

ShopBot PRSalpha 144-60

Operating, maintenance and debugging

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The ShopBot PRSalpha 144-60: how it works, how to run it, what goes wrong

Read sections 1, 2 and 4 before your induction; section 3 is the detail behind section 4. Print section 5 and keep it at the machine until the procedures are in your hands. When something goes wrong, go to section 6 and start from what you see. The figures in the PDF are static illustrations. The [online 3D model](#) demonstrates ten faults; all 39 are described in section 7.

1 Before you touch it: the rules

A 4 HP spindle turning a 6 mm cutter at 12 000 rpm does not know you are there. The machine moves at up to 760 mm/s between cuts and has no idea what a hand is. The rules below are ShopBot's own safety list plus the lab's; each one is there because the alternative is an injury, a broken machine or a fire.

- **Trained and signed off.** You run this machine only after the lab's induction and with the instructor's sign-off. Students who have not been signed off operate the machine only with a signed-off person at the E-stop.^[4,60]
- **Never alone, never tired.** Two people in the room; the second person knows where the E-stop is: the red button on the wall-mounted pendant by the monitor, the only one on this machine.^[60,63,64]
- **Eye and ear protection for you and anyone watching,** from the moment the machine is powered. No gloves, loose clothing, hair, lanyards anywhere near the gantry.^[4]

- **Hands off the rails and out of the cutting area whenever the control box is on** — unless the spindle is stopped, the interlock key is OFF and in your pocket, the keypad is closed and no file is loaded or paused. The machine can move without warning, in any direction.^[4]
- **Key out for hands-on work.** Spindle off and stopped, interlock key OFF and in your pocket before you change a bit, touch the collet, or load, move or clamp material.^[4, 11, 63]
- **Never leave a running job.** Fires start in dust under the brush when a tool rubs, hits a screw, or a dull cutter burns hardwood. Stand where you can see the cut and reach the E-stop.^[4, 36, 43]
- **Know the two ways to stop** — the box below. Use them without hesitating; a ruined sheet is cheaper than anything else.^[4, 10, 11]
- **Spindle at speed before OK.** When the screen says “Press START on control before pressing OK”, start the spindle from the pendant; it must be running at the commanded speed before you click OK — the box below. A still bit dragged through plywood snaps and the pieces fly.^[4]
- **Extraction on.** Switch the dust collector on at the collector itself (it is manual; the software does not switch it). It runs whenever the spindle runs. If the hose comes off the foot or the brush skirt is damaged, stop and tell staff.^[13]
- **Clean up; leave the machine powered.** Stop the file and spindle, remove the key before reaching in, brush the rails and racks, vacuum the deck, put the bits back and report problems. Users never power down the machine; leave it for lab staff. Use E-stop in an emergency, not to finish a session.^[13]

How to stop a PRSalpha

Spacebar (or Enter, or the on-screen Stop)

Routine stop. Motion ramps down, Z lifts to its safe height, position is kept, so you can resume. **Treat the spindle as live:** depending on setup it may keep turning, coast down, or restart when you resume. A spacebar stop is not isolation. Before reaching in: spindle stopped, key OFF and removed, keypad closed, no file loaded or paused. Keep clear before restarting.^[4, 11]

E-stop (the red mushroom on the wall-mounted pendant by the monitor — the only E-stop on this machine. The red-and-yellow rotary handle on the control cabinet is the power disconnect, not an E-stop)

When something is wrong. Cuts spindle power immediately and motor power about 5 s later. Afterwards the machine no longer knows where it is: twist the E-stop to release it, press pendant **Reset**, then **C3** and **C2** before cutting again. There is no soft "Stop" button on an alpha pendant; its three buttons are **Reset · Start · E-stop**.^[2, 10, 11]

If the software has frozen or lost the controller

The spacebar does nothing and the spindle keeps running. **E-stop** is the only control that still kills the spindle.^[10]

How to start a job on a PRSalpha

1. Spindle RPM Control window open (Tools → Spindle RPM Control, or type **TR**), RPM typed, **Enter**. Leave the window open all session.^[4]
2. **FP**, pick the file, check Offset = **No Offset**, Start.^[4]
3. The screen prompts “Press START on control before pressing OK”. Press the green **START on the three-button pendant**.^[4,63]
4. Check the spindle is running at the commanded speed; the VFD's rpm display should show the number you typed. There is no separate RUN step on the VFD.^[4,63]
5. Only then: **OK** on the screen. Cutting begins. Hand near the stop for the first plunge.^[4,63]

ShopBot's own list, from the manuals

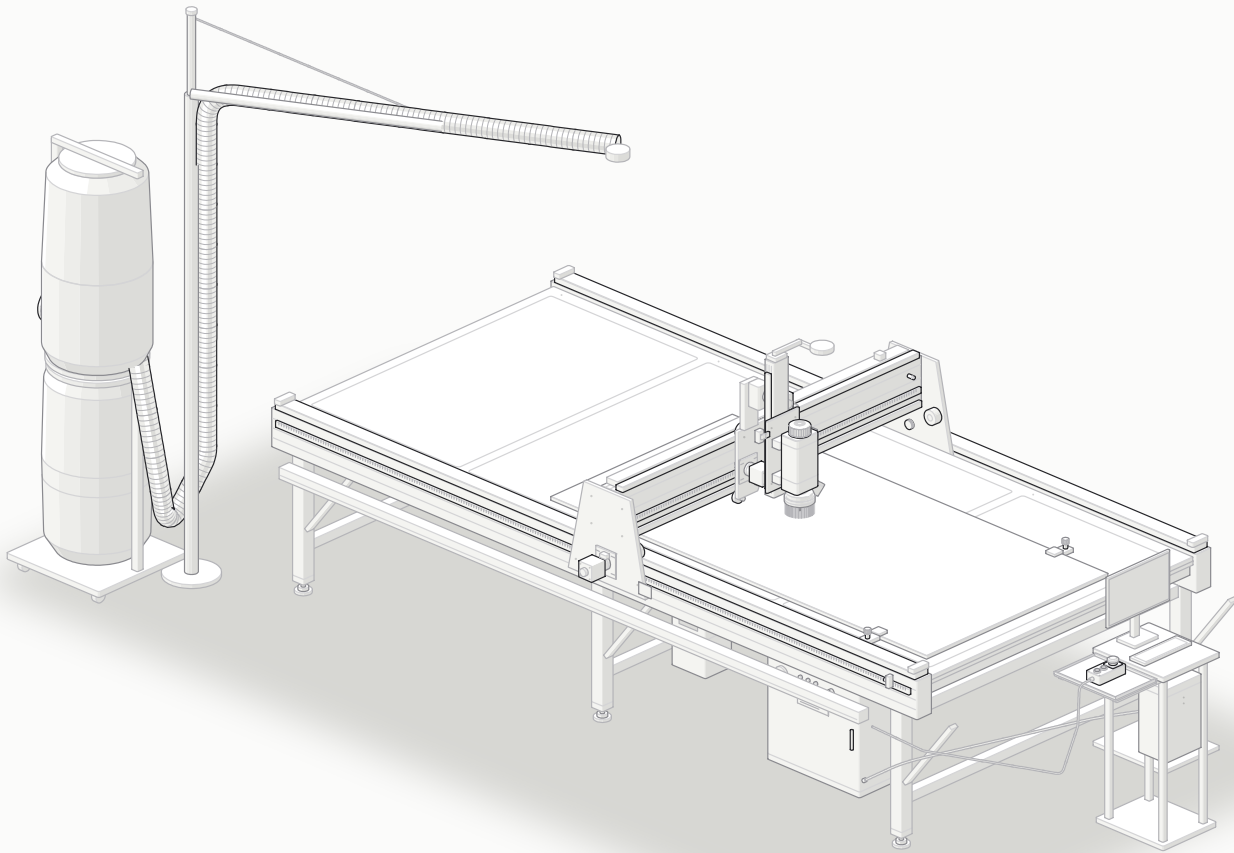
- Wear eye and ear protection. This applies to the operator and to everyone watching ^[QS 5].
- Wear closed-toe shoes. Never wear gloves at the machine ^[QS 5].
- Never put your hands on the rails. The machine can move without warning ^[QS 5].
- Never leave the machine running unattended. A spinning tool makes heat and is a fire risk. Keep a working extinguisher within reach ^[QS 5; UG 5].
- Know where the E-stop is before operating. This machine has **one**: the red mushroom on the wall-mounted pendant by the monitor. The red-and-yellow rotary handle on the control cabinet is the power disconnect, not an E-stop ^[QS 5].
- During a cut, stand within reach of the keyboard or the STOP button and away from the tool path ^[UG 6].
- Position the dust skirt correctly. It guards against flying particles ^[UG 6; UG 45].
- Practise with the software before you turn on the spindle ^[UG 5].
- Before reaching into the machine: spindle off and stopped, interlock key OFF and removed, keypad closed, no file loaded or paused. Keep the key in your pocket while loading or moving material, changing a bit or cleaning ^[UG 5; QS 5].

2 The machine

The University's PRSalpha is a 12 × 5 ft moving-gantry router: the table stands still, a bridge carries the spindle along the table (X), a car carries it across the bridge (Y), and a plate lifts it (Z). Four closed-loop stepper motors turn pinions in racks; nothing is hydraulic, nothing is a ball screw. Learn the parts by name now: every fault later in this page is one of them failing.

