homed or referenced.
ALREADY TRIGGERED	The probe input already reads made before the cycle starts. Refused before any motion, since the cycle would otherwise terminate instantly at the wrong height.
PROBE PIN IS A LIMIT	The probe input shares a pin mapped as a limit.
NO CONTACT	A probe travelled its full configured distance without a trip. No offset is written.
GO ZERO: NOT REF	A traverse to work zero was requested on an axis that is not referenced.
TOOL REF $\pm x.xxx$ / TOOL $+x.xxx$ APPLIED	The first tool-change probe of a session sets the reference (no shift); a later one reports and applies the length difference.
SAVE FAILED - NOT WRITTEN - CHECK SD	A configuration save did not complete. The edits remain live so they can be retried or discarded; nothing on the card changed.

NOTE

A failed or skipped axis does not abort a homing cycle for the others — the remaining axes still get their turn, and the summary names what stayed unreferenced.

Chapter 14 — Warranty and Support

What the warranty covers, what it excludes, how to return a unit, and how to reach support.

14.1 Warranty

Tiny Controls warrants the TNC-M24 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.

14.2 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.

14.3 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.

14.4 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

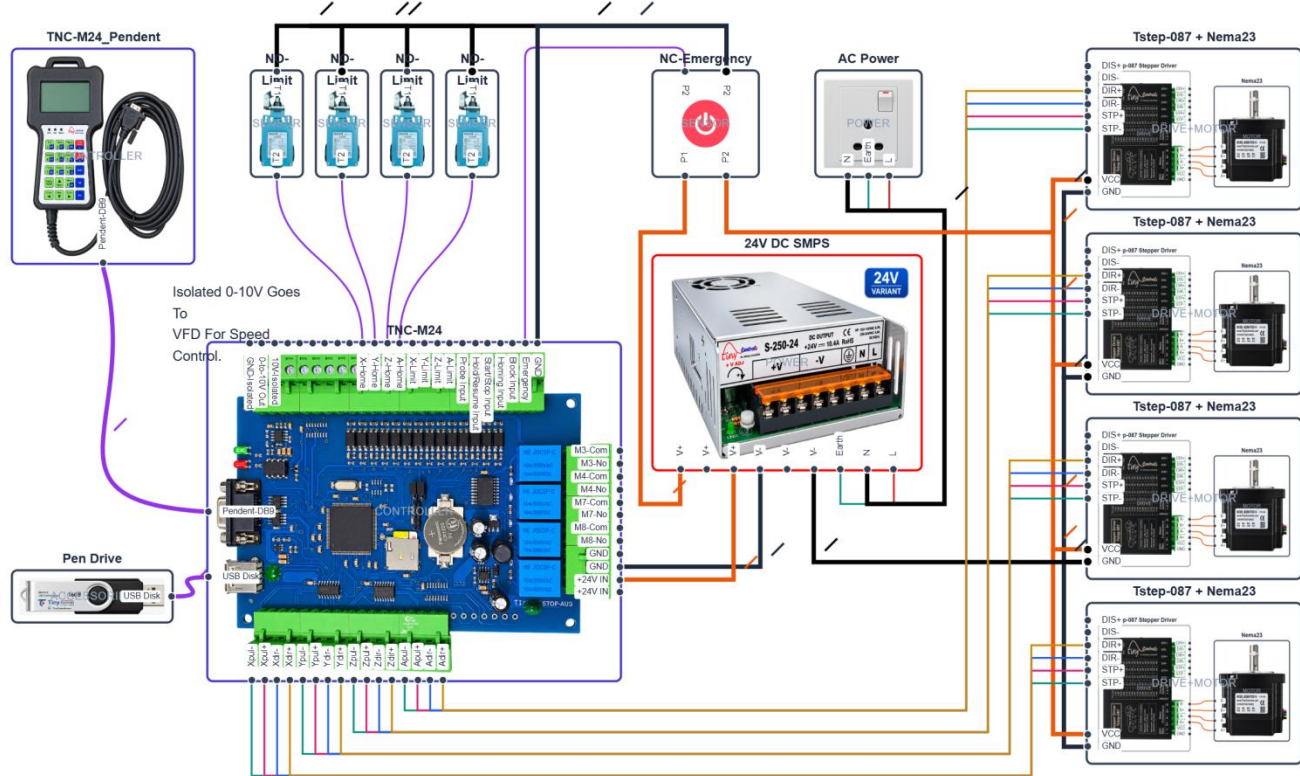
NOTE

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 using the limit switches, E-Stop chain and stepper drivers described in Chapter 3. Terminal names match the board exactly; use Chapter 3 for what each function does.

Figure A.1 — TNC-M24 Connection Diagram



Appendix B — Integrator Technical Specifications

Derived limits: figures that follow from a combination of settings rather than being set directly. Each is stated with the setting that governs it.

B.1 Step Rate Ceiling

The step interrupt has a fixed period of 8 microseconds — a ceiling of 125 kHz — because each interrupt does a limit check, a trip check, a four-axis interpolation and a square root, and asking for a shorter gap gives an interrupt that re-enters before it finishes rather than a faster machine. If maximum rate multiplied by steps per unit exceeds this ceiling, the axis simply runs slower than the configured number, on every axis it applies to at once — the page warns on the rate rows as well as the pulse-width row.

CAUTION

The step pulse width is checked against the ceiling this way: a 20 microsecond pulse cannot coexist with a 100 kHz step rate, since the pulse would not finish before the next edge is due. The settings page names the widest pulse that fits while the cursor is on that row.

B.2 Direction Setup Time

A direction change is followed by one whole step interval by construction, which at the 8-microsecond interrupt period is at least that long — so any setup time up to 8 microseconds is already paid for free. This setting only does anything when it asks for more than that, and then only on a move that actually reverses a direction line: it stretches that one interval. An axis continuing the same way waits for nothing.

