USER MANUAL

CLEARPATH MOTORS

MODELS MCVC, MCPV, SDSK, SDHP

NEMA 23 AND NEMA 34 FRAME SIZES

VERSION 2.23 OCTOBER 15, 2017

TEKNIC, INC FAX (585)784-7460 VOICE (585)784-7454

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QUICK START GUIDE

This section was designed to help you get your ClearPath motor up and running quickly and safely.

ITEMS COVERED IN THIS SECTION

- How to download and install *ClearPath MSP* (setup and configuration software)
- How to power up your ClearPath motor
- How to connect your ClearPath to a PC and establish communication
- How to spin your unloaded[1] ClearPath motor under MSP software control

PLEASE READ THIS IMPORTANT WARNING

Always use caution and common sense when handling motion control equipment. Even the smallest ClearPath motor is powerful enough to seriously damage fingers, turn a tie into a noose, or tear out a patch of hair and/or scalp in just a few milliseconds (by comparison, it takes between 100 and 400 milliseconds to blink). We're not trying to scare you (...OK maybe a *little*) but we do want all ClearPath users to stay safe and *fully intact*. **These devices are very powerful and can be extremely dangerous if used carelessly.** Please read and understand all safety warnings in the ClearPath User Manual before operating a ClearPath motor.

BEFORE YOU BEGIN (SUGGESTED VIEWING MATERIAL)

Check out the ClearPath overview video. This is a great way to learn about ClearPath motors (and Teknic as well). Note: There's a great ClearPath demonstration at time reference 3:50.

Try watching a few ClearPath operational mode videos. There is a separate short video for each ClearPath operational mode (11 in all). Each video includes an overview of the operating mode, a brief discussion of software controls and settings, and a demonstration featuring a real mechanical system.

ClearPath Video Links

https://www.teknic.com/watch-video/

https://www.youtube.com/channel/UC4Q91tGO80QMSHyy1SoHrtg

[1] Unloaded means *with nothing attached to the motor shaft*. ClearPath comes factory preconfigured for unloaded operation. **ClearPath must be tuned** whenever it is connected to a new type of mechanical system.

CLEARPATH QUICK SETUP

REQUIRED ITEMS

- A ClearPath motor
- A 24-75 VDC Bus Power supply (with cables)
- A Windows PC (Win 7, 8.1, 10)
- A USB cable (USB type-A to micro-B)
- A Clamp or vise

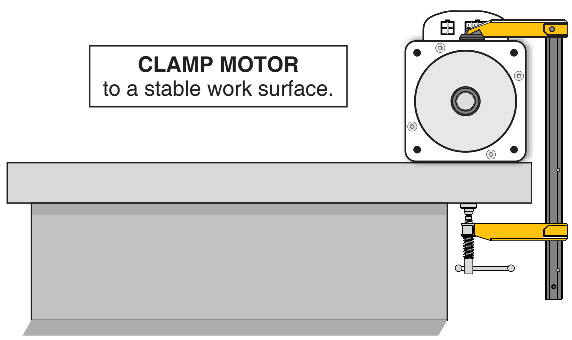
INSTALL CLEARPATH MSP SOFTWARE

MSP is a free download from Teknic's website. From the Downloads menu, select "ClearPath". Select ***motor_setup.zip*** (under ClearPath MC and SD series) or click here for a direct link. Save the zip file to your local computer, extract the .exe file, and run it.

SECURE YOUR MOTOR

Injury Warning: To prevent broken toes, and damage to your motor, always secure your ClearPath motor to a stable, flat, level work surface before operating it; otherwise, your motor will buck and jump during operation. A “quick-grip” style clamp or vise is recommended.

Tip: If you use a vise to secure your motor, you can preserve the motor's finish by taping the vise jaws or by placing scrap cardboard or wood between the vise and the motor body. Do not over tighten vise.



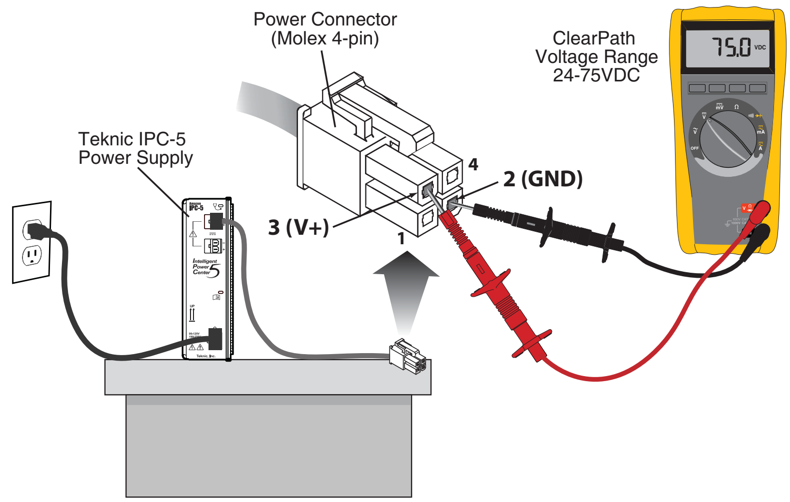
Clamp it!

Check DC Bus Power Polarity

Damage Warