# CNC Table

Power & Control System – V1

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2026-01-15

## Contents

# Readme

Proverbs 15:32 - “Whoever ignores instruction despises himself, but he who listens to reproof gains understanding.”

Proverbs 12:15 - “The way of a fool is right in his own eyes, but a wise man listens to advice.”

Proverbs 13:18 - “Poverty and shame come to him who ignores instruction, but whoever heeds reproof is honored.”

## Reference Materials

1. 3 Axis Table and Gantry System Configuration - V1 (OnShape Assembly)
2. Power and Control System Configuration - V1
3. Wiring Shopping List
4. Glossary of Terms

## Build and Commissioning Order (Authoritative)

Build Order Dependency Chart

All setup, configuration, and commissioning steps must follow this order.
Mechanical and electrical systems are interdependent and must be validated at their defined gates.

### 3 Axis Table and Gantry System - V1 - Instructions

1. Mechanical Leveling and Squaring

### Power and Control System - V1 - Instructions

1. Control Cabinet Physical Plan
2. Wire Gauge Specification
3. AC Power Supply Specification
4. DC Power Supply Specification
5. DIN-Rail Placement Plan
6. Terminal-by-Terminal Wiring Table
7. DMA860S Tuning
8. DDCSV4.1 Axis and Dual-X Homing Configuration
9. Steps-Per-Unit Calibration
10. Enable and Configure Soft Limits

11. Configure Acceleration and Maximum Velocity
12. Validate Spindle Speed Scaling
13. Dry-Run G-code Test

### Commissioning

Commissioning validates the combined mechanical and power/control systems.
Neither system is considered complete in isolation.

1. Commissioning Checklist
2. Pre-Cut Checklist

## Build-Order Dependency Chart

Power & Control System – V1

Each section **depends on all sections above it**. If work stops and resumes later, restart at the highest unchecked section.

### Administrative Baseline

- System named and labeled as Power & Control System – V1
- Component selection frozen
- Wiring, configuration, and commissioning documents created

### Mechanical Foundation

- CNC table assembled
- Frame leveled relative to gravity
- X, Y, and Z axes mechanically square
- Linear motion smooth across full travel
- Mechanical alignment declared valid

Electrical motion, homing, and calibration assume mechanical alignment has been verified and locked.

### Electrical Infrastructure

- Cabinet installed
- Ground bar installed and bonded to earth
- Main disconnect installed
- Branch protection installed
- AC integrity verified with no loads

## Power Conversion and Distribution

- Control PSU installed and verified
- Stepper PSU installed and verified
- DC distribution terminals installed
- Voltage domains labeled

## Motion and Logic Hardware

- DDCSV4.1 installed
- DMA860S drivers installed
- DIN-rail terminals installed
- Device frames bonded to ground
- Controller boots normally

## Signal Wiring

- Step, direction, and enable signals wired
- Driver-to-motor wiring complete
- Limit and home switches wired
- E-stop logic wired
- Spindle control signals wired

## Static Electrical Verification

- Continuity checks complete
- Ground isolation verified
- Shield termination verified
- Power-up with motors disabled
- No faults or overheating

## Motion Enablement

- Drivers enabled
- Individual axis jogging verified
- Axis directions verified
- Dual-X coherence verified
- Motion disabled and inspected

## Homing and Squaring

- Homing directions configured
- Home switches verified
- Dual-X homing enabled
- Gantry squaring verified

- Homing repeatability confirmed

## Motion Calibration

- Driver current and microsteps set
- Initial steps-per-unit entered
- X axis calibrated
- X calibration copied to A
- Y axis calibrated
- Z axis calibrated under load

## Safety Envelope

- Soft limits enabled
- Soft limits verified
- Hard limits verified
- E-stop removes motion power
- E-stop stops spindle

## Spindle Validation

- Cooling system verified
- VFD terminal control verified
- 0–10 V scaling validated
- Commanded RPM matches actual RPM
- Thermal behavior observed

## Integrated Testing

- Dry-run G-code loaded
- Full dry-run executed
- Axis coordination verified
- No lost steps
- No limit faults

## Commissioning Complete

- Configuration values recorded
- Cabinet closed and ventilated
- Wiring labeled
- V1 declared commissioned

# Power & Control System Configuration

Power & Control System – V1

- **Controller:** CNCTOPBAOS DDCSV4.1 (stand-alone, PLC-capable, MPG)
- **Axes:** 4 total
  - X axis: dual NEMA 34 (slaved, auto-squaring)
  - Y axis: single NEMA 34
  - Z axis: single NEMA 34
- **Motors:** HobbyUnlimited NEMA 34, 6 A, 12 Nm, 156 mm
- **Drivers:** 4 × DMA860S digital stepper drivers
- **Stepper power:** Single high-voltage DC bus (60–72 VDC class)
- **Control power:** 24 VDC logic and I/O supply
- **Spindle system:** Huanyang 2.2 kW VFD + 80 mm water-cooled spindle, 0–10 V speed, relay run control
- **Safety model:** Hardware E-stop cutting stepper power and spindle run, plus controller awareness
- **Architecture:** Fully stand-alone, no PC dependency during runtime

# Wiring Shopping List

Power & Control System – V1

## 1. AC Mains and Power Distribution Wire

**High-current AC (cabinet internal)**

- **10 AWG stranded copper wire (green)**
  - Purpose: main cabinet ground bond
  - Buy: 10–15 ft
- **10 AWG stranded copper wire (black/red)**
  - Purpose: main AC feed inside cabinet
  - Buy: 10–15 ft
- **12 AWG stranded copper wire (black/red)**
  - Purpose: VFD input power
  - Buy: 10–15 ft
- **14 AWG stranded copper wire (black/red)**

  - Purpose: stepper PSU AC feed
  - Buy: 10–15 ft

- **16 AWG stranded copper wire**
  - Purpose: control PSU AC feed
  - Buy: 10 ft

Insulation type:

- MTW or THHN, 600 V rated, 75 °C or higher

## 2. VFD to Spindle Cable (critical item)

- **Shielded VFD motor cable, 4-conductor**
  - Conductors: **14 AWG**
  - Configuration: 3 phases + ground
  - Shield: braided or foil + drain
  - Length: machine dependent
    - Typical router: **15–25 ft**

Do not substitute generic SOOW here. This cable matters.

