Appendix J: Troubleshooting

Contents

Appendix J: Troubleshooting Flowcharts and Diagnostics

J.1 No Motion on Axis

```
START: Axis does not move when commanded
|
|-> Test 1: Does motor make any sound when commanded?
|   |
|   |-> NO sound
|   |   |-> Check controller LED (step pulses present?)
|   |   |   |-> LED flashing → Problem: Cable/driver connection
|  |  |  |  +-> Solution: Check step/dir cable continuity, reseat connectors
|   |   |   +-> LED not flashing → Problem: Controller configuration
|   |   |       +-> Solution: Check steps/mm, enable signal, port assignment
|   |   |
|   |   +-> Check driver enable signal (is driver enabled?)
|      |             |-> Disabled → Solution: Check enable wiring, E-
stop circuit, software enable
|   |       +-> Enabled → Problem: Driver fault
|   |           +-> Solution: Check driver LEDs for fault code, reset driver
|   |
```

```
|   +-> YES sound (motor humming/vibrating)
|       |-> Test 2: Is motor stalled (high current, hot)?
|       |   |-> YES → Problem: Excessive load or mechanical binding
|     |  |  +-> Solution: Manually move axis (disconnect motor), check for binding,
|       |   |       reduce load, increase motor torque setting
|       |   +-> NO → Problem: Motor not receiving step pulses correctly
|       |      +-> Solution: Check step/dir polarity, microstepping setting,
|       |           driver current setting (too low)
|       |
|       +-> Test 3: Does motor shaft turn when commanded?
|        |-> YES (shaft turns, no axis motion) → Problem: Mechanical disconnect
|        |  +-> Solution: Check coupling (set screws loose), ball screw connection
|           +-> NO (shaft locked) → Problem: Driver or motor fault
|            +-> Solution: Swap driver with known-good, test motor resistance
|                   (should be <5Ohms per phase)
```

J.2 Poor Surface Finish

```
START: Part surface finish is rough, chatter marks, or uneven
|
|-> Type of defect?
|   |
|   |-> CHATTER (regular ripple pattern)
|   |   |-> Is chatter frequency regular (harmonic)?
|   |   |   |-> YES → Resonance problem
|  |  |  |  |-> Check spindle RPM (adjust +/-10% to move off resonance frequency)
|   |   |   |   |-> Increase rigidity (tighten gibs, preload bearings)
|   |  |   |  +-> Reduce depth of cut or width of cut (lower cutting forces)
|   |   |   |
|   |   |   +-> NO → Random chatter
|   |   |       |-> Check tool overhang (reduce as much as possible)
|   |   |       |-> Increase feeds (exit from rubbing to cutting)
|   |   |       +-> Use carbide tooling (stiffer than HSS)
|   |   |
|   |   +-> Test: Does chatter change with RPM?
|   |       |-> YES → Spindle speed related (adjust RPM)
|   |       +-> NO → Structural issue (low rigidity, loose parts)
|   |
|   |-> ROUGHNESS (uneven texture, not chatter)
|   |   |-> Check feed per tooth (too high causes rough finish)
|   |   |   +-> Solution: Reduce feedrate or increase RPM (lower chip load)
|   |   |-> Check tool condition (dull or chipped)
|   |   |   +-> Solution: Replace tool, check for proper chip evacuation
|   |   +-> Check coolant (inadequate cooling/lubrication)
|   |       +-> Solution: Increase coolant flow, use finishing flood coolant
|   |
```

```
|   |-> STEPS/RIDGES (visible facets instead of smooth surface)
|   |   |-> Problem: Steps/mm or microstepping incorrect
|  |  |  +-> Solution: Calibrate steps/mm, enable microstepping (min 1/8 step)
|   |   +-> Problem: Backlash or lost steps
|  |    +-> Solution: Check ball screw preload, tighten couplings, reduce acceleration
|   |
|   +-> BURN MARKS (discolored, overheated)
|       |-> Problem: Excessive heat from cutting (too slow feeds, dull tool)
|     |  +-> Solution: Increase feed rate, reduce RPM, replace tool, add coolant
|       +-> Problem: Rubbing (feeds too low for given RPM)
|        +-> Solution: Increase IPM (chip load must be >0.05mm/tooth minimum)
```