Fig 1

SHOPBOT PRSALPHA 144-60



idle

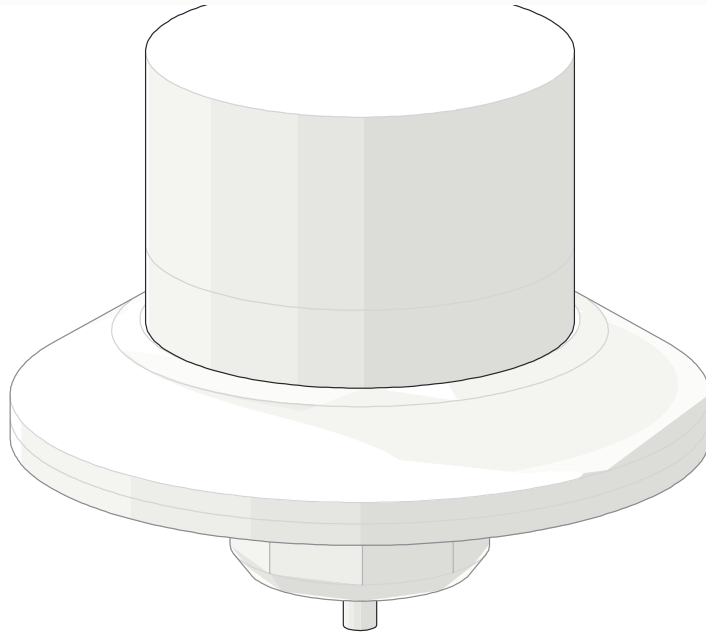
- ◇ The cut: the groove the bit leaves in the sheet
- ◇ Drive train: V-rails, V-wheels, racks and pinions on all three axes
- Services: dust hose, cable carriers, Z-zero lead, control box, VFD, pendant and PC

ShopBot PRSalpha 144-60, viewed from the operator's corner. Catalogue reference movement area 389 × 155 × 20.3 cm (153 × 61 × 8 in). Two closed-loop alphaStep motors, one on each tapered end plate, pull the gantry along racks on the outside of the aluminium table sides through 7.2:1 gearboxes and 30-tooth pinions; V-wheels on the inside of the plates ride hardened rails on top of the sides. The YZ car hangs on a top V-rail and a lower V-rail on the beam's front face and is driven by the Y motor through

the rack between them; the Z extrusion runs in bearing blocks on the car and is lifted by the Z motor on a rack along its side. One step is 0.01 mm; rapids reach 760 mm/s. The HSD spindle holds a 6 mm two-flute bit in an ER25 collet at 12000 rpm; at 60 mm/s the chipload is 0.15 mm per tooth. The figures are static illustrations. The online 3D model runs a 600 × 400 mm profile and a 300 × 200 mm pocket in an 18 mm plywood sheet and demonstrates ten faults.

Fig 1b

AT THE TOOL



The same moment, 11× closer, with the brush half of the dust foot pulled off its magnets the way you do to reach the collet. The spindle nose with the foot's collar, the ER25 collet nut and the 6 mm two-flute bit. The tool detail shows the spindle nose, collet and cutter above the sheet.

Open the [online 3D model](#) to run the example job and view ten fault demonstrations.

What it is, in numbers

“144-60” is the nominal sheet class, not the footprint. The 2023 specification sheet lists a **153 × 61 × 8 in (3.89 × 1.55 × 0.20 m) movement area** and a **168 × 91 × 67 in (4.27 × 2.31 × 1.70 m) footprint**; the May 2022 assembly guide still describes the conventional **6 in (152 mm) Z**, with 12 in and 24 in tall-Z options.^[1,2] These are catalogue reference dimensions, not usable clearance for a job. Before running a tall setup, have staff check that the stock, fixtures, tool length and retract height fit. Do not disable limits.

table	bolted steel legs and supports with aluminium T-slot side extrusions; not a welded one-piece frame. Base layer 3/4 in plywood on 3/8 in carriage bolts, replaceable 3/4 in MDF spoilboard on top. ^[1,2,3]
rails	hardened steel V-rails with V-roller bearings on X and Y; eccentric rollers set the preload on the YZ car. Z rides a captured rail on five bearings per side (three concentric, two eccentric). ^[1,13,18,19]
drive	rack and pinion on all three axes , including Z. Two X motors (one per side), one Y, one Z. Pinions: 30 teeth on X and Y, 25 on Z. Gearboxes 7.2:1 low-backlash tapered-hob. ^[1,2,27]
motors	This machine uses Oriental Motor ARM98AC-T7.2 alphaStep closed-loop steppers. Feedback is at the motor shaft — not at the rack, the bit or the workpiece. ^[2,23,27]
resolution	2482.8 steps/in on X and Y (0.0004 in ≈ 0.010 mm), 2979.4 steps/in on Z, resolution multiple 5. ^[1,27]
speed	positioning 1800 in/min (30 in/s, 762 mm/s) XY and 900 in/min Z; up to 720 in/min (12 in/s) XY and 360 in/min Z under full cutting force; about 150 lbf of cutting force at 60 in/min. ^[1]
control	Windows PC → USB → PRSalpha control box (control board, four drivers, contactors) → motors. Files are OpenSBP .sbp text. 8 inputs / 8 outputs at 5 V logic (~5 mA). This machine's control box: Alpha control Box Model# 10372 , firmware 224; SB3 version 3.8.70. ^[1,2,10,11]
spindle	Spindle: HSD AT/MT 1073-140 . Nameplate rating: 3 kW S6 , 220 V three-phase, 300 Hz, 18,000 rpm, 13 A. S6 is an intermittent periodic duty rating, not an S1 continuous-power claim, and 18,000 rpm is the nameplate operating speed, not a confirmed maximum. Spindle controller: Yaskawa V1000, CIMR-VU2A0020GAA. ER25 collets with their matching nut. 24 V cooling fan. (ShopBot's packages: HSD 2.2 or 4 HP, or Colombo 5 HP.) ^[2,20,21,41]
sensors	input 1 Z-zero plate, input 2 X proximity, input 3 Y proximity, input 4 stop circuit, input 5 Z proximity; output 1 spindle, output 4 safety/spindle-enable. ^[2]

How the mechanisms work

The gantry (X)

The bridge is an aluminium extrusion between two end plates. Each plate hangs four V-rollers on the hardened rail that runs along the top of the side plate; two ride above, two below, so the car cannot lift. A motor on each end plate sits on a hinged mount pulled by a spring (3.5 turns past contact on spring mounts; on bolted motor plates, hold the pinion into the rack with 15–20 lb while tightening the four plate screws) so its pinion stays pressed into the rack on the outside of the side plate.^[2,13] Both X motors receive identical step trains. If one side stalls, its driver alarms and everything stops. If a pinion jumps teeth or slips on its shaft, the motor still turns the commanded amount: the bridge racks out of square *silently*.

The car (Y) and the Z plate

The YZ car repeats the same idea rotated 90°: rollers on a V-rail across the face of the beam, one motor on a pinion in the beam's rack. The Z plate rides one captured rail between two rows of five V-bearings (three fixed, two eccentric) per side and is lifted by a vertical rack — no leadscrew — so it moves at the same 7.2:1 ratio as the other axes. Because the gear train back-drives, Z can drop when unpowered; never push any axis by hand with the motors connected — position is lost and the drivers can be damaged.^[2,18,27] Too tight on the Z eccentrics means binding and lost position; too loose means a lateral slop you will see as a bad fourth side on every pocket.^[18]

Closed loop, but closed around the motor

An alphaStep motor runs open-loop until rotor position deviates by $\pm 1.8^\circ$ from command; at that point the driver switches to closed-loop correction. If correction cannot hold (an obstruction, a wrong feed, a damaged cable), the driver alarms, the control board stops everything, and the software says the location is no longer accurate.

^[1,22,23,30] Red LED blink codes on the AS driver: 1 overheat (~85 °C heatsink), 2 overload (>5 s above max torque), 3 overvoltage, 4 speed error, 5 overcurrent, 6 overspeed, 7 EEPROM, 8 sensor.^[22] What the loop cannot see: a pinion slipping on its shaft, a bit creeping in the collet, or a sheet moving under the clamps.

Spindle and VFD

The VFD makes the spindle's three-phase supply; the control box only tells it *on* (output 1 through the key interlock and the pendant Start) and, on packages with the RPM controller, *how fast* (the `TR` window or `TR,12000` in a file, SB3.5.5 or newer).^[4,21,53] The lab's full sequence: the screen prompts “Press START on control before pressing OK” → pendant Start → check the spindle runs at the commanded speed → OK → cutting begins. There is no separate RUN step on the VFD.^[4] Warm-up (`C5` , the lab's standard routine): 9000, 10 000 and 12 000 rpm for 3 min each at the start of the day or after more than 4 h idle.^[4,13] Chipload = feed ÷ (rpm × flutes); the figure runs a 6 mm two-flute bit at 60 mm/s and 12 000 rpm, 0.15 mm per tooth.^[11]

Zeroing and homing

`C3` drives to the X and Y proximity switches and backs off to the configured home. `C2` touches the Z-zero plate twice; input 1 must light when plate meets bit and clear when they separate. Zero can be the **material top** or the **table surface** — it has to match what the CAM post expects. If CAM assumed the stock top and you zeroed on the bed, every rapid and retract runs *inside* the material and every cut goes a sheet thickness into the spoilboard: crashes and broken bits. The reverse mismatch cuts air. Check `&PWZorigin` in the file header against the surface you touched.^[4,6] In this lab the ground clip stays clamped on the aluminium carriage plate; the circuit runs through plate → spindle → collet → bit, and `C2` is the only way students zero Z. `Z2` sets a temporary job origin where the tool stands; `SA / SR` switch absolute/relative, and units are set in Values → Display (`VD`), not by any of those.^[10,47]

Dust extraction and hold-down

The brush skirt under the spindle is clamped to the spindle collar; a 4 in flex hose runs to the collector. The dust collector is switched manually at the collector itself and is on whenever the spindle runs.^[13] Hold-down is a separate matter and, in this lab, mechanical only: screws into the spoilboard through the waste, clamps and shims for bowed stock, and tabs or an onion skin of 0.25–0.75 mm for every part that will be freed from the sheet.^[12]

3 Standard procedures

Power-up and leaving the machine

Power-up order

1. Check the area first. Inspect the wiring, the dust hoses and the table surface ^[MS 3]. Check the rails and racks. They must be clean, with no chips or scraps ^[QS 18]. Do not run the machine if a motor cable is damaged ^[QS 18].
2. Do not push the gantry by hand. If it looks out of square against the end stops, tell staff; squaring and pinion alignment are a staff task ^[MS 3; TM 19].
3. Turn on the control box. The box must be on before SB3 opens, or the software cannot connect ^[UG 10; QS 11]. A "thunk" when the motors power up and a hum at standstill are normal ^[UG 64].
4. Release the E-stop by **twisting** it if it was latched, then press **Reset** on the wall-mounted pendant by the monitor (its three buttons are Reset, Start and E-stop). Input 4 on the screen must stop flashing before the machine will move ^[CR 39; UG 47].
5. Start the PC and launch SB3 (version 3.8.70 on this machine). Double-click the ShopBot 3 icon ^[QS 10]. The correct machine settings are already loaded on the control PC; do not reload or change them. The ShopBot USB should use the same port every time ^[QS 9]. **Sleep mode and screen savers must be off.** If they are on, a long file can stop mid-cut ^[UG 10]. If SB3 starts in Preview mode, the tool is not connected. Check the box and the USB ^[UG 10; CR 27].
6. Open Spindle RPM Control (Tools → Spindle RPM Control). Keep this window open the whole session: SB3 talks to the VFD — the spindle's speed controller, the box with the rpm display — only while it is open ^[QS 15].
7. With everyone clear of the machine, insert the spindle interlock key into the safety lockout next to the power switch and turn it to **ENGAGED** ^[QS 12]. Before hands-on work, stop the spindle, turn the key OFF and remove it. Keep it in your pocket ^[UG 5].
8. Switch the dust collector on **at the collector itself**; it is switched manually, not by SB3. It stays on for the whole job ^[MS 3].
9. Warm up, home, then zero: C5 (the lab's standard warm-up), then C3, then C2 ^[MS 3].