## 3. Stepper DC Power Wiring

**DC bus (PSU to distribution)**

- **10 AWG stranded copper wire (red and black)**
  - Purpose: stepper PSU DC output to terminal block
  - Buy: 10 ft each color

**DC distribution to drivers**

- **14 AWG stranded copper wire (red and black)**
  - Purpose: terminal block to each DMA860S
  - Buy: 25–30 ft total (covers all four drivers)

## 4. Stepper Motor Cables

You have **4 NEMA 34 motors**.

- **Shielded motor cable, 4-conductor**
  - Conductors: **14 AWG**
  - Twisted pairs preferred

- Shield with drain wire
- Length per motor:
  - X motors: gantry travel + service loop
  - Y motor: full axis travel
  - Z motor: shorter run
- Typical total buy: **60–80 ft**

Label both ends before installing.

## 5. Control Power (24 VDC)

- **16 AWG stranded copper wire**
  - Purpose: 24 VDC PSU to distribution
  - Buy: 10 ft
- **18 AWG stranded copper wire**
  - Purpose: distribution to DDCSV, relays, fans
  - Buy: 30–40 ft

Color suggestion:

- Red = +24 V
- Black or blue = 0 V

## 6. Step / Direction / Enable Signal Wiring

- **Shielded, twisted-pair control cable**
  - Conductors: **22 AWG**
  - Pairs: at least 2 pairs per axis
  - Shield with drain wire

Usage:

- DDCSV → DMA860S (Step, Dir, Enable)

Buy:

- **30–40 ft total**

You can run one multi-pair cable per driver or bundle pairs neatly.

## 7. Limits, Homes, and E-stop Wiring

**Limit and home switches**

- **Shielded control cable**

- Conductors: **22 AWG**
- 2–3 conductors per switch
- Buy: **40–60 ft** (depends on machine size)

**E-stop control loop**

- **18 or 20 AWG stranded copper**
  - Purpose: E-stop logic loop
  - Buy: 15–20 ft

## 8. Analog Spindle Speed Control (0–10 V)

- **Shielded twisted-pair cable**
  - Conductors: **22 AWG**
  - Buy: 10–15 ft

This must be its own cable. Do not bundle with step/dir.

## 9. Grounding and Shield Termination

- **14 AWG green stranded copper wire**
  - Purpose: bonding PSUs, drivers, VFD chassis
  - Buy: 15–20 ft
- **Drain wire (18–22 AWG)**
  - Purpose: shield termination to ground bar
  - Usually included in shielded cable, but have extra on hand

## 10. Optional but strongly recommended

- Ferrules for:
  - 10 AWG
  - 12 AWG
  - 14 AWG
  - 16 AWG
  - 18–22 AWG
- Heat-shrink labels
- Cable clamps and strain reliefs
- Wire duct (slotted)

# Control Cabinet Physical Plan

Power & Control System – V1

## Purpose

Define a clean, low-noise, serviceable cabinet layout. This plan prioritizes EMI control, airflow, and maintenance access.

## Cabinet Zoning

Divide the cabinet into vertical zones.

### Zone 1: High Voltage AC

- Main disconnect
- Circuit breakers
- EMI filter (if used)

Keep wiring short and isolated.

### Zone 2: VFD Zone

- Huanyang VFD
- VFD line filter (optional)
- Spindle output exit point

Rules:

- Physical separation from logic
- Dedicated wire routing
- Shielded spindle cable exit

### Zone 3: Power Conversion

- Stepper PSU
- Control PSU
- DC distribution terminals

Mount centrally for short DC runs.

### Zone 4: Motion and Logic

- DDCSV4.1 controller
- DMA860S drivers
- Signal terminal blocks

Rules:

- DIN rail mounting
- Clear airflow
- Easy access for tuning

**Zone 5: Grounding and I/O**

- Ground bar
- Shield termination points
- Limit and sensor terminals

Single-point grounding only.

## Electrical Separation and Grounding

The stepper DC supply and the control DC supply must remain electrically isolated. DC negative rails must not be tied together.

Both power supply chassis must be bonded to the cabinet ground bar, and all protective earth connections must converge at a single grounding point. This approach minimizes noise coupling and limits fault propagation.

## AC Power Entry and Distribution

### Main Disconnect Placement

AC power entry, disconnects, and branch protection shall be implemented in accordance with AC Power Supply Specification.

This device establishes the primary safety boundary for the cabinet.

### Branch Breaker Layout

Branch protection devices shall be DIN-rail mounted and located downstream of the main disconnect. Branch breakers should be arranged in a logical top-to-bottom or left-to-right order corresponding to load type:

1. VFD branch
2. Stepper DC power supply branch
3. Control and logic power supply branch

Each breaker shall be clearly labeled to indicate the load it serves.

### Separation of Noisy and Quiet Loads

The cabinet layout shall physically separate high-noise and low-noise components.

- Noisy components:
  - VFD
  - VFD branch breaker

  - Spindle power wiring
- Quiet components:
  - Control PSU
  - DDCSV4.1 controller
  - Signal terminal blocks

Noisy and quiet wiring shall be routed in separate wire ducts where practicable. Crossings, if unavoidable, shall be made at right angles to minimize coupling.

This separation reduces EMI, improves signal integrity, and increases overall system reliability.

### Airflow Plan

- Bottom or side intake
- Top or opposite-side exhaust
- Airflow across drivers and PSUs
- VFD heatsink unobstructed

Use filtered intake.

### Serviceability Rules

- No wire crossing zones unnecessarily
- Label both ends of every cable
- Leave service loops
- Keep DIP switches accessible

### Status

Cabinet physical plan drafted for V1.