J.3 Axis Stalling or Skipping Steps

```
START: Axis loses position, motors skip steps, or stall during operation
|
|-> Test 1: Does stalling occur at specific location or random?
|   |
|   |-> SPECIFIC LOCATION (same spot every time)
|   |   |-> Problem: Mechanical obstruction or tight spot
|   |   |   +-> Solution:
|   |   |       |-> Check linear guides for damage, debris
|   |   |       |-> Check ball screw for bent shaft, damaged balls
|  |  |    |-> Lubricate guides and screw (inadequate lubrication causes binding)
|   |   |       +-> Check rail parallelism (misaligned rails cause binding)
|   |   |
|   |   +-> Problem: Electrical interference at specific location
|  |    +-> Solution: Check for nearby power cables (VFD, spindle), reroute signal cables
|   |
|   +-> RANDOM LOCATION (inconsistent)
|       |-> Test 2: Does stalling occur during rapid moves or cutting?
|       |   |
|       |   |-> RAPID MOVES (G00)
|       |   |   |-> Problem: Insufficient motor torque at high speed
|       |   |   |   +-> Solution:
|      |   |   |      |-> Reduce max velocity (rapid override in controller)
|       |   |   |       |-> Increase driver voltage (48V → 72V for steppers)
|     |  |  |    +-> Check driver current setting (must be >=motor rated current)
|       |   |   |
|       |   |   +-> Problem: Excessive acceleration
|     |  |    +-> Solution: Reduce acceleration setting in controller (lower is smoother)
|       |   |
|       |   +-> CUTTING MOVES (G01)
|       |       |-> Problem: Cutting forces too high for motor
|       |       |   +-> Solution:
|       |       |       |-> Reduce depth of cut (lower axial force)
```

```
|       |       |       |-> Reduce width of cut (lower radial force)
|       |       |       |-> Increase motor size (NEMA 23 → NEMA 34)
|       |       |       +-> Use sharper tool (reduce cutting force)
|       |       |
|       |       +-> Problem: Ball screw binding under load
|     |       +-> Solution: Check preload (too high causes binding), increase diameter
|       |
|       +-> Test 3: Check driver fault LED
|           |-> Fault LED on → Driver overheating or over-current
|       |  +-> Solution: Add cooling fan to driver, reduce motor current, check short circu
|           +-> No fault → Problem: EMI/noise causing missed steps
|          +-> Solution: Use shielded cables, ferrite cores on motor leads, separate power/
```

J.4 Spindle Issues

J.4.1 Spindle Won't Start

```
START: Spindle does not rotate when M03 commanded
|
|-> Test 1: VFD display shows error code?
|   |
|   |-> YES → Error Code Diagnostics
|  |  |-> E001 (Over-current) → Check motor for short, reduce acceleration parameter
|  |  |-> E002 (Over-voltage) → Check input voltage, brake resistor if decelerating
|  |  |-> E003 (Over-temperature) → Clean VFD heatsink, check fan, reduce load
|  |  |-> E010 (Ground fault) → Check motor insulation, ground wire continuity
|   |   +-> Other → Consult VFD manual, reset parameters to factory default
|   |
|   +-> NO error → Test 2: VFD receives run command?
|     |-> Check VFD input terminals (FOR/REV closure or 0-10V signal present?)
|       |   |-> NO signal → Problem: Controller output or wiring
|      |   |   +-> Solution: Check relay, optocoupler output, wire continuity
|       |   +-> Signal present → Problem: VFD parameter configuration
|     |     +-> Solution: Check VFD source (terminal/Modbus), run enable, frequency source
|       |
|       +-> Test 3: Does spindle motor hum but not rotate?
|           |-> YES → Problem: Single-phase input to 3-phase motor
|       |  +-> Solution: Check all 3 phases present (measure VAC on U, V, W outputs)
|           +-> NO sound → Problem: VFD output disabled
|          +-> Solution: Check enable switch, emergency stop circuit, VFD enable parameter
```

J.4.2 Spindle Runout or Vibration

```
START: Spindle has excessive runout (>0.02mm TIR) or vibration
|
|-> Test 1: Measure runout at spindle taper (ER collet/tool holder interface)
|   |
```

```
|   |-> Runout >0.01mm → Problem: Spindle bearing wear or damage
|   |   +-> Solution:
|   |       |-> Replace spindle bearings (angular contact bearings)
|   |       |-> Check preload (adjust or replace preload springs/spacers)
|  |     +-> Verify spindle taper not damaged (clean thoroughly, inspect for dings)
|   |
|   +-> Runout <0.01mm → Test 2: Measure runout at tool tip
|       |
|       |-> Runout >0.05mm → Problem: Tool holder or collet issue
|       |   +-> Solution:
|       |       |-> Clean ER collet and nut (remove all chips/debris)
|       |       |-> Replace worn collet (clamping surfaces worn)
|      |      |-> Check tool shank diameter (must match collet size exactly)
|     |     +-> Torque collet nut to spec (too loose causes runout, too tight damages collet
|       |
|      +-> Runout acceptable → Problem: Tool unbalance (high-speed vibration)
|           +-> Solution:
|               |-> Use balanced tool holders (BT40, HSK for >10,000 RPM)
|               |-> Reduce RPM (lower vibration frequency below resonance)
|           +-> Check motor mounting (motor must be rigidly attached, no play)
```