When you are finished

Users never power down the machine. Finish or stop the file and leave the machine powered for lab staff. Do not exit SB3, turn off the control cabinet or switch off the spindle controller. Use the E-stop in an emergency, not as an end-of-session switch. Follow "After the job" for spindle stopping, key removal and cleanup.

Keypad and jogging (K / SK)

Opening and closing the keypad

- Type **K** (shortcut for **SK**) or click the yellow keypad icon in the red Position window ^[QS 11; CR 26].

- The keypad works **only in Move/Cut mode** and not in Preview ^[CR 26]. If the icon is missing, select Mode → move/cut ^[QS 11].
- Opening the keypad lights **output 4** in the Position window ^[QS 12].
- Close it with the X in the corner ^[QS 11].
- If a part file called SK, the file continues when you press Esc ^[CR 27].
- Esc generally steps you back one level in SB3 ^[UG 11].

Moving the axes

- ← → move X. ↑ ↓ move Y. **Page Up / Page Down** move Z ^[CR 26; QS 11].
- You can also click the blue arrows on screen ^[QS 11].
- / moves on the +X+Y diagonal; \ moves on the +Y-X diagonal. Add Alt to reverse the diagonal ^[CR 26].
- Hold **Ctrl** with an arrow to move at **Jog** speed instead of Move speed ^[CR 26].

Speeds

- Move (feed) and Jog (rapid) speeds appear on the left of the Control Console. You can type new values there ^[UG 10].
- You can also set them with **MS** (move), **JS** (jog) or **VS** (all eight speeds) ^[CR 16; CR 20; CR 42].
- Units are in/s or mm/s, not per minute ^[CR 20].
- Jog speed is normally faster than Move speed and is used for positioning ^[UG 39].

Continuous vs Fixed keypad modes

- **Continuous (normal):** the axis moves while you hold the key ^[XY 5].
- **Fixed:** click **Fixed** or press **D**. Each tap then moves one set increment. Set the increment in the box that appears, or in VD under "KeyPad Fixed Distance" ^[CR 26; XY 5]. Click Fixed again or press Esc to return to continuous motion ^[XY 5]. Use Fixed for fine positioning near the stock.

Before a test move

- Park Z at a safe height below the Z proximity switch, near the middle of the deck ^[QS 11].

Spacebar vs the yellow/red STOP button

- **Spacebar (and Enter, or the on-screen Stop button):** a ramped software stop. Z pulls out of the material and position is kept, so you can continue ^[CR 39]. **Treat the spindle as live afterwards:** it may keep turning, coast, or restart when you resume. A spacebar stop is not isolation. Before reaching near the bit, confirm that the spindle has stopped, the interlock key is OFF and removed, the keypad is closed and no file is loaded or paused. Keep clear before re-engaging the key or restarting ^[UG 5; QS 5; QS 17].
- **Yellow-and-red E-stop on the pendant:** a true E-stop wired to ES1-ES4 on the control board. It cuts power to the motors **and** the spindle ^[UG 47]. On this machine it is the only E-stop; twist to release.

Limits while jogging

- If a limit (input 2 or 3) stops the keypad, the next keypad move ignores limits so you can drive off the switch. A new limit will **not** stop that move ^[CR 38].

Homing (C3, XY with proximity switches)

- **C3** homes X and Y. The machine touches off each proximity switch, giving a repeatable start point ^[QS 15]. It also sets the table base coordinates correctly ^[UG 20].
- **Input 2** is the X proximity switch and **input 3** is the Y proximity switch. Both are configured as limit switches ^[CR 39; UG 46]. By default, when either one triggers, motion stops and a "table limit" message asks whether to continue ^[UG 46–47]. **VN** configures what these inputs do ^[UG 47; CR 38].
- Students never change VN or disable limits; report a limit fault to staff ^[CR 39].
- If the machine stops with a limit message and nothing is at the end of the table, tell staff.
- "Move off prox" prompt: C3 asks you to move the spindle carriage off a switch if it starts out sitting on one. Repeated prompts while the carriage is clear mean an input or target fault (polarity, target alignment, wiring). Report it rather than defeating the limits.
- A proximity target must be met before the hard stop.
- Where C3 lands (its offset from the switches) is set in **TS** (Tools → ShopBot Setup) ^[QS 15; XY 3–6; CR 30].

When to rehome (C3)

- At the start of every session ^[MS 3].
- Whenever the power has been off ^[UG 20].
- After the gantry was pushed by hand or moved with the motors unpowered ^[UG 20].
- After an E-stop on an alpha. Re-home XY and re-zero Z before cutting again ^[CR 39; QS 17].
- After a driver fault or "location no longer accurate".
- After you have moved the zero point and want the standard one back ^[UG 20].

Material setup and hold-down

General rules

- Never cut material that is not firmly secured. This includes any cutouts or offcuts the file will free ^[UG 5].
- Never push material by hand into a moving bit ^[UG 5].
- Small cut-free parts can be caught by the bit and thrown. Choose the hold-down method as part of planning ^[HD 5; QS 16].
- The worst hazard is the bit hitting a clamp or screw. Plan every path, including rapids, so clamps are clear ^[UG 44; HD 6].

Screws

- Screw into the spoilboard. This is quick and suits most materials ^[HD 5].
- Keep every screw clear of the cut path ^[HD 5].
- For larger jobs, run a separate drilling file first to make screw holes in safe places, then screw down and run the main cut ^[HD 5; UG 44].
- While that drilling file runs, one clamp at each end is enough. An end mill drilling puts little sideways force on the stock ^[HD 5].

Clamps

- Clamps hold strongly where there is no spare material for screws. Plan carefully so the bit avoids them ^[HD 6].
- Rapids need enough clearance height to pass over clamps ^[UG 44].
- Scrap-wood clamps can work: a rabbeted block, with the rabbet slightly shallower than the stock ^[HD 6]; a flexible strip with a stop glued on ^[HD 6].
- Spring clamps and pistol-grip clamps tend to move. Check that they actually hold rigidly ^[UG 44].

Tabs and onion skin (holding parts inside the sheet)

- **Tabs** are bridges of material left between the part and the sheet. CAM programs add them automatically ^[HD 8]. SB3 can also add tabs when a file runs (FP Tab option, sized in VB) ^[CR 11–12; UG 45].
- **Onion skin:** set the final depth slightly short of the stock thickness, typically **.010”–.030”** depending on material and part size ^[HD 8]. It holds better and is easier to sand off than thick tabs ^[HD 8]. It fails if stock thickness varies or the table is not flat ^[HD 8].

What this lab uses

- Use **screws through the waste into the spoilboard, clamps, and shims under bowed stock**. Retain freed parts with tabs or an onion skin. Plan every screw and clamp position in CAM, clear of the full cutter envelope, and verify all paths.

Tool (bit) change

1. Make the spindle safe. Turn the spindle off ^[UG 5]. Change bits only with the spindle stopped and the key OFF in your pocket ^[UG 5]. Disengage the interlock key during bit changes.
2. Clean everything. The collet, nut, spindle taper and shaft must be completely clean. Use a wire or brass brush, compressed air and/or mineral spirits to remove dust or excess grease ^[QS 15; QS 18]. Small contamination causes misalignment, imbalance and slippage ^[MS 3].
3. Assemble the ER25 collet into the nut **first**. Press the collet into the nut until it **clicks**. If it will not seat, press it in at a slight angle ^[QS 15; TM 15]. Check it: hold the nut upside down. The collet should hang without falling out ^[QS 15].
4. Insert the bit into the collet ^[QS 15]. The collet must grip **only the shank**. No part of the flute may enter the collet. Ideally the shank fills **at least 75 %** of the collet length.
5. Thread the nut, collet and bit together onto the spindle **without compressing the collet** ^[QS 15].
6. Hand-tighten the nut ^[QS 15; TM 15]. It must go on easily. If it resists, **do not force it**. Back it off and start again. Once it is finger-tight, check the bit has not slipped.
7. Tighten the matching ER25 collet nut using the hook spanner on the nut and the 27 mm wrench on the shaft. Follow the tightening method demonstrated during induction; do not use a torque value for a different nut ^[QS 15; TM 15].
8. Do not over-tighten to stop a slipping bit. That damages the threads. A slipping bit means a dirty or worn collet ^[MS 3].
9. **Re-zero Z after every bit change** ^[QS 14].

Collet facts

- This spindle uses **ER25 collets with the matching ER25 collet nut**. Select a collet that matches the tool shank ^[TM 15].
- The collet size must match the bit shank. Metric and inch collets are not interchangeable ^[TM 15].
- **Collet life:** collets are consumables; staff replace them on schedule or after any crash ^[MS 3; TM 13].
- Replace the collet immediately after any "event": it was dropped, a bit broke inside it, or a plunge bottomed out on it ^[MS 3; TM 13].
- Signs of a worn collet ^[TM 14]: the bit creeps up into the collet and Z position is lost; bits break at sane feeds; a bit falls out; a bit is hard to pull out.

Z zero

Choose the reference to match your CAM file

- **Material top:** best when depth must be precise, for example an inlay pocket ^[QS 14].
- **Table (spoilboard) surface:** best for through-cutting wood, because sheet thickness varies ^[QS 14].
- **The CAM setting and what you do at the table must match.** A mismatch ruins material and breaks bits ^[QS 14].
- Z must be zeroed every time the machine is turned on and every time the bit is changed ^[QS 14].

C2 with the Z-zero plate

1. Work in Move/Cut mode ^[QS 14].
2. Check that the ground clip remains clamped to bare aluminium on the carriage-plate edge. The circuit runs through plate → spindle → collet → bit. Never clip onto the bit or nut.
3. Place the plate directly under the bit, on the surface you chose ^[QS 14].
4. **Test the circuit.** Touch the plate to the stationary bit. **Input 1** must light on screen and go out as soon as contact breaks ^[QS 14]. If input 1 does not light and clear, **do not run C2; call staff**. ShopBot's FAQ warns that a failed contact circuit lets the bit keep descending [FAQ]. If the bit reaches the plate during C2 and does not reverse, press the **spacebar**; if Z still moves, use the **E-stop**. Do not rely on C2 to detect a failed contact circuit.
5. Run **C2** or click the Z-zero button. Z touches the plate **twice**, then pulls up to a safe height ^[QS 14].
6. Leave the clip on the carriage plate, coil the lead, and put the plate back in its holder on the YZ car — the carriage that carries the spindle across the gantry ^[QS 14].
7. If the zero looks wrong, stop and call staff. Staff can check **MZ,0** over an open area and verify the plate thickness in **TS** (default **3.073 mm**) ^[TM 11–12; MS 3]. Keep hands clear during every commanded move. Before a hands-on check: spindle off and stopped, key OFF and removed, keypad closed, no file loaded or paused ^[UG 5; QS 5].

Manual Z zero (ZZ): not taught

- Use **C2** for Z zero. Manual **ZZ** with a paper feeler is not part of the student procedure; ZZ is listed in the glossary for reference only ^[CR 45].

XY zero: machine home vs job zero

Home vs job zero

- **Machine home (C3):** a repeatable XY origin taken from the proximity switches ^[QS 15]. C2 and C3 also set the **table base coordinates**, which software limit checking (SF/VL) uses ^[UG 20; CR 26].
- **Job (working) zero:** wherever you zero X and Y for this job. **Z2** zeros X and Y ^[CR 43]. **ZX** zeros X only and **ZY** zeros Y only ^[CR 44–45]. On the keypad, the blue "**Zero Axes**" button does the same ^[XY 5]. **VA** sets the axes to any chosen value. VA 0,0 is equivalent to Z2 ^[UG 18].
- Re-zeroing the working coordinates does not lose the base coordinates. **ZT** sets the base zero ^[CR 44]. **ST** restores the working display to base coordinates ^[CR 28; UG 19].
- After setting a temporary 0,0, **write down the coordinates** so you can find it again ^[QS 15].
- **2D offset in FP:** the current XY becomes the file's 0,0 for that run only, and Z is not shifted. Use it to place or nest parts ^[UG 18–19; CR 12].

Fixed C3 offsets

- Where C3 lands relative to the switches is a staff setting (TS). Students never change it.

Loading and running a file

Preview first (SP)

- **SP** switches to Preview mode. Running SP again clears the preview ^[CR 28; UG 11].
- **FP** opens the Part File dialog. Pick the `.sbp` file, then press Enter to accept the fill-in sheet and Enter again to run it in preview ^[UG 13].
- FP also runs most G-code files (.tap, .nc). Select "ALL" file types to see them ^[CR 12].
- In preview the tool does not move. The position readouts reset when you leave Preview ^[CR 28].
- Use preview with software limit checking (SF/VL) to confirm every move stays inside the table ^[UG 20; CR 38].

Move/Cut mode (SM)

- **SM** makes all commands drive the real machine ^[CR 27].
- Click "Cut Part" or use File → Part File Load (FP) ^[QS 16–17].

What the FP fill-in sheet asks ^[CR 12; QS 16–17]

- Proportion X, Y, Z (default 1,1,1).
- Repetitions (default 1).
- **Offset: none / 1 = 3D / 2 = 2D.** None is the default.
- Plunge, used for template files.
- Tab feature on/off.
- Plunge from Z 0.
- Then click START or press Enter.

Spindle warm-up (C5)

- Before cutting at the start of the day or after more than **4 h idle**, open Spindle RPM Control and run **C5**. It runs **9000, 10 000 and 12 000 rpm for 3 min each**, then stops the spindle ^[QS 16]. Check that the cooling fan runs ^[MS 3].

Setting RPM (TR / Spindle RPM Control)

- **TR** opens the Spindle RPM Control window. In a part file, `TR,12000` requests 12000 RPM. This is a request, not a measured speed.
- To change speed by hand: with the spindle running, click the RPM value, type the new value, press **Enter**. The VFD display must match ^[QS 16].

Spindle-start order on a PRSalpha

- **Keypad test:** turn output 1 on in the keypad, then press the green **START** on the three-button pendant ^[QS 12–13].
- **Running a file:** after Start/Enter in FP, SB3 shows the prompt “Press START on control before pressing OK”. **PRSalpha:** press the pendant **Start BEFORE clicking OK** ^[QS 17].
- Start a job in this order: **1.** Spindle RPM Control window open, RPM typed, Enter ^[QS 15]. **2.** FP → Start. **3.** Screen prompt “Press START on control before pressing OK” → pendant green **START** ^[QS 17]. **4.** Verify the spindle is running at the commanded speed; the VFD (Yaskawa V1000) display should show the RPM you typed ^[QS 16]. **5.** OK on screen → cutting begins. There is no separate RUN step on the VFD.
- Never assume the spindle is turning because the axes move; a stationary cutter can break when driven into stock.

Air-cut practice

Method 1, 3D offset ^[QS 16]:

- Raise the bit above the material and run FP with **3D offset**. The current XYZ becomes 0,0,0 and the file runs in the air.
- The gap between the bit and the stock **must be larger than the file's maximum cut depth**.

Method 2, spindle off ^[UG 13]: run the file in Move/Cut with the spindle **off**, above the material, to check the motion. Before the real cut, set Offset back to **"No Offset"** ^[QS 17].

Watch the first plunge

- Stay at the keyboard with your hand near the spacebar, and know where the E-stop is ^[UG 6; QS 5].
- Be ready to pause if anything looks wrong ^[QS 5].
- Burning, smoke or excessive tool heat means something is wrong. Stop and report it; do not touch the cutter to test its temperature.

Pausing, stopping and resuming

Software (soft) stop

- Press the **spacebar** (or Enter, or the on-screen Stop). Motion ramps down and Z lifts out of the material ^[CR 39; QS 17].
- Position and zero are **kept**, so you can resume with no loss of location ^[CR 39; QS 17].

- SB3 then prompts you for what to do next ^[UG 14].
- At very slow speeds the stop is immediate ^[UG 14].
- After a spacebar stop you can resume **without resetting the drivers** ^[UG 47]. This is not isolation: before reaching in, stop the spindle, remove the interlock key, close the keypad and end the loaded/paused file. Keep clear before restarting.

Emergency stop (PRSalpha)

- The E-stop **immediately** stops the tool and removes spindle power. After about **5 s**, motor power is removed too ^[CR 39].
- **Position is lost:** rehome XY with C3 and re-zero Z with C2 before cutting again ^[CR 39; QS 17].
- Use the E-stop for emergencies. Use the spacebar for routine stops ^[CR 39].

Resuming a file

- **FG** loads a file in Goto/Single-Step mode. You can single-step or start from a chosen line ^[CR 11].
- FG can jump automatically to the **last line executed**, for example after a broken bit ^[CR 11].
- After an E-stop or driver fault: have staff clear the cause, rehome and re-zero first, then use FG ^[CR 39; CR 11].
- Before resuming, enter the required RPM and press Enter. Confirm the actual speed on the VFD display before allowing cutting to continue; do not assume the previous RPM was retained.
- **3D offset** (Offset = 1) treats the current X, Y and Z as 0,0,0 for that run ^[CR 11–12]. Do not use it to resume a real cut unless you have deliberately set the start position. It shifts Z ^[QS 16].
- A file can contain **PAUSE**, which waits for a key, or **PAUSE n**, which waits n seconds. A comment line just before it is displayed as the message, for example "Change bits" ^[UG 27].

After the job

1. Finish or stop the file. Stop the spindle (output 1 off) and wait until the bit has stopped ^[QS 13].
2. With everyone clear, raise Z to a safe height and jog the gantry clear of the work. **JH** raises Z to Safe-Z, then jogs to the current **working** XY 0,0, not the proximity-switch home; use it only if that route is clear ^[CR 17].
3. Close the keypad and end any loaded or paused file. Turn the interlock key OFF and remove it before reaching in. Keep it in your pocket during cleanup ^[UG 5; QS 5]. Switch the dust collector off at the collector.
4. Remove parts, hold-downs and loose offcuts. Vacuum the deck and brush chips from the rails and racks. Remove, clean and stow the bit; inspect the collet and nut ^[QS 18].
5. Record the material, cutter, feed, rpm and any fault in your job notes. Report faults or damage to staff.
6. **Leave the machine powered for lab staff. Users never power down the machine.** Do not exit SB3 or switch off the control cabinet or spindle controller. In an emergency, press the **E-stop**.

4 Your first job, step by step

The whole flow for one plywood part, in order, with the command you type at each step. Section 3 has the detail behind every line; this is the skeleton to hold in your head.

1. **At the computer.** Autodesk Fusion (the lab's usual CAM): stock measured (write the thickness down), origin corner chosen, Z0 on the surface you will touch (lab convention for through-cuts: bed), screws placed in the waste, tabs or onion skin on every freed part, feeds computed (plywood: 14 000 rpm, 4200 mm/min, 3 mm per pass). Post with the ShopBot OpenSBP post, mm.
2. **Read the .sbp** in a text editor: `&PWZorigin`, units, `MS`, `TR`, the first `JZ` and `M3`. Anything surprising: back to step 1.
3. **Power.** Control box on → PC and SB3 (Move/Cut mode, `SM`) → Spindle RPM Control window open → key ENGAGED → E-stop twisted to release, pendant **Reset** → dust collector on, at the collector. The machine settings are already loaded; do not reload them.
4. `C5` at the start of the day or after more than 4 h idle. `C3` home.
5. **Stock on.** Spindle stopped, key OFF and removed, keypad closed, no file loaded or paused. Sheet flat, screwed down where the CAM said. Key back in.
6. **Bit.** Spindle stopped, key OFF and removed, keypad closed, no file loaded or paused. ER25 collet snapped into the nut, bit in (shank $\geq 75\%$ in the collet), then thread the assembly onto the spindle. Use the tightening method demonstrated during induction. Key back in.
7. **XY zero.** `K` to jog to the origin corner, close the keypad, `Z2`. Write the base coordinates down (you will need them after any E-stop).
8. **Z zero.** Clip stays on the carriage plate; plate on the bed (or stock top — whatever `&PWZorigin` says), test input 1: it must light on contact and clear on separation. If it fails, do not run C2; call staff. Then `C2` (always C2 — no manual zeroing), plate stowed.
9. **Air cut.** `FP`, Offset = 3D, bit raised above the stock by more than the deepest cut, run it with the spindle off and watch the path. Then Offset = No Offset; `C2` again if Z was moved.
10. **Cut.** RPM typed, Enter → `FP` → at the prompt "Press START on control before pressing OK": pendant **START** → spindle running at the commanded speed, its display shows the rpm → **OK** → cutting begins. Hand at the spacebar for the first plunge. Watch the chips. Stay.
11. **Done.** Finish or stop the file; stop the spindle. With everyone clear, raise Z and jog clear; use `JH` only if the route to working XY 0,0 is clear. Close the keypad, end any loaded/paused file and remove the key before cleanup. Collector off; parts out, screws out, deck vacuumed, racks brushed, bit stowed. Report faults. Leave the machine powered for lab staff; users never power down. Use E-stop in an emergency.