## Wire Gauge Specification

Power & Control System – V1

### Conventions used

- Copper conductors, 75 °C minimum insulation (THHN/MTW inside cabinet)
- Stranded wire for anything that moves or lands on terminals
- Shielded cable where noted
- All grounds bonded to a single cabinet ground bar

### 1. AC mains and protection

| Circuit | Voltage | Current (typical) | Wire gauge | Notes |
|---|---|---|---|---|
| Main AC feed (to cabinet disconnect) | 240 VAC | ≤30 A | **10 AWG** | Headroom, mechanical robustness |
| Disconnect → VFD input | 240 VAC | ~10–12 A | **12 AWG** | Dedicated run |
| Disconnect → Stepper PSU | 240 VAC | ~8–10 A | **14 AWG** | Separate branch |
| Disconnect → Control PSU | 120/240 VAC | <2 A | **16 AWG** | Light load |
| Safety ground (PE) | — | — | **10 AWG** | Cabinet ground bond |

## 2. VFD to spindle (noise-critical)

| Circuit | Voltage | Current | Wire gauge | Cable type |
|---|---|---|---|---|
| VFD → spindle U/V/W | 0–240 VAC, 3-phase | ~6–9 A | **14 AWG** | **Shielded VFD motor cable** |
| Spindle ground | — | — | **14 AWG** | Bond to spindle body |

Rules:

- Shield grounded at **VFD end only**
- Route alone, no parallel signal wiring

## 3. Stepper DC power distribution

| Circuit | Voltage | Current | Wire gauge | Notes |
|---|---|---|---|---|
| Stepper PSU DC output → distribution | 60–72 VDC | up to 20 A | **10 AWG** | Short run to terminal block |
| Distribution → each DMA860S | 60–72 VDC | ≤6 A per driver | **14 AWG** | Star topology, not daisy-chain |
| DC negative return | 60–72 VDC | — | **10–14 AWG** | Match positive size |

## 4. Stepper drivers to motors

| Circuit | Voltage | Phase current | Wire gauge | Cable type |
|---|---|---|---|---|
| DMA860S → NEMA 34 motor | Pulsed DC | 6 A | **14 AWG** | **Shielded, twisted pairs** |

Notes:

- One cable per motor
- Shield grounded at cabinet end only
- Keep away from VFD output cable

## 5. Control power (24 VDC)

| Circuit | Voltage | Current | Wire gauge | Notes |
|---|---|---|---|---|
| Control PSU output → distribution | 24 VDC | ≤5 A | **16 AWG** | Short internal run |
| Distribution → DDCSV4.1 | 24 VDC | <1 A | **18 AWG** | Clean logic feed |
| Distribution → relays, MPG, fans | 24 VDC | <1 A each | **18 AWG** | Label circuits |

## 6. Step/Dir and enable signals (DDCSV → DMA860S)

| Signal type | Voltage | Current | Wire gauge | Cable type |
|---|---|---|---|---|
| Step / Dir / Enable | 5–24 V logic | mA | **22 AWG** | Shielded, twisted pairs |

Notes:

- Differential wiring preferred where available
- Shield grounded at controller end only

## 7. Limits, homes, E-stop

| Circuit | Voltage | Current | Wire gauge | Cable type |
|---|---|---|---|---|
| Limit & home switches | 24 VDC | mA | **22 AWG** | Shielded if long runs |
| E-stop loop (control) | 24 VDC | mA | **18–20 AWG** | Robust insulation |
| E-stop power interrupt | AC | varies | **Same as interrupted circuit** | Through contactor/relay |

### 8. Analog spindle speed control (DDCSV → VFD)

| Circuit | Voltage | Current | Wire gauge | Cable type |
|---|---|---|---|---|
| 0–10 V analog | 0–10 VDC | mA | **22 AWG** | **Shielded twisted pair** |

Rules:

- Shield grounded at DDCSV end only
- Never share conduit with VFD output

### 9. Grounding and shields

| Purpose | Wire gauge |
|---|---|
| Cabinet ground bar → earth | **10 AWG** |
| PSU frames → ground bar | **12–14 AWG** |
| Driver frames → ground bar | **14 AWG** |
| Cable shields → ground bar | **Drain wire, 18–22 AWG** |

# AC Power Supply Specification

Power & Control System – V1

This document defines the AC power requirements, protection strategy, and internal distribution architecture for Power & Control System – V1.

All downstream DC power specifications and wiring decisions depend on the requirements defined here.

## Overview

Power & Control System – V1 operates from a single-phase 240 VAC supply and contains three primary AC loads:

- VFD and spindle system
- Stepper motor DC power supply
- Control and logic power supply

All AC power enters the cabinet through a single main disconnect and is distributed to individual loads through branch protection devices mounted on DIN rail.

## Incoming Service

- Nominal voltage: 240 VAC
- Acceptable range: 200–240 VAC

- Phase: single-phase
- Frequency: 50/60 Hz
- Recommended service rating: 30 A
- Neutral conductor: not required unless future 120 VAC loads are added

A 30 A service provides sufficient capacity for continuous simultaneous axis loading, spindle operation, and future expansion while maintaining acceptable thermal and inrush margins.

## Main Disconnect

A single main disconnect shall be installed at the cabinet power entry.

Requirements:

- Two-pole disconnect switching both hot conductors
- Minimum rating: 30 A
- Lockable in the OFF position
- Clearly labeled and readily accessible

The main disconnect provides the primary safety boundary for the cabinet and shall interrupt all AC power entering the system.

## Branch Protection

Downstream of the main disconnect, AC power shall be divided into three protected branches using DIN-rail mounted circuit breakers or fused disconnect devices.

Residential breaker panels are not appropriate for use inside a control cabinet.

### Branch assignments and ratings

VFD branch:

- Two-pole breaker
- 15 A rating
- C or D trip curve to tolerate inrush current
- Dedicated branch

Stepper DC power supply branch:

- Two-pole breaker
- 15 A rating
- C trip curve

Control and logic power supply branch:

- Two-pole breaker
- 5 A rating
- B or C trip curve

Each branch breaker provides both overcurrent protection and a means of isolating individual subsystems for service and troubleshooting.

## AC Wiring

Recommended conductor sizes:

- Incoming service to main disconnect: 10 AWG copper
- Branch wiring to VFD: 12 AWG copper
- Branch wiring to stepper DC power supply: 12 AWG copper
- Branch wiring to control PSU: 16 AWG copper (14 AWG acceptable)

All protective earth conductors shall terminate at a single cabinet ground bar. Ground conductors shall not be daisy-chained.