Appendix C — Complete Settings Menu Tree

Every settable value on the panel, in menu order, with the range the editor enforces. Chapter 11 carries the reasoning.

```
MENU
+- MACHINE CONFIG                                machine.cfg
| +- GENERAL
| | opt stop ..... IGNORE M1 | HONOR M1
| | tool_change ..... IGNORE | PAUSE
| | step_pulse_us ..... 1 .. 100             whole us
| | step_delay_us ..... 0 .. 100             us, DIR setup
| | 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
| | max_rate ..... 1 .. 200000              mm/min
| | accel ..... 1 .. 200000                mm/s2
| | travel_min ..... +-100000              mm, machine frame
| | travel_max ..... +-100000              mm, machine frame
| | invert ..... NORMAL | REVERSED          direction output
| | flip_jog ..... NORMAL | FLIPPED         jog keys only
| | backlash ..... 0 .. 100                mm
| +- 4TH AXIS
| | type ..... ROTARY | LINEAR
| | rollover ..... OFF | ON
| | letter ..... A | B | C
| | steps_deg ..... 1 .. 100000
| | max_rate ..... 1 .. 200000              deg/min
| | accel ..... 1 .. 200000                deg/s2
| | continuous ..... OFF | ON              unlimited, no soft limits
| | travel_min ..... +-100000              deg
| | travel_max ..... +-100000              deg
| | invert ..... NORMAL | REVERSED
| | flip_jog ..... NORMAL | FLIPPED
| | backlash ..... 0 .. 100                deg
| +- 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 mm         (4 rows)
| | pos_x y z a ..... +-100000 mm         (4 rows)
| | search_cycles ..... 1 .. 10
| | debounce_ms ..... 0 .. 1000           ms
| | sensor_clear ..... 0 .. 1000          mm
| | feedrate ..... 1 .. 200000            mm/min, FAST approach
| | seekrate ..... 1 .. 200000            mm/min, SLOW confirm
| | z_safe ..... +-100000                 mm, WORK frame
| | 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
| | mode ..... 0-10V | PWM
| | min_rpm ..... 0 .. 300000
| | max_rpm ..... 0 .. 300000
| | pwm_freq ..... 1 .. 1000000           Hz
| | pwm_min_duty ..... 0 .. 100           %
| | pwm_max_duty ..... 0 .. 100           %
| +- TOOL ZERO
```

```
|
| sensor_height ..... +-100000      mm
| backoff ..... +-100000      mm
| distance ..... +-100000      mm
| feed ..... 1 .. 200000      mm/min, FAST
| seek ..... 1 .. 200000      mm/min, SLOW
| pulloff ..... +-100000      mm
| use_pos ..... OFF | ON
| setter_x ..... +-100000      mm, machine frame
| setter_y ..... +-100000      mm, machine frame
|
+- CONTROLLER CONFIG                      controller.cfg
| +- RATES
| | fixed_feed ..... 0 .. 200000      mm/min, 0 = off
| | fixed_rapid ..... 0 .. 200000      mm/min, 0 = off
| | jog_vel ..... 1 .. 200000      mm/min, continuous jog
| +- DISPLAY
| | pend_backl ..... 0 .. 100          %
| | pend_contrast ..... -1 .. 63      -1 = panel default
| | pend_ratio ..... 0 .. 7
| | led_shift ..... 0 .. 100          %
| | led_run ..... 0 .. 100          %
| | led_status ..... 0 .. 100          %
|
+- I/O MAPPING                            io.cfg
|   two rows per function: PIN then POLARITY
| inputs x14 ..... pin -1 .. 15 (-1 = none), pol NC | NO
|   HOME X . HOME Y . HOME Z . HOME 4TH
|   LIMIT X . LIMIT Y . LIMIT Z . LIMIT 4TH
|   PROBE . EXT E-STOP . CYCLE START . FEED HOLD . STOP . BLOCK RUN
| outputs x4 ..... pin -1 .. 15 (-1 = none), pol HI | LO
|   SPINDLE EN . SPINDLE DIR . COOLANT . MIST
|
+- DIAGNOSTICS ..... INPUTS / OUTPUTS / LINK -- no settings (Chapter 8, Diagnostics)
+- UPDATE PENDANT .... reflash the panel over the link -- no settings
+- SECURITY ..... device ID and licence -- read-only
```

NOTE

Work offsets and the tool table are not in this tree: offsets are reached from Shift + WT (Chapter 7, Work Offsets and Touch-Up) and the tool table is measured, not typed, and is not reachable from the panel at all (Chapter 9, Tool Changes and Tool Length).

Appendix D — Quick Reference Card

D.1 Three Keys to Learn First

Key	Behaviour
Esc	Stops the machine, from anywhere.
Shift	One-shot latch — press it, then the key it modifies.
Long press	0.6 seconds, fires while held.

D.2 Shifted Keys

Key	Does
WT	WCS Table.
WC	Touch Up.
SL	Store Location.
ST	Spindle toggle.
FO / SO	Feed / spindle override.
LO	Limit override.
DR	Z-Inhibit.
JS	Jog speed.

D.3 Before the First Run

1. Set steps per unit, rates and accelerations on every axis in use.
2. Watch every input on Diagnostics before arming the hard limit kill.
3. Test every relay — four distinct clicks.
4. Prove jog: move one axis, confirm the other three are unchanged.
5. Home one axis at a time, with a hand near Esc.
6. Probe to set a work datum, then load and run a program.

D.4 Three Things That Bite

- XYA Zero does nothing while Z is the selected jog axis — it never falls through to Z.
- A shared home/limit switch refuses homing until limit override is used.
- Z-Inhibit still moves the machine in X, Y and the 4th axis — only Z is held.