5 Pre-flight checklist

Print this section on its own and keep it at the machine. Tick every line, in order, every time. If a line cannot be ticked, stop and ask.

Before power

- ☐ Signed-off operator present; second person knows the E-stop (wall pendant by the monitor)
- ☐ Glasses, ear protection; no gloves, loose sleeves, hair, lanyards
- ☐ Table and rails clear of tools, offcuts, clamps from the last job
- ☐ Dust hose on the foot, brush skirt intact
- ☐ Key OFF and in your pocket for the bit change; bit correct and sharp, collet clean, nut torqued, stick-out minimal
- ☐ Stock: thickness measured and written down, flat on the deck
- ☐ Hold-down planned: screws/clamps outside every toolpath, tabs or onion skin for freed parts

Running

- ☐ Air cut a new file: FP with Offset = **3D**, bit raised above the stock by **more than the file's deepest cut**, spindle may stay off; then Offset = **No Offset** and C2 again if you moved Z
- ☐ RPM typed in the Spindle RPM Control window and **Enter**
- ☐ FP → prompt "Press START on control before pressing OK": pendant **START**, spindle at commanded speed, VFD shows the rpm, **then** OK (no separate VFD RUN)
- ☐ Hand near the spacebar, E-stop in reach, for the first plunge and the first pass

Power and zeroing

- ☐ Control box on → E-stop twisted to release, pendant **Reset** pressed (input 4 not flashing) → PC on, SB3 open in Move/Cut mode (SM)
- ☐ Spindle RPM Control window open; interlock key in and ENGAGED; dust collector switched on at the collector
- ☐ C5 warm-up at the start of the day or after 4 h idle
- ☐ C3: machine homes on both proximity switches without complaint
- ☐ Read the .sbp header: mm, and which surface is Z0 (`&PWZorigin` : material top or table), feed, rpm, first Z move sane
- ☐ Jog to the CAM file's XY origin (centre or corner); Z2 (or ZX/ZY). The drawing uses the material centre
- ☐ C2: clip in place on the carriage plate, plate under the bit on the surface the file expects; touch plate to bit — **input 1 lights and goes out**; run C2 (two touches, lift); clip stays on the plate, Z-zero plate back in its holder on the car
- ☐ Keypad closed before FP

After

- ☐ File finished/stopped, spindle stopped; raise Z and jog clear with everyone outside the cutting area; collector off
- ☐ Key OFF and removed, keypad closed, no loaded/paused file before clearing parts, screws and offcuts; deck vacuumed, racks and rails brushed
- ☐ Bit removed, cleaned, back in its place; collet checked
- ☐ Material, cutter, feed, rpm and any fault recorded in your job notes; problems told to staff
- ☐ Machine left powered for staff. Users never power down; E-stop is for emergencies

- ☐ Watch the chips: ribbons/curls good, dust and smoke bad
- ☐ Never leave the room while it runs

6 Something went wrong: start from the symptom

Find what you see, not what you suspect. Each card names the most likely causes in order and links to the fault card (E-numbers in the next section) and, where the online model can demonstrate it, to the online model key that plays it.

Everything stopped dead, red LED on the box, "location no longer accurate"

Alpha driver alarm. Stop and call staff; do not open the cabinet. Staff check the driver alarm and cause (clamp strike, packed rack, cable). After recovery, **rehome and re-zero**. → [E01](#) · [online model key 1](#)

Software froze or says the controller disconnected; spindle still running

USB dropped: the PC went to sleep or the cable was knocked. **Press an E-stop**: the software can no longer stop the machine and the E-stop is the only control that kills the spindle. Then fix the cause, Reset, C3, C2, resume with FG. → [E02](#) · [online model key 8](#)

C2 drives the bit into the plate and keeps going

Input 1 not seeing the touch: clip off, dirty plate, open lead. **Spacebar**; if Z still moves, **E-stop**. The circuit test (input 1 lights on contact) before C2 is the only guard against this. → [E05](#) · [online model key 2](#)

C2 touches once and then stops with an error

Plate moved before the second touch; or (staff: check the C2 settings) a zero Safe-Z pull-up. → [E06](#)

C3 runs into the end of the table, or nags "move off prox"

Stop and call staff. Staff check switch gap, input polarity and wiring; do not adjust or disable the limits. → [E04](#) · [online model key 3](#)

Spindle did not start but the axes move

Interlock key, output 1, pendant START not pressed before OK, VFD in LOCAL. Spacebar before the bit reaches the stock; E-stop if it already has. → [E07](#), [E09](#) · [online model key 4](#)

Typed a new RPM, nothing changed

Enter not pressed in the Spindle RPM Control window, window closed, or RPM controller not talking to the VFD. Read the rpm on the spindle controller's display, not in the software. → [E08](#)

Cut gets deeper every pass; the last pass goes through the spoilboard

Bit slipping in the collet. The motors cannot see it. Stop and call staff. With the spindle stopped and key removed, staff inspect the tool and collet; re-zero Z after recovery. → [E10](#), [E11](#) · [online model key 5](#)

Snapped bit

Was the spindle turning? Then: chipload too high or too low, straight plunge too fast, dull cutter, or it hit a clamp/screw.

→ [E12](#), [E21](#), [E39](#)

Loud bang, bit broke mid-cut

With the spindle running, the bit hit metal: a hold-down screw or a clamp on the path, or a clearance height below a screw head. **Spacebar**, spindle stopped, key OFF and removed, tell staff; the bit and possibly the collet are scrap. Before the next run, check every screw and clamp position against the toolpaths in CAM. → [E39](#), [E21](#), [E28](#) ·

[online model key 5](#)

Melted plastic, aluminium welded to the flutes

Feed too slow for the rpm, chips being recut. Faster feed, shallower depth, single flute for plastics. → [E13](#)

Frayed plywood veneer, fuzzy edges

Up-cut tooling on the top face, dull bit, wrong direction. Compression or down-cut bit, climb finishing pass. → [E14](#), [E24](#)

Burn marks, smoke, hot dust

Rubbing, not cutting: too slow, dull. Stop and check the dust under the brush for embers. → [E15](#), [E25](#)

Second pass offset from the first; circles come out oval; sides not square

Position creep: packed rack teeth, worn pinion, loose pinion set screw, tired motor spring, or roller wheels wrong. →

[E16](#), [E17](#), [E18](#), [E19](#), [E38](#) · [online model key 7](#)

Ticking or a bump at the same place every time

Debris on the V-rail or in the rack at that spot. Clean it; do not grease over it. → [E16](#), [E20](#)

Part lifted, moved or flew; sheet wandered

Hold-down failed as the profile cut through: no tabs/onion skin, bowed stock, too few screws. → [E22](#), [E23](#) ·

[online model key 6](#)

Right shape, wrong place on the sheet

Job zero not where CAM thought: wrong corner, wrong Z surface (`&PWZorigin` in the file header vs the surface you touched), zeroed with Z2 before homing. Air-cut first next time. → [E26](#), [E32](#)

Everything is 25.4× too big or too small; feeds absurd

Inch/mm mismatch between the file and the software (VD). → [E27](#)

Rapid move hit a clamp

CAM clearance height below the clamp. → [E28](#), [E21](#) · [online model key 9](#)

"Z limit" or "table limit" message

Retract height exceeds usable Z travel, or the job runs past the table limits (VL). Stop and have staff check the setup.
Never disable limits. → [E29](#), [E35](#)

Preview plays, nothing moves

Software in Preview (SP) instead of Move/Cut (SM), or no controller connection. → [E33](#)

An axis moved when I touched the keyboard

The keypad window still had focus. Close it when you are done jogging. → [E34](#)

Spindle stopped with a code on its controller display

Overcurrent/overload. Stop the file, record the code, find the cause before resetting. → [E36](#), [E37](#)

I stopped the job and need to continue

Decide whether position survived (spacebar stop: yes; E-stop or driver fault: no → Reset, C3, re-zero). Then restart from a line with FG, spindle started by the start sequence. → [E30](#), [E31](#)

When to stop and call staff

Stop (E-stop in an emergency). Before reaching in: spindle off and stopped, key OFF and removed, keypad closed, no file loaded or paused. Get a signed-off staff member before continuing if you see any of these:

- A driver alarm (red LED, "location no longer accurate").
- Any fault code on the spindle controller's display.
- C3 nags "move off prox" or runs into the end of the table.
- Input 4 keeps flashing after Reset; input 1 does not light in the circuit test.
- A damaged, pinched or hot motor or spindle cable; the dust hose off the foot or split.
- Smoke, embers, burning smell, or hot dust under the brush.
- A bit that pulled out, snapped, or hit a screw or clamp.
- Anything in the glossary marked **staff only** (VN, VL, SF, ZT, TS offsets, eccentrics, pinion re-engagement, VFD parameters).

7 Failure modes, one by one

Each entry: what you see, why, what to do. Numbers in brackets are the sources at the end. Entries with a related online demonstration carry its keyboard shortcut.

E01 • key 1 **Alpha driver fault — “location no longer ACCURATE”**^[1,22,30]

SEE Abrupt stop, driver-fault dialog, red LED on the box; coordinates untrustworthy.

why Obstruction or excessive load, chips in the rack, a struck clamp, a damaged motor cable; AS drivers also trip on heat, voltage, speed and sensor faults.

do Stop and call staff. Staff check the driver LED and cause; students do not open the cabinet. After recovery, reset, re-home (C3) and re-zero. Reduce feed or depth if it was the cut.

E02 • key 8 **USB disconnect / communications failure**^[7,55]

SEE SB3 loses the controller mid-file; spindle keeps running.

why PC power management (USB selective suspend, sleep), long or damaged cable.

do E-stop first and call staff. Staff check PC power settings and the direct USB cable (under 3 m, no extension). Rehome and re-zero after recovery.

E03 **Dust hose off the foot / skirt torn**^[13]

SEE Chips everywhere, dust in the air, the brush not sweeping.

why Hose pulled off the foot by a long move; brush skirt torn or lost.

do Stop, spindle off, refit the hose or tell staff; never cut without the foot on.

E04 • key 3 **C3 homes early, fails, or asks to “move off prox”**^[2,6,49]

SEE Wrong zero, stop before the target, or a nagging prox dialog.

why Misaligned target, swapped input polarity, bad switch or cable, dead input channel.

do Stop and call staff to check inputs 2/3, target alignment and wiring. Do not disable limits.