## Noise Considerations

The VFD and its associated branch wiring are the primary sources of electrical noise in the system.

AC routing and cabinet layout shall ensure:

- Physical separation between VFD power wiring and control wiring
- Short, direct AC runs to the VFD
- Dedicated branch protection for the VFD

Noise mitigation is addressed further in the Control Cabinet Physical Plan.

# DC Power Supply Specification

Power & Control System – V1

This document specifies the DC power supplies required for reliable operation of Power & Control System – V1 under continuous, simultaneous multi-axis loading.

## Overview

The system uses two electrically separate DC power domains:

- High-voltage DC for stepper motor power
- Low-voltage DC for control, logic, and I/O

These supplies must remain electrically isolated from each other while sharing a common protective earth reference.

## Stepper Motor DC Power Supply

### Purpose

The stepper motor DC power supply provides the DC bus power for all DMA860S stepper motor drivers. It must support continuous simultaneous axis loading without excessive voltage sag or thermal stress.

### Electrical Requirements

- Nominal voltage: 68 VDC
- Acceptable operating range: 60–72 VDC
- Topology: single shared DC bus
- Output type: regulated switching DC supply
- Ripple tolerance: minimal ripple preferred; transient sag must be avoided

### Load Characteristics

The system uses four stepper motors:

- Quantity: 4
- Type: NEMA 34
- Rated phase current: 6.0 A
- Drive method: bipolar, microstepped
- Expected duty cycle: continuous multi-axis motion

Stepper motor drivers do not draw phase current directly from the DC supply. Instead, they draw average electrical power based on motor load, acceleration, and driver efficiency.

### Numerical Sizing

A conservative per-motor electrical power estimate under sustained load is approximately 200–250 W. This accounts for copper losses, driver inefficiency, and continuous torque demand.

For four motors:

- Base electrical demand: approximately 1000 W

Additional margin is required to accommodate:

- Simultaneous acceleration events
- DC bus capacitance recharge
- Thermal headroom and long-term reliability

Recommended margin: 30–50 percent.

### Final Recommended Rating

- Minimum acceptable continuous rating: 1200 W
- Recommended continuous rating: 1500 W

- Voltage rating: 60–72 VDC, with 68 VDC nominal preferred

### Quantity

A single shared high-voltage DC power supply is recommended. Multiple supplies provide no functional advantage and introduce unnecessary grounding and fault complexity.

## Control and Logic DC Power Supply

### Purpose

The control and logic DC power supply provides power for:

- DDCSV4.1 motion controller
- Limit and home switches (if powered)
- Relays or contactors with 24 VDC coils
- Indicator lights and auxiliary logic

### Electrical Requirements

- Output voltage: 24 VDC regulated
- Output type: industrial-grade switching power supply
- Electrical noise: low ripple preferred
- Isolation: galvanically isolated from the stepper DC power supply

### Load Estimate

Typical control system loads are modest and include controller logic, I/O circuits, and auxiliary devices. Estimated continuous current draw is less than 3 A.

Recommended supply rating:

- Minimum: 24 VDC at 5 A
- Preferred: 24 VDC at 10 A for headroom and future expansion

## Acceptance Criteria

The DC power system is considered valid when:

- The stepper DC bus remains within the specified voltage range during sustained simultaneous axis motion
- No stepper driver faults occur during heavy multi-axis operation
- Power supplies remain within thermal limits
- Control logic remains stable during aggressive motion events

## Status

DC power supply requirements are defined and approved for Power & Control System – V1.

# DIN-Rail Placement Plan

Power & Control System – V1

This is a **textual placement plan**, suitable for a sketch or CAD later.

## Rail 1: High-Voltage AC (Top or Left)

Order from incoming power:

1. Main disconnect
2. EMI line filter (optional)
3. Branch breakers or fuses
4. VFD input terminals

Rules:

- Short runs
- No signal wiring on this rail
- Clear finger-safe spacing

## Rail 2: Power Conversion (Center)

Left to right:

1. Stepper PSU
2. Control PSU
3. DC distribution terminals

Rules:

- Keep DC runs short
- Label voltage clearly
- Leave airflow clearance

## Rail 3: Motion and Control (Opposite Side)

Left to right:

1. DDCSV4.1 controller
2. DMA860S drivers (even spacing)
3. Signal terminal blocks

Rules:

- Signal wiring only
- No AC crossings
- DIP switches accessible

### Rail 4: Ground and I/O (Bottom)

1. Ground bar
2. Shield termination points
3. Limit and sensor terminals

Rules:

- Single-point ground
- Shields land here
- Easy inspection

# Terminal-by-Terminal Wiring Table

Power & Control System – V1

## 1. Power distribution (AC side)

**1.1 Main AC → devices**

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| AC mains L1 | — | Main disconnect | L1 | 240 VAC |
| AC mains L2 | — | Main disconnect | L2 | 240 VAC |
| Earth | — | Ground bar | GND | 10 AWG |

**1.2 Main disconnect → VFD**

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| Disconnect L1 | — | VFD | R | 12 AWG |
| Disconnect L2 | — | VFD | T | 12 AWG |
| Ground bar | GND | VFD | GND | Chassis ground |

(Do not connect S for single-phase unless your VFD manual explicitly instructs it.)

**1.3 Main disconnect → power supplies**

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| Disconnect L1 | — | Stepper PSU | L | 14 AWG |
| Disconnect L2 | — | Stepper PSU | N | 14 AWG |
| Disconnect L1 | — | Control PSU | L | 16 AWG |
| Disconnect L2 | — | Control PSU | N | 16 AWG |
| Ground bar | GND | All PSUs | GND | Bond frames |

## 2. Stepper DC power

### 2.1 Stepper PSU → DC distribution

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| Stepper PSU | V+ | DC terminal block | + | 10 AWG |
| Stepper PSU | V− | DC terminal block | − | 10 AWG |

### 2.2 DC distribution → DMA860S (repeat for each driver)

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| DC block + | + | DMA860S | V+ | 14 AWG |
| DC block − | − | DMA860S | V− | 14 AWG |
| Ground bar | GND | DMA860S | GND | Frame ground |

## 3. DMA860S → stepper motors

(Repeat per motor)

| Driver terminal | Motor lead | Notes |
|---|---|---|
| A+ | Phase A+ | Twisted pair |
| A− | Phase A− | |
| B+ | Phase B+ | Twisted pair |
| B− | Phase B− | |
| Shield drain | — | To ground bar only |

## 4. DDCSV4.1 → DMA860S (motion signals)

### Axis assignment

- X → X-Left motor
- A → X-Right motor
- Y → Y motor
- Z → Z motor

### 4.1 Step / Direction / Enable (per axis)

| DDCSV terminal | To driver | Driver terminal | Notes |
|---|---|---|---|
| XPUL+ | X driver | PUL+ | Shielded |
| XPUL− | X driver | PUL− | |
| XDIR+ | X driver | DIR+ | |

| DDCSV terminal | To driver | Driver terminal | Notes |
|---|---|---|---|
| XDIR− | X driver | DIR− | |
| XENA+ | X driver | ENA+ | Optional but recommended |
| XENA− | X driver | ENA− | |

(Repeat the same mapping for A, Y, Z using APUL, YPUL, ZPUL, etc.)

## 5. DDCSV4.1 power (logic)

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| Control PSU +24 V | + | DDCSV | +24 V | 18 AWG |
| Control PSU 0 V | − | DDCSV | GND | Common reference |

## 6. Limit and home switches

(Recommended: normally closed switches)

### 6.1 Home switches

| Switch | From | To | Notes |
|---|---|---|---|
| X-Left home | DDCSV X-HOME | Switch → GND | Independent |
| X-Right home | DDCSV A-HOME | Switch → GND | Enables squaring |
| Y home | DDCSV Y-HOME | Switch → GND | |
| Z home | DDCSV Z-HOME | Switch → GND | |

### 6.2 Limit switches (if separate)

| Axis | From | To | Notes |
|---|---|---|---|
| X limits | DDCSV X-LIMIT | Switch chain → GND | Series NC |
| Y limits | DDCSV Y-LIMIT | Switch chain → GND | |
| Z limits | DDCSV Z-LIMIT | Switch chain → GND | |

## 7. E-stop wiring

### 7.1 E-stop logic input

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| DDCSV | E-STOP IN | E-stop NC contact | — | 24 V logic |

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| E-stop | — | DDCSV GND | — | Controller awareness |

### 7.2 E-stop power interruption

| Circuit interrupted | Method | Notes |
|---|---|---|
| Stepper PSU AC | Contactor or relay | Motion stops |
| VFD Run | Relay opens FOR | Spindle stops |

(Do not rely on software stop alone.)

## 8. DDCSV4.1 → Huanyang VFD (control)

### 8.1 Run / Stop

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| DDCSV relay COM | — | VFD | DCM | Digital common |
| DDCSV relay NO | — | VFD | FOR | Run forward |

### 8.2 Speed control (0–10 V)

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| DDCSV analog out | 0–10 V | VFD | AVI | Shielded pair |
| DDCSV analog GND | GND | VFD | ACM | Shared analog ref |

## 9. VFD → spindle

| From | Terminal | To | Terminal | Notes |
|---|---|---|---|---|
| VFD | U | Spindle | Phase 1 | 14 AWG |
| VFD | V | Spindle | Phase 2 | |
| VFD | W | Spindle | Phase 3 | |
| Ground bar | GND | Spindle | GND | Bond body |

## 10. Grounding summary

| Item | To |
|---|---|
| Cabinet | Earth |
| VFD frame | Ground bar |
| PSU frames | Ground bar |
| Driver frames | Ground bar |
| Cable shields | Ground bar (cabinet end only) |

# DMA860S Tuning

Power & Control System – V1

## Scope

This section covers:

- Output current settings for your 6 A NEMA 34 motors
- Microstep selection appropriate for machine mass and controller pulse rate
- Idle current reduction
- Direction, enable, and signal integrity notes
- A safe initial steps-per-unit baseline

## Motor facts

- Motor type: NEMA 34
- Rated current: 6.0 A per phase
- Rated torque: 12 Nm
- Application: Large CNC router, dual-X gantry
- Controller: DDCSV4.1 (500 kHz capable)

## 1. Output current setting

Set the DMA860S **peak current to 6.0 A**.

Do not overshoot the motor rating. These motors already have ample torque, and excess current only adds heat.

### Typical DMA860S current table mapping

DMA860S labels vary slightly, but most follow this pattern.

| Peak current (A) | Switch setting |
|---|---|
| 5.6 A | Near but under rated |
| **6.0 A** | **Recommended** |
| 6.8 A | Not recommended |

| Peak current (A) | Switch setting |
| --- | --- |
| 7.2 A | Do not use |

If the driver only offers 5.6 A and 6.8 A options, choose **5.6 A** for initial testing. You can increase later after thermal checks.

### Thermal check rule

After 20 to 30 minutes of holding torque:

- Driver case should be warm, not hot
- Motor case should be touchable for several seconds

If either is too hot to touch, reduce current one step.

## 2. Idle current reduction

Enable idle current reduction at **50 percent**.

This reduces heat when the axis is stationary without sacrificing holding accuracy during motion.

If the DMA860S offers multiple idle options:

- Choose 50 percent or equivalent
- Avoid aggressive reductions below 30 percent on Z

## 3. Microstep selection

### Design goals

- Smooth motion
- Reasonable top speed
- No unnecessary pulse load on the controller
- Identical behavior on X and A axes

### Recommended starting microstep

10 microsteps per full step

This is a very common and well-balanced choice for large NEMA 34 systems.

### Why not higher

- Above 10 to 16 microsteps, torque per microstep drops
- Mechanical stiffness dominates accuracy, not microstep count
- Higher microsteps increase pulse rate with no real gain

## 4. Steps per revolution and steps per unit

### Motor basics

- Full steps per revolution: 200
- Microsteps: 10

```
Steps per motor revolution = 200 × 10 = 2000
```

### Leadscrew or rack conversion

You will calculate steps per unit later based on:

- Ballscrew pitch or rack travel per revolution
- Gear reduction, if any

For now, lock **2000 steps per motor revolution** as the electrical constant.