J.5 Homing and Limit Switch Issues

```
START: Homing fails or limit switch triggers unexpectedly
|
|-> Test 1: Do limit switches trigger correctly when manually pressed?
|   |
|   |-> NO (switch not detected)
|   |   |-> Check wiring continuity (multimeter in continuity mode)
|   |   |-> Check switch type (NO vs. NC - CNC typically uses NC for safety)
|   |   |-> Verify input pin assignment in controller config
|  |  +-> Test with multimeter (should see 24V when switch open, 0V when closed for NC)
|   |
|   +-> YES (switch works manually) → Test 2: False triggering?
|       |
|       |-> Triggers during rapid moves or spindle operation
|       |   |-> Problem: Electrical noise (EMI from motor/VFD)
|       |   |   +-> Solution:
|     |  |     |-> Use shielded cable for limit switches (ground shield at controller end or
|     |  |     |-> Add RC filter (0.1muF capacitor + 1kOhms resistor across switch)
|     |  |     |-> Separate switch wiring from motor power cables (min 30cm separation)
|       |   |       +-> Use opto-isolated inputs (if controller supports)
|       |   |
|       |   +-> Problem: Mechanical vibration causing switch to flutter
|     |     +-> Solution: Secure switch mounting, adjust switch actuation distance
|       |
```

```
|       +-> Test 3: Homing direction wrong or doesn't stop at switch?
|       |-> Homing in wrong direction → Problem: Home direction parameter inverted
|         |   +-> Solution: Change home search direction in controller config
|         +-> Doesn't stop at switch → Problem: Home switch polarity inverted
|           +-> Solution: Invert switch input logic (active high/low setting)
```

J.6 Controller Faults

J.6.1 LinuxCNC Joint Following Error

```
ERROR: Joint [N] following error (position command vs. feedback mismatch)
|
|-> Stepper system (open-loop, no encoder feedback)
|   |-> This error should NOT occur (no feedback loop)
|   +-> Problem: Closed-loop mode enabled accidentally
|     +-> Solution: Set controller to open-loop (step/dir mode), disable PID loop
|
+-> Servo system (closed-loop with encoder)
    |-> Check following error amount
    |   |-> Small error (<1mm) → Problem: Tuning (PID gains too low)
   |  |  +-> Solution: Increase proportional gain (Kp), check derivative gain (Kd)
    |   +-> Large error (>10mm) → Problem: Mechanical or feedback issue
   |      |-> Check encoder wiring (A/B phases swapped causes wrong direction)
    |       |-> Check encoder counts per revolution (must match motor spec)
   |     |-> Check for mechanical binding (manually move axis, should be smooth)
   |     +-> Check motor direction (command forward, motor should move forward)
    |
    +-> Error occurs during rapid acceleration
     +-> Solution: Increase ferror limits in HAL config, reduce max acceleration
```

J.6.2 Mach3/Mach4 Charge Pump Fault

```
ERROR: Charge pump fault (external E-stop or interlock open)
|
|-> Check E-stop circuit
|   |-> All E-stop buttons released (twisted to unlock)?
|   +-> E-stop relay energized (contactor pulled in)?
|       +-> If not: Check 24V supply to E-stop circuit, check relay coil
|
|-> Check safety interlocks
|   |-> All doors closed (limit switch actuated)?
|   |-> Guard interlock switches closed?
|   +-> If not: Adjust switch position, check NC contact wiring
|
+-> Check breakout board (BOB)
    |-> Charge pump signal present? (10-25 kHz square wave on output pin)
    |   +-> If not: Reinstall Mach3, check parallel port driver
```

```
    +-> Charge pump relay energized?
        +-> If not: Check relay coil voltage, replace relay if faulty
```

End of Troubleshooting Flowcharts and Diagnostics Appendix