E05 • key 2 **Z plate not detected**^[4,6]

SEE Input 1 stays dark; the bit keeps descending.

why Clip knocked off the carriage plate or on paint/dust, a dirty plate or bit, dirty contact, open lead or connector.

do Test input 1 before every C2; it must light on contact and clear on separation. If it fails, do not run C2. If Z fails to reverse at contact, spacebar; if Z still moves, E-stop. Call staff.

E06 · key 2 **C2 touches but stops**^[4,6]

SEE First touch registers, routine halts.

why Plate moved before the second touch; or (staff: check the C2 settings) a zero Safe-Z pull-up.

do Leave the plate until both touches finish. If C2 halts, stop and call staff; students do not change pull-up settings.

E07 · key 4 **Spindle will not start**^[4,21,24,25]

SEE Axes move; spindle stays still; a still bit snaps instantly.

why Interlock key off, no output 1 / pendant Start, VFD in LOCAL, or a drive fault.

do Stop the file. Check the key, output 1 and pendant Start sequence with everyone clear. If it still fails, call staff; do not change VFD parameters.

E08 · key 4 **RPM will not change**^[4,6,52]

SEE Typed value ignored; speed stays as before.

why RPM window closed, Enter not pressed, wrong VFD selected, RPM-board USB lost, legacy keypad-only VFD.

do Open TR, type the required rpm and press Enter; confirm on the VFD display. If it does not respond, stop and call staff; do not change drive settings.

E09 · key 4 **Wrong spindle-start order**^[4]

SEE File starts with a still spindle.

why Pendant green START pressed after OK (alpha wants it before), or not at all.

do At the spindle prompt: pendant START, hear it reach speed, read the rpm on the VFD, then OK.

E10 · key 5 **Bit slips in the collet**^[4,13,16,31]

SEE Cuts get deeper pass by pass; Z zero seems to drift.

why Dirty or worn ER25 collet, nut not snapped onto the collet first, wrong torque, wrong shank size.

do Clean taper/collet/nut; collet into nut first; use the tightening method demonstrated during induction, not a torque for another nut; replace collets after 400–700 h or any incident.

E11 · key 5 **Tool pull-out read as axis drift**^[1,13,16]

SEE Depth changes while coordinates look right; witness mark on the shank has moved.

why Inadequate grip; the motor encoder cannot see a bit sliding.

do Compare Z zero before/after a test cut; replace suspect collet and bit; don't clamp on the flutes.

E12 **Broken bits — chipload, plunge, ramping**^[10,11,25,26]

SEE Snapped cutter, chatter, spindle bogging.

why Wrong feed/rpm/depth, aggressive straight plunge, dull cutter — or a spindle that was never running.

do Maker's chipload chart, ramped entries, reduce depth; distinguish VR acceleration ramping from CAM entry ramps.

E13 **Plastic melts / aluminium welds to the cutter**^[11,35]

SEE Gummed flutes, fused chips, repeated breakage.

why Feed too low for rpm, recutting chips, heat.

do Make chips not heat: faster feed, shallower depth, proper evacuation.

E14 **Plywood tear-out**^[11]

SEE Frayed veneer, rough edges.

why Cut direction, dull or wrong geometry, grain, feed.

do Sharp compression or down-cut tooling, test both directions on scrap; don't slow down until it burns.

E15 **Burning in hardwood**^[4,11]

SEE Scorched edge, smoke, hot dust.

why Too slow, rubbing with a dull tool.

do Sharp tool, correct chipload; stop and check for embers; never leave a running job.

E16 · key 7 **Dust packed in rack teeth**^[13,32]

SEE Ticking, uneven motion, erratic Z.

why Chips filling the gear mesh.

do Brush racks and pinions clean, then light grease (schedule: BB-sized blob every 6 in, run the axes, wipe excess).

E17 · key 7 **Worn rack or pinion**^[13,15,16,33]

SEE Oval circles, Z notches at certain heights, reversal play.

why Worn teeth or poor mesh.

do Push-pull test, inspect full travel, replace pinions as a set; CC circle test separates mechanics from bad CAD.

E18 · key 7 **Loose pinion set screw / tired motor spring**^[2,13,15]

SEE Clunks, sudden registration loss, backlash.

why Pinion moving on its shaft or not fully engaged.

do Staff task: tighten set screw and key, set spring preload and full-width engagement; rehome afterwards.

E19 **Roller bearings loose or over-tight**^[13,16,18,19]

SEE Lateral Z slop, bad fourth pocket wall, binding, axis faults.

why Eccentrics wrongly set, contamination, worn bearings.

do Staff task: adjust eccentrics with drives disengaged; replace worn bearings rather than overtighten.

E20 **Debris on the V-rails**^[13,16]

SEE Bumps that repeat at one spot.

why Build-up on rail edges or rollers.

do Scotchbrite + WD-40 on rails, brass brush on rollers, every 40 h.

E21 · key 9 **Crash into a clamp or screw**^[1,4,12]

SEE Bang, broken cutter, alarm, shifted cut.

why Toolpath or rapid intersects hardware.

do Stop, inspect tool/mount/drives, fix clearance, rehome and re-zero; plan screw zones.

E22 · key 6 **Part lifts or flies**^[4,12,29]

SEE Sheet rises or a cut-out catches the bit and is thrown.

why Poor hold-down, bowed stock, no tabs.

do Screws in the waste, tabs or 0.25–0.75 mm onion skin, never reach in.

E23 · key 6 **Clamps or shims let go**^[12,11]

SEE Sheet shifts after the first passes; parts come out the right shape in the wrong place.

why Spring or pistol-grip clamps creeping, shims loosening as the sheet relaxes, too few screws, screws only at the edge.

do Screws into the spoilboard through the waste, at least every 300–400 mm and near every freed part; re-check clamps after the first pass; shim bowed stock flat before screwing.

E24 **Climb vs conventional**^[11,12,16]

SEE One direction chatters, the other is clean.

why Edge engagement changes with direction; looseness compounds it.

do Verify mechanics and hold-down first; climb on the finishing pass often helps, test on scrap.

E25 **Fire in the dust path**^[4,36,43]

SEE Sparks, smoke, smouldering dust.

why Friction heat, screws hitting the impeller, hidden fasteners.

do Never unattended; keep fasteners out of the intake; extinguisher within reach.

E26 **Wrong XY zero / origin corner**^[4,26,42,47]

- SEE Right shape, wrong place.
- why Job origin differs from the CAM origin; jogging confused with zeroing; Z2 and C3 mixed up.
- do Home with C3, move to the chosen origin, Z2; verify the CAM corner; air-cut first.

E27 **Inch/mm or SA/SR mismatch**^[10,11,27,54]

- SEE Toolpath scaled or offset; speeds absurd.
- why Active units don't match the file; wrong distance mode; edited unit values.
- do Check units in Values → Display before loading; the Autodesk post's CN,90 header only checks units, it doesn't set them.

E28 · key 9 **Retract height too low for clamps**^[10,12]

- SEE Traverse hits a clamp though the contours clear.
- why CAM clearance below fixture height, or Z reference changed.
- do Clearance = tallest fixture + margin; preview rapid links.

E29 **Retract beyond Z stroke**^[1,2,10]

- SEE Z-limit message, top-stop approach.
- why Safe height + offset + tool length exceeds usable Z travel. Have staff check that the setup fits before running.
- do Revise fixtures/toolpath; don't disable limits to reach the unreachable.

E30 **"Stop button pressed" / won't resume**^[4,11]

- SEE Stopped dialog, no motion.
- why Input 4 still active, E-stop latched, driver not reset.
- do Clear the cause; after an electrical E-stop rehome and re-zero — positions did not survive.

E31 **Restarting a broken job by line**^[10]

- SEE Half-cut part; restarting from line 1 recuts or collides.
- why Restart point lacks speed, spindle, offset state.
- do Re-establish zeros, FG (File Load in Goto mode), pick the line, approach at verified safe Z.

E32 **Table-surface vs part-surface zero**^[4,13]

- SEE Rapids and retracts run inside the stock, cuts go a sheet thickness into the spoilboard (bed zero, top-zero CAM) — or the whole job cuts air (the reverse).
- why C2 zeroed to one surface, CAM assumed the other.
- do Match CAM zero option to the touched surface at every setup.

E33 **Stuck in Preview**^[10,34]

- SEE Animation, no motion.
- why SP active instead of SM; or no controller connection.
- do Check connection, then SM; never toggle with hands in the envelope.

E34 **Accidental keyboard jog**^[4,47]

- SEE Axis moves when an arrow key is pressed.
- why Keypad window has focus.
- do Exit keypad when done; Fixed increments for fine approach.

E35 **Table limit trips mid-cut**^[2,10,11]

- SEE Limit warning near an edge.
- why Real limit, wrong base offset, VL/SF/VN settings, false input.
- do Check coordinates and switch state; limits use the base system, not Z2 zero.

E36 **VFD overcurrent / overload**^[24,30,39]

- SEE Spindle stops with a drive code; gantry may keep moving.
- why Load, acceleration demand, short, loose motor wiring.
- do Stop the file, record the Yaskawa code and call staff. Staff clear the cause before resetting; do not open the cabinet or change parameters.

E37 **Motor/driver overheating, spindle fan dead**^[2,13,22,41]

- SEE AS code 1, thermal stop, no fan noise.
- why Driver heatsink at ~85 °C, blocked cooling, failed 24 V fan.
- do Stop and call staff. Cooling-system and fan-cable checks are staff tasks.

E38 · key 1 **Gantry out of square**^[2,13,16]

- SEE Diagonals differ; corners not 90°.
- why Gantry reset with sides misaligned; unequal mesh; table shifted.
- do Stop and call staff for gantry alignment and diagonal checks; validate squareness before cutting again.

SEE	A loud bang mid-cut with the spindle running; the bit breaks off and a screw head in the waste is chewed up.
why	A screw placed on or too close to a toolpath, or the CAM clearance height set below the screw heads so a move between cuts runs into one. Carbide shatters on steel.
do	Spacebar (E-stop in an emergency), spindle stopped, key OFF and removed, tell staff; the bit and possibly the collet are scrap. Screws only in planned safe zones of the waste, drawn in CAM and checked against every toolpath and rapid; clearance above the tallest screw head.