## 5. Signal polarity and enable behavior

### Direction signal

- Default direction polarity is acceptable
- Reverse direction in DDCSV if needed
- Do not swap motor phase wiring to fix direction unless necessary

### Enable signal

- Use ENA on all axes
- Active-low enable is typical
- Confirm behavior by disabling the axis in DDCSV and verifying free rotation

## 6. Pulse timing considerations

The DMA860S is tolerant, but best practice is:

- Step pulse width: $\geq 5$ microseconds
- Direction setup time: $\geq 5$ microseconds before step

The DDCSV4.1 defaults are usually safe here. No special tuning required initially.

## 7. Axis-specific notes

### X and A axes (dual gantry)

- Identical driver settings
- Identical microstep and current
- Mechanical squaring handled in homing, not in driver tuning

#### Y axis

- Same settings as X and A
- No special handling required

#### Z axis

- Same current and microstep initially
- If Z runs warmer, reduce idle current only, not peak

## 8. Initial verification checklist

Before commanding motion:

- All four drivers set identically
- DIP switches documented or photographed
- Motors rotate smoothly by hand when disabled
- No driver fault LEDs active

During first motion:

- Jog at low speed only
- Listen for harsh resonance or growling
- Confirm correct direction per axis
- Confirm X and A move together

# DDCSV4.1 Axis and Dual-X Homing Configuration

Power & Control System – V1

## 1. Axis role definition

You have four motors and four driver channels.

#### Axis mapping (locked)

| Physical axis | DDCSV axis | Notes |
|---|---|---|
| X-Left gantry motor | X | Master |
| X-Right gantry motor | A | Slaved to X |
| Y axis motor | Y | Independent |
| Z axis motor | Z | Independent |

Do not attempt to electrically tie the two X motors together. Slaving is done in software.

## 2. Entering axis configuration mode

1. Power on the DDCSV4.1
2. From the main screen, enter:
    - **System Settings**
    - **Axis Settings**

All configuration below happens in this area.

## 3. Enable and assign axes

For each axis (X, A, Y, Z):

- Axis enabled: **Yes**
- Axis type: **Linear**
- Units: **mm** (recommended, even if you think in inches)

Confirm that **all four axes are enabled**.

## 4. Axis direction check (before homing)

This step prevents crashes.

For each axis:

1. Exit settings
2. Use jog mode at **very low speed**
3. Jog positive direction

If motion is reversed:

- Return to Axis Settings
- Invert direction for that axis
- Do not swap motor wires unless absolutely necessary

Repeat until:

- X jogs in expected machine +X
- A jogs in the same physical direction as X
- Y and Z jog correctly

## 5. Steps per unit configuration

This connects driver tuning to motion.

### Electrical constant (from DMA860S tuning)

- Steps per motor revolution: **2000**

### Enter preliminary values

In Axis Settings for X, A, Y, Z:

- Steps per unit: **TEMPORARY VALUE**
  - Use a safe placeholder such as **200 steps/mm**
  - Final calibration comes later

The critical rule here:

- **X and A must have identical steps-per-unit values**

## 6. Axis slaving configuration (dual-X)

Navigate to:

- **System Settings**
- **Axis Relation / Slave Settings**

Configure:

| Master axis | Slave axis |
|---|---|
| X | A |

Rules:

- Only A is slaved
- X remains the master
- Do not slave in reverse

Save settings.

## 7. Homing switch assignment

This is the heart of gantry squaring.

### Required switches (already wired)

- X-Left home switch
- X-Right home switch
- Y home switch
- Z home switch

### DDCSV home input mapping

In **I/O Settings**:

| Axis | Home input |
|---|---|
| X | X-HOME |
| A | A-HOME |
| Y | Y-HOME |
| Z | Z-HOME |

Each switch must be independent.

## 8. Homing direction and order

Navigate to:

- **Homing Settings**

### Homing direction

Set per your machine geometry. Typical example:

| Axis | Direction |
|---|---|
| Z | Positive |
| X | Negative |
| A | Negative |
| Y | Negative |

Direction must move the axis **toward its home switch**.

### Homing order (recommended)

| Order | Axis | Reason |
|---|---|---|
| 1 | Z | Get tool out of the way |
| 2 | X and A | Gantry squaring |
| 3 | Y | Table reference |

If the DDCSV allows grouping:

- Home X and A together
- Ensure they stop independently on their own switches

## 9. Dual-X squaring behavior

During homing:

1. X and A move toward home
2. One side hits its switch first and stops
3. The other side continues until its switch triggers
4. Gantry is squared mechanically
5. X and A zeroed together

This only works if:

- Switches are wired independently
- X and A are not electrically tied
- Slaving is configured correctly

## 10. Homing speed and backoff

Recommended initial values:

- Homing speed: **Slow**
- Backoff distance: **2 to 5 mm**
- Second approach (if available): **Enabled, slow**

This improves repeatability and reduces switch stress.

## 11. Soft limits (enable later)

For initial testing:

- Soft limits: **Disabled**

After calibration:

- Enable soft limits
- Set travel ranges per axis
- X and A must match exactly

## 12. First homing test procedure

Perform this sequence exactly:

1. Power on control PSU only
2. Enable DDCSV
3. Enable stepper PSU
4. Jog each axis slightly away from home
5. Press **Home All**

Observe:

- Z homes first
- X and A home together and square
- Y homes last
- No axis stalls or overshoots

If any axis moves the wrong way:

- Abort immediately
- Fix direction setting
- Retry

# Steps-Per-Unit Calibration

Power & Control System – V1

## 1. Preconditions

Before calibrating, confirm:

- DDCSV4.1 axis and dual-X homing are working
- X and A home independently and square the gantry
- DMA860S drivers are set identically on X and A
- All axes jog smoothly at low speed
- No binding across full travel

Do not calibrate until the machine can home reliably.

## 2. What steps-per-unit actually is

Steps-per-unit expresses the relationship between:

- Electrical pulses from the controller
- Mechanical motion of the axis

The formula is:

```
Steps per unit =
( Motor steps per revolution × Microsteps × Gear ratio )
/ Linear travel per revolution
```

## 3. Electrical constants (locked)

- Motor full steps per revolution: 200
- Microsteps: 10
- Steps per motor revolution: 2000

These values apply to **all axes**, including X and A.

## 4. Mechanical inputs you must supply

You need one of the following per axis:

**Ballscrew-driven axis**

- Ballscrew pitch in mm per revolution Example: 10 mm per revolution

**Rack-and-pinion axis**

- Pinion circumference in mm Example: 20-tooth, module 1.5 gear

If an axis uses reduction:

- Include gear or belt ratio

Each axis can differ mechanically.

## 5. Initial calculation (example)

**Example: 10 mm ballscrew**

```
Steps per mm = 2000 / 10
Steps per mm = 200
```

Enter **200** as the initial value.

**Example: rack-and-pinion**

```
Pinion circumference = π × pitch diameter
Steps per mm = 2000 / circumference
```

Use this value only as a starting point.

## 6. Enter initial values in DDCSV4.1

1. Go to **System Settings**
2. Open **Axis Settings**
3. For each axis:
    - Enter the calculated steps-per-unit
    - Ensure X and A are identical
4. Save settings

Do not attempt fine tuning yet.

## 7. Measurement setup

You need a reliable reference.

Recommended tools:

- Dial indicator with magnetic base or

- Steel rule with fine graduations

Measurement rules:

- Measure along the axis line of travel
- Do not measure diagonally
- Use at least **100 mm of travel** if possible

Longer moves reduce error.

## 8. Calibration move procedure

For each axis independently:

1. Home the machine
2. Zero the axis DRO
3. Command a move of a known distance Example: 100.000 mm
4. Measure actual movement

Record:

- Commanded distance
- Actual distance

## 9. Correction calculation

Use this exact formula:

```
New steps per unit =
( Current steps per unit × Commanded distance )
/ Actual distance
```

### Example

- Current value: 200
- Commanded: 100.000 mm
- Actual: 99.600 mm

```
New value = (200 × 100.000) / 99.600
New value ≈ 200.80
```

Enter the new value.

## 10. Apply and repeat

1. Enter corrected value
2. Save settings
3. Re-home
4. Repeat the same move

5. Re-measure

Stop when:

- Error is less than 0.05 mm over 100 mm
- Or better, depending on your goals

## 11. Dual-X axis rule

- Calibrate **X only**
- Copy the final X value to **A**
- Never calibrate A independently

If the gantry does not square:

- Fix homing switch alignment
- Do not alter steps-per-unit to compensate

## 12. Z-axis special notes

Z axes often have:

- Higher friction
- Gravity load

Calibrate Z with:

- Tool holder installed
- Normal operating load

If Z error differs up vs down:

- That is mechanical, not steps-per-unit
- Do not compensate electrically

## 13. Verify full-travel accuracy

After fine calibration:

1. Move the axis close to maximum travel
2. Measure cumulative error
3. Confirm no binding or missed steps

If error grows with distance:

- Check mechanical alignment
- Check couplings
- Check rack mounting

## 14. Lock the values

Once satisfied:

- Record final steps-per-unit values
- Store them as **Power & Control System – V1 calibration**
- Photograph or document DDCSV screens

These values should not change unless mechanics change.

## 15. What this completes

At this point, V1 has:

- Electrically correct motion
- Mechanically squared gantry
- Dimensionally accurate axes
- A known-good calibration baseline

# Enable and Configure Soft Limits

Power & Control System – V1

## Purpose

Soft limits prevent axis motion beyond the usable travel range. They are a software safety layer and must never replace hard limits or E-stop behavior.

## Preconditions

- Machine homes reliably on all axes
- Steps-per-unit calibration is complete
- Dual-X homing and squaring are correct
- No binding across full axis travel

## Procedure

1. Power on the system
2. Home all axes
3. Navigate to:
    - System Settings
    - Axis Settings
    - Soft Limits

## Configure Travel Limits

For each axis, enter the usable travel range.

Example values only:

- X axis
  - Minimum: 0.0
  - Maximum: measured usable X travel
- Y axis
  - Minimum: 0.0
  - Maximum: measured usable Y travel
- Z axis
  - Minimum: safe lower limit
  - Maximum: safe upper limit

Rules:

- X and A must have identical limits
- Do not include crash margin in usable travel
- Leave mechanical margin at both ends

## Enable Soft Limits

- Soft limits: Enabled
- Overtravel action: Stop motion
- Alarm or warning: Enabled if supported

Save settings.

## Verification

1. Home the machine
2. Jog toward each soft limit at low speed
3. Confirm motion stops before mechanical end
4. Confirm no false triggering during normal motion

## Notes

- Soft limits only function after homing
- Loss of position invalidates soft limits
- Mechanical changes require revalidation

## Status

Soft limits enabled and validated for V1.

# Configure Acceleration and Maximum Velocity

Power & Control System – V1

## Purpose

Acceleration and velocity settings define machine performance and reliability. Overly aggressive values cause missed steps and mechanical stress.

## Preconditions

- Steps-per-unit calibration complete
- Motors and drivers tuned
- No axis binding
- Machine fully assembled

## Initial Conservative Settings

Use these as safe starting points.

### Velocity

- X axis: Low to moderate
- A axis: Same as X
- Y axis: Same as X
- Z axis: Significantly lower

Example approach:

- Start at 25 percent of expected maximum
- Increase incrementally

### Acceleration

Acceleration has greater impact than top speed.

- X and A: Moderate
- Y: Moderate
- Z: Low

Start low. Increase only after stable testing.

## Configuration Steps

1. Enter System Settings
2. Open Axis Settings
3. For each axis:

    - Set maximum velocity
    - Set acceleration
4. Save settings

### Testing Procedure

1. Jog each axis at increasing speeds
2. Listen for harsh noise or stalling
3. Perform rapid direction reversals
4. Observe for missed steps

If any issue occurs:

- Reduce acceleration first
- Reduce velocity second

### Locking Values

Once stable:

- Record final values
- Apply identical values to X and A
- Do not exceed tested limits

### Status

Acceleration and velocity configured for V1.

## Validate Spindle Speed Scaling

Power & Control System – V1

### Purpose

Ensure commanded RPM matches actual spindle speed. This validates 0–10 V scaling between DDCSV and Huanyang VFD.