8 Feeds, speeds and the one number that matters

The cutter removes a chip every time a flute passes. The thickness of that chip, the **chipload** f_z , decides almost everything: too thin and the edge rubs, heats, dulls and burns; too thick and the cutter deflects, chatters and snaps.

$$f_z = \text{feed} \div (\text{rpm} \times \text{flutes}) \qquad \text{feed} = \text{rpm} \times \text{flutes} \times f_z$$

Worked example (the calculator's default): 4200 mm/min $\div$ (14 000 rpm $\times$ 2 flutes) = **0.15 mm per tooth**, a reasonable chip for a 6 mm cutter in plywood. **CAM works in mm/min; SB3 and the .sbp file use mm/s — divide by 60** (4200 mm/min = 70 mm/s).^[11]

Starting points used in Icelandic Fab Labs (6 mm two-flute unless stated)

birch / spruce plywood

Start at 14 000 rpm, 4200 mm/min (0.15 mm/tooth), 3 mm pass, 40 % stepover. Icelandic labs report 2000–6500 mm/min working (0.07–0.23 mm/tooth), but below ~3600 mm/min at 14 000 rpm you are under ShopBot's plywood chipload range (0.13–0.5 mm/tooth for a ¼ in cutter): if you need to go gentler, drop rpm, not feed.^[11] down-cut to 3 mm then up-cut to 0.2 mm past the thickness, tabs 12 $\times$ 3 mm.^[56,57,58]

MDF

similar feeds, expect fine dust: extraction and a mask. MIT's table: ¼ in cutter 0.33–0.40 mm/tooth, plunge $\leq$ 50 % of the XY feed.^[59]

EB700 epoxy tooling board, 12 mm 3-flute

8000 rpm, 8400 mm/min (0.35 mm/tooth), plunge 300 mm/min, adaptive 20 mm max / 5 mm fine stepdown — one worked job, not a validated recipe; respirator.^[61]

PU foam / tooling foam

0.28–0.33 mm/tooth; it cuts easily but the dust is the hazard.^[59]

plastics (HDPE, acrylic)

single-flute O-flute, high feed, low rpm; the test is a clean curl, not a weld.^[11,35]

aluminium

possible but marginal on a router: shallow depth, high feed, lubricant, single flute; lower depth and raise feed if it welds.^[35]

Rules of thumb. Plunge at half the XY feed or less; ramp into pockets. Keep the bit's stick-out as short as the job allows. If depth of cut is 2 $\times$ the diameter, reduce chipload 25 %; at 3 $\times$ diameter, 50 %. A spindle loses torque at low rpm: if it bogs, raise rpm and feed together to keep the chip the same. Record the material, cutter, feed, rpm and any fault in your job notes and report problems to staff.^[11,59]

9 From CAM to the machine

Most "machine" failures are decided at the computer. Go through this list every time you post a file. Post with Autodesk Fusion's official ShopBot (OpenSBP) post processor. The correct machine settings are already loaded on the control PC; setup is then checked by hand at the machine.^[54,63]

1. **Units.** File and software agree (mm). If SB3 stops with UNIT_ERROR, the file and SB3 disagree on mm/inch: re-post the file in mm. Do not change or reload the machine settings — they are already correct on the control PC; ask staff if the units still disagree.^[10,54,63]
2. **Origin corner and Z reference.** Which corner is X0 Y0? Is Z0 the **material top** or the **table surface** (&PWZorigin in the posted file)? It must match what you touch with C2. Bed zero with a top-zero file puts every rapid and retract *inside* the stock and every cut a sheet thickness into the spoilboard; the reverse cuts air.^[4,6,54]
3. **Stock thickness measured**, not assumed. Plywood sold as 18 mm is 17.4–18.6 mm; through-cuts and onion skins depend on it.^[56]
4. **Clearance / retract height** above the tallest clamp or screw head, with margin — and below the Z stroke.^[10,12]
5. **Hold-down planned in the CAM:** screw positions in the waste, screws and clamps clear of every toolpath including the tool's radius; tabs or a 0.25–0.75 mm onion skin for every part that will be freed. Plan the full cutter envelope in CAM and check it in the simulation.^[12,63]
6. **Feeds, rpm, flutes, depth per pass** computed, not copied; check the first-pass depth in the simulation and posted file before running.^[11,62]
7. **Simulate** and look for: straight plunges into solid stock, rapids posted as feed moves above the stock (slow and dangerous at clamp height), curves turned into thousands of tiny steps (the machine stutters) — ask staff about the post settings.^[62]
8. **One file per tool** unless you are sure of the tool-change prompts; name files with the tool and the date.^[62]
9. **Open the .sbp in a text editor** and read the header: units, MS feed, TR rpm, &PWZorigin , the first JZ and M3 . If a number surprises you, it will surprise the machine.^[10,62]

10 Maintenance that prevents most of the above

Students clean accessible surfaces, inspect tooling and report faults. Mechanical adjustments, lubrication and servicing are staff tasks.

- **Daily:** C5 warm-up and listen for the fan; inspect bit, collet, nut, hose; check alignment without pushing the gantry; tell staff if it is out of square. Jog, C3, C2.^[13,4]
- **Every 40 h:** brush X/Y/Z racks and pinions, then a BB-sized blob of light grease every 6 in, run the axes ~10 times, wipe the excess; Scotchbrite + WD-40 on the V-rails, brass brush on the rollers; push-pull play check at every drive.^[13]
- **Quarterly / semiannually:** spin-test rollers, tighten pinion set screws, check Z eccentrics and spindle square; back up settings with US (restore with UR).^[13,18]
- **Semiannually at 40 h/week:** all pinions replaced, Z extrusion stripped, cleaned and re-set, collets replaced as required.^[13]

On lubrication. The received wisdom to run racks dry is not ShopBot's instruction. Their 2016 schedule says light grease; the 2014 troubleshooting guide says heavy grease; the 2022 assembly guide uses lithium grease on the pinions. The sources disagree on formulation, not on greasing — and all of them say clean first, never grease over packed chips.^[2,13,15]

The published schedule, in full

Students clean accessible surfaces, inspect tooling and report problems. Mechanical adjustments, electrical checks, lubrication and servicing below are **staff tasks**, not permission to power down or open the machine.

Daily, before cutting ^[MS 3]

1. Run C5 (9000, 10 000 and 12 000 rpm for 3 min each). Confirm the spindle fan runs.
2. Check the bit, collet and collet nut for wear and debris. Keep the spindle body, fans and airways clean. Tapers, shafts and collets must be scrupulously clean. Use the tightening method demonstrated during induction; do not substitute a torque for another nut.
3. Square the gantry against the end stops, hold it there, and press reset.
4. Push-pull test each motor area: X1, X2, Y, Z. A slight click is acceptable, but no movement beyond a few thousandths. If there is play, adjust the motor-mount spring (**3½ turns after slack is removed**) and/or tighten the set screws.
5. Move the machine around at both M and J speeds, or run a short warm-up routine.
6. Run C3.
7. Run C2.
8. Verify the zero with MZ,0 over the surface.
9. Visually inspect the machine, wiring, dust hoses and table.

10. Check that the dust collector works.

Also daily ^[QS 18]:

- Clean bits with solvent and discard dull or damaged ones.
- Check cables for cuts and pinch points.
- Keep the rails and gear racks clear of chips.

Every 40 h of use ^[MS 3]

1. **Rack greasing:** Clean the X, Y and Z racks and pinions with a small brush. Add a **BB-sized blob of light grease every 6"**. Run each axis to its extents about **10 times**. Wipe off the excess and redo the X/Y push-pull test.
2. Clean the Z-assembly V-bearing edges with Scotch-Brite and WD-40, then wipe with light grease or machine oil. Clean and adjust the V-rollers as needed.
3. Scrub the X and Y V-rails with Scotch-Brite soaked in WD-40, then wipe clean. Clean roller buildup with a small brass brush.
4. Repeat the push-pull test and adjust the motor-mount springs (3½ turns past contact) or set screws.

Grease (staff):

- MS says **light** grease ^[MS 3].
- TM recommends **heavy automotive or industrial** grease ^[TM 7].
- UG says **any regular bearing grease**, and that grease does not trap debris badly ^[UG 63].
- The Quick-Start, by contrast, says to **remove** excess grease from the collet and nut, so keep grease off tooling ^[QS 15].

Monthly (from Troubleshooting Mechanicals)

- Drop and re-engage the X and Y pinions, at least monthly or whenever there is play. Press with 15–20 lb while tightening the 4 motor-plate screws ^[TM 4–5].
- Check that the YZ-car lower rollers are seated ^[TM 9].
- Check that the spindle is tight in its bracket ^[TM 17].

Quarterly (40 h/week) to semi-annual (20 h/week): everything above, plus ^[MS 3–4]

1. With the motors removed or disengaged from the racks, move each axis through its full travel. Check for looseness or binding.
2. With the motors removed, spin-test every X and Y car V-roller.
3. Tighten all pinion set screws. Replace pinions and key stock if they show movement.
4. **Adjust the Z-axis V-roller bearing eccentrics** with the provided flat wrench.
5. Check the spindle is square and aligned.
6. **Remove the lower YZ-car V-roller dust covers and adjust the eccentrics.**
7. Update software and firmware.
8. Back up settings with **US** (a C:\SB BKUP folder exists if ShopBot did a support visit). Restore with **UR**.

Semi-annual (40 h/week) to annual (20 h/week): everything above, plus ^[MS 4]

1. Replace all pinions. TM also says pinions are consumables, to be replaced every 6–12 months ^[TM 7].
2. Remove, clean, inspect, reassemble, lubricate and adjust the complete Z extrusion assembly.
3. Replace the collets, and the collet nuts if they are damaged.

Z bearing adjustment outline (staff task)

- **Too loose:** the top or lower bearings spin freely and do not touch the inner captured rail. The Z axis shows sideways "slop" ^[TM 18].
- **Too tight:** Z loses steps, binds or stops abruptly. The inner rail wears early ^[TM 18].
- Adjust the eccentrics with the flat wrench a little at a time ^[MS 4]. The full procedure is ShopBot's "Adjust PRS Z Car Bearings" document ^[TM 18].
- Uneven or slanted step-downs: first check the spindle is tight in its bracket, then the Z bearings ^[TM 17].

YZ-car lower wheel adjustment outline (staff task)

- **Test:** grip the bottom of the YZ car and pull it toward you. It must not move away from the cross-beam ^[TM 9].
- **Symptom when wrong:** a part cuts correctly on 3 sides with a bad 4th side, consistent with cut direction ^[TM 9].
- **Hint:** drop the Y pinion out of the rack first, so you can feel how freely the car rolls while held against the beam. Re-engage the pinion afterwards ^[TM 10].
- **Adjustment:** the two lower bearings have eccentric nuts. Rotate each **slightly counter-clockwise** to tighten ^[UG 64]. The full procedure is "Adjusting the Lower Wheels on the YZ car" ^[TM 10].

Squareness check

- Cut or scribe a large rectangle (for example 30"×50") and compare the diagonals. They should be equal ^[TM 19].
- If they differ, first re-square the gantry against the end stops ^[TM 19–20].