### Preconditions

- VFD parameters set
- Spindle cooling operational
- Analog control enabled
- No cutting load applied

### Test Setup

Tools:

- Optical tachometer or RPM probe
- Eye protection
- Clear spindle area

### Validation Procedure

1. Power on VFD and controller
2. Command spindle on at low RPM
    - Example: S6000
3. Measure actual spindle speed
4. Record commanded vs actual RPM

Repeat at:

- 25 percent
- 50 percent
- 75 percent
- 100 percent of max RPM

### Adjustment

If error exists:

- Adjust DDCSV spindle scaling
- Or adjust VFD analog gain
- Never adjust both simultaneously

Repeat measurement until error is acceptable.

### Acceptance Criteria

- Linear response across range
- Error less than 2 percent preferred
- Smooth ramping without surging

### Status

Spindle speed scaling validated for V1.

## Dry-Run G-code Test

Power & Control System – V1

## Purpose

Validate coordinated motion without cutting. This is the final logic and motion verification step.

## Preconditions

- All axes calibrated
- Soft limits enabled
- Spindle control verified
- No tool installed

## Test File Characteristics

The dry-run program should include:

- X, Y, and Z motion
- Direction reversals
- Rapid and feed moves
- Safe Z clearance

No spindle cutting load.

## Execution Steps

1. Home the machine
2. Load dry-run G-code
3. Enable single-block mode if available
4. Run program at reduced feed override
5. Observe full execution

## Observations to Make

- Axis coordination
- No unexpected pauses
- No limit alarms
- No loss of position
- Correct Z clearances

## Failure Handling

If an issue occurs:

- Stop immediately
- Identify root cause
- Correct configuration
- Restart from homing

### Status

Dry-run G-code test complete for V1.

## Commissioning Checklist

Power & Control System – V1

This checklist defines when **V1 is complete and safe to operate**. All items should be verified in order. Do not skip steps.

### Phase 0: Administrative and Baseline

☐ Power & Control System labeled as **V1**
☐ Wiring diagrams match actual build
☐ All PSU voltages labeled
☐ Cabinet ground bonded to earth
☐ Emergency stop physically accessible

### Phase 1: Electrical Integrity

#### Grounding and bonding

☐ Single ground bar installed
☐ VFD chassis bonded
☐ PSU frames bonded
☐ Stepper driver frames bonded
☐ Spindle body bonded
☐ Cable shields terminated at cabinet end only
☐ Stepper DC power supply installed per specification
☐ Control / logic DC power supply installed per specification

#### Power integrity

☐ Main disconnect interrupts all AC
☐ AC branch protection verified against AC Power Supply Specification
☐ Stepper PSU AC feed fused
☐ Control PSU AC feed fused
☐ VFD on dedicated branch
☐ Control PSU stable at 24 VDC
☐ No unexpected heating under idle power

## Phase 2: Controller and Logic

### DDCSV4.1 basic operation

- ☐ Controller boots normally
- ☐ MPG recognized and functional
- ☐ Axis enable toggles correctly
- ☐ E-stop input recognized by controller

### Axis mapping

- ☐ X motor responds to X jog
- ☐ A motor responds to A jog
- ☐ X and A jog in same physical direction
- ☐ Y jog correct direction
- ☐ Z jog correct direction

## Phase 3: Homing and Squaring

- ☐ All home switches trigger reliably
- ☐ Z homes first
- ☐ X and A home independently
- ☐ Gantry squares during homing
- ☐ Y homes after gantry
- ☐ No switch overtravel or chatter

## Phase 4: Motion Calibration

### Driver configuration

- ☐ DMA860S current set correctly
- ☐ Microstep settings consistent across axes
- ☐ Idle current reduction enabled
- ☐ Drivers remain thermally stable

### Steps-per-unit

- ☐ Initial calculated values entered
- ☐ X calibrated and copied to A
- ☐ Y calibrated
- ☐ Z calibrated under load
- ☐ Error less than target tolerance

## Phase 5: Limits and Safety

- ☐ Soft limits enabled

- ☐ X and A soft limits identical
- ☐ Soft limits stop motion before mechanical ends
- ☐ Hard limits still functional
- ☐ E-stop cuts motion power
- ☐ E-stop stops spindle
- ☐ Stepper DC bus voltage verified under simultaneous axis motion

### Phase 6: Spindle Validation

- ☐ Cooling system operational
- ☐ VFD parameters verified
- ☐ Spindle runs from controller command
- ☐ 0–10 V scaling linear
- ☐ Commanded RPM matches measured RPM
- ☐ No abnormal noise or vibration

### Phase 7: Dry-Run Validation

- ☐ Dry-run G-code loads correctly
- ☐ No limit alarms during run
- ☐ Axis coordination correct
- ☐ Z clearance maintained
- ☐ No lost steps
- ☐ No unexpected pauses or resets

### Phase 8: V1 Acceptance

- ☐ DC power capacity validated for continuous multi-axis operation
- ☐ Cabinet closed and ventilated
- ☐ All wiring labeled
- ☐ Configuration values recorded
- ☐ V1 declared complete

### Status

Power & Control System – V1 commissioned.

## Pre-Cut Checklist

Power & Control System – V1

This is the checklist you run **right before committing tool to material**.

## Mechanical sanity

- ☐ Tool properly seated and tightened
- ☐ Workpiece clamped securely
- ☐ No loose hardware
- ☐ Axis travels clear of clamps

## Control sanity

- ☐ Correct G-code file loaded
- ☐ Units verified
- ☐ Work offset set
- ☐ Z zero verified

## Motion sanity

- ☐ Run path visually simulated
- ☐ Dry-run completed with tool raised
- ☐ Feed override available
- ☐ E-stop tested immediately before cut

## Spindle sanity

- ☐ Correct RPM commanded
- ☐ Cooling running
- ☐ Spindle direction verified
- ☐ No abnormal noise

## Final decision

- ☐ Operator alert and focused
- ☐ Hands clear
- ☐ One finger near feed hold
- ☐ One eye on the machine

Only then:

- ☐ Press Cycle Start