11 Command and signal reference

Command glossary

Command	Meaning	Src
MS	Set Move (feed) speed, XY/Z/A/B, in/s or mm/s	[CR 20]
JS	Set Jog (rapid) speed, XY/Z/A/B	[CR 16]
VS	Set all 8 move and jog speeds in one sheet	[CR 42]
TR	Opens Spindle RPM Control; TR,n requests n RPM in a file (SB3.5.5+)	[QS 15–16]
C2	Z-zero with the plate (input 1): two touches, then pull-up	[QS 14]
C3	XY homing using the proximity switches (inputs 2/3)	[QS 15; UG 20]
C5	Spindle warm-up: 9000/10000/12000 RPM for 3 min each, then off	[QS 16]
C6, C7, C9	Custom-cut slots. Student procedures use the standard C2, C3 and C5 routines. Do not remove C-commands from posted files	—
JZ	Jog Z to a location (or by a distance in relative mode)	[CR 17]
JH	Safe-Z, then jog to XY 0,0	[CR 17]
J2	Jog X,Y at Jog speed	[CR 15]
J3	Jog X,Y,Z at Jog speed	[CR 16]
M2 / M3	Move XY / XYZ at Move (cutting) speed	[CR 17–18]
MZ	Move Z at Move speed (MZ,0 checks Z zero)	[CR 21; TM 11]
SA / SR	Absolute / relative distances; use absolute in part files	[CR 25; CR 28]
VD	Display values: linear units 0 = in, 1 = mm (3rd field), keypad fixed distance, logs	[CR 35; UG 21]
VL	Staff only: table limits in base coordinates, plus a limit-check flag	[CR 38; UG 20]
VN	Staff only: input assignment: limits on/off, input 4 stop mode, input modes	[CR 38–39]
VI	Comm port and driver channel settings (staff only)	[CR 37]
VO	Temporary tool offset (dual Z / air drill)	[CR 40]
SO	Set output n on/off: S0,1,1 = output 1 on	[CR 27; UG 48]
SK (K)	Keypad arrow control; Move mode only	[CR 26]
ZZ	Zero Z here (reference only; students use C2)	[CR 45]
Z2	Zero X and Y here	[CR 43]
Z3	Zero X, Y and Z here	[CR 44]

Command	Meaning	Src
ZX / ZY	Zero X only / Y only	[CR 44–45]
ZT	Staff only. Redefines the table base coordinates that limit checking and C3 rely on; never use it for a job origin (use Z2). ST resets the working display to base	[CR 44; CR 28]
FP	Load and run a part file (fill-in sheet: proportion, reps, offset, tabs)	[CR 12]
FG	Run a file in Goto/single-step mode; resume from the last line	[CR 11]
SP / SM	Preview mode / Move-Cut mode	[CR 28; CR 27]
PAUSE	In a file: wait for a key (PAUSE n = n seconds)	[UG 27]
CN,90	Calls custom cut 90; the CAM post uses it to expose controller variables for a units check	[54]
&var	Part-file variable, e.g. &Zdepth = -0.52 then MZ,&Zdepth	[UG 28]
MO	Staff only: motors off and all outputs off. Not an end-of-job command	[CR 20]
TS	Staff only: ShopBot Setup: plate thickness, prox-switch offsets	[CR 30; TM 12]
SF	Staff only: file and move limit checking on/off	[CR 26]

Inputs, outputs and status indicators

I/O	Function on this machine	Src
Input 1	Z-zero plate. Lights when bit and plate touch	[QS 14]
Input 2	X proximity switch, configured as a limit (VN)	[CR 39; UG 46]
Input 3	Y proximity switch, configured as a limit (VN)	[CR 39; UG 46]
Input 4	Stop circuit. On an alpha: normally-closed E-stop, wired ES1–ES4; cannot be reassigned	[CR 39; UG 47]
Input 5	Z proximity switch	[2]
Output 1	Spindle/router (on an alpha, used with the pendant Start)	[QS 12–13; UG 74–75]
Output 4	Safety/"tool active" output; on during motion and with the keypad open	[CR 27; UG 48; QS 12]

Reading the indicators

- An active input turns **green** in the input section of the Position window ^[UG 46].
- Output 4 lights when the keypad opens ^[QS 12]. Its default mode is –1: on with the warning signal before a move, off at the end of it ^[CR 27].
- Inputs are 5 V TTL. An input reads ON when pulled to ground, which is why the Z-plate clip closes input 1 ^[UG 46].
- Outputs are 5 V TTL, about 5 mA. They signal relays and must not power accessories directly ^[UG 47].
- **Motor driver LEDs (alpha AS-type drivers):** green **OPERATION**, red **ALARM**. The red LED blinks a fault code.

Driver and controller alarm handling (alpha)

- If an obstruction or heavy cutting load makes a closed-loop alpha driver fall behind, it tries to correct, then raises an **alarm**, stops the machine and shows an alarm message.

- Typical SB3 wording: "**Driver fault! (location no longer ACCURATE)**".

- What to do:

1. **Stop.** Do not restart the file. The displayed coordinates can no longer be trusted ^[QS 17].
2. Make the spindle safe: off and stopped, key OFF and removed, keypad closed, no file loaded or paused ^[UG 5; QS 13].
3. Record the screen message and tell staff which axis faulted. Staff read the **red LED blink pattern** on the driver; students do not open the control cabinet.
4. Staff find and remove the cause: a collision, clamp, bound axis, too deep or too fast a cut, or damaged cable. Motor and driver faults can show only during movement.
5. **Never unplug a motor cable with power on.** It can destroy the driver ^[UG 64].
6. Reset the drivers. A software spacebar stop does not need this; a driver or E-stop event does ^[UG 47].
7. **Rehome with C3 and re-zero Z with C2**, then resume with FG if appropriate ^[CR 39; CR 11].
8. Do not reset repeatedly into the same fault. Report it to staff.
9. If an axis is not powered or locked after reset, stop and call staff. Connector and driver checks are staff tasks ^[UG 69–70].
10. Drivers and motors run warm. Excessive heat indicates a fault; report it rather than touching electrical equipment ^[UG 64].

12 Self-check before your first solo job

Passing this is part of the sign-off. Answers follow each question; try answering before reading on.

1. The file is loaded, you clicked OK on the spindle prompt and the gantry is moving toward the stock — but the spindle is silent. What do you do in the next two seconds, and what went wrong?

▼ ANSWER

Spacebar now; E-stop if the bit is already in the stock. You clicked OK before pressing START on the pendant (or the key/output 1 was off). See [the start sequence](#) and [E07](#), [E09](#).

2. You press the E-stop halfway through a job. Which of X, Y and Z zero can you trust afterwards, and what must you do before restarting?

▼ ANSWER

None. Release, pendant Reset, C3 to rehome, jog to the recorded job-origin coordinates and Z2 again, C2 for Z, then FG from a line before the stop. See [Stops](#), [E30](#).

3. C2 ran and reported Z zero, but the first pass cuts 2 mm too deep across the whole sheet. Name three possible causes and the test for each.

▼ ANSWER

Wrong plate thickness in the settings (staff measure the plate and check TS); zeroed on the wrong surface for the file's `&PWZorigin` (read the header); bit slipping in the collet (witness mark on the shank, staff check after correct tightening). [E05](#), [E10](#), [E32](#).

4. The second profile pass is 1 mm to the left of the first. The alpha drivers did not alarm. Why could they not have noticed, and where do you look?

▼ ANSWER

The loop is closed around the motor shaft: a pinion that jumps teeth or slips on its shaft, or packed chips in the rack, move the gantry without the motor knowing. Look at rack teeth, pinion set screws, motor spring tension, roller wheels. [E16–E19](#).

5. Your CAM file has Z0 at the material top; the lab convention for through-cuts is Z0 on the bed. What happens if you zero on the bed and run it anyway?

▼ ANSWER

Every rapid and retract runs inside the stock and every cut goes a full sheet thickness into the spoilboard: crashed clamps, broken bit. Match `&PWZorigin` to the surface you touch, every time. [E32](#).

6. You want 0.15 mm/tooth with a 6 mm two-flute at 14 000 rpm. What feed in mm/min? What plunge?

▼ ANSWER

$14\,000 \times 2 \times 0.15 = 4200$ mm/min; plunge at half or less, ≤ 2100 mm/min, ramped if possible. [Feeds](#).

7. You pressed the spacebar to pause and want to check the cut. What must you confirm before your hand goes near the bit?

▼ ANSWER

A spacebar stop is not isolation. Before reaching near the bit, confirm that the spindle has stopped, the interlock key is OFF and removed, the keypad is closed and no file is loaded or paused. Keep clear before re-engaging the key or restarting. [Stops](#).

8. The part you are cutting out is 300×200 mm. List three ways to keep it from flying on the last pass, and the drawback of each.

▼ ANSWER

Tabs (hand finishing); onion skin 0.25–0.75 mm (hand finishing, needs accurate thickness); screws through the part into the spoilboard (holes, must be clear of toolpaths). [E22](#), [E23](#).

9. What does the alphaStep driver's closed loop see, and what does it not see? Give one failure from each category.

▼ ANSWER

Sees rotor position vs command: a stalled motor from a clamp strike alarms (E01). Does not see anything downstream of the shaft: a slipping pinion, a creeping bit, a moving sheet (E17, E10, E22).

10. After the job: name five things you do before you walk away.

▼ ANSWER

Finish or stop the file and stop the spindle; raise Z and jog clear with everyone outside the cutting area; close the keypad, end the loaded/paused file and remove the key; clear and clean the deck and stow the bit; report faults. Leave the machine powered for lab staff. Users never power down the machine; E-stop is for emergencies.

11. Name the three buttons on our pendant and what each does.

▼ ANSWER

Reset re-enables the drives after an E-stop (twist the E-stop to release it first); green Start starts the spindle (when output 1 and the key allow it); E-stop cuts spindle power at once and motor power about 5 s later. [Stops](#).

12. Where does the Z-plate's clip go, and where does the plate go back to?

▼ ANSWER

Nowhere new: the clip stays clamped on the aluminium carriage plate; the circuit runs through plate → spindle → collet → bit. The plate goes back in its holder on the YZ car with the lead coiled. Never put the clip on the bit or nut: the spindle whips it off.

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Manual page tags in the procedures: AG Assembly Guide 2022 [2] · QS Quick Start 2016 [4] · UG User Guide 2015 [11] · CR Command Reference 2015 [10] · HD Holding Down 2016 [12] · MS Maintenance Schedule 2016 [13] · TM Troubleshooting Mechanicals 2014 [16] · XY Manually Setting XY Zero [47] · FAQ Z-zero plate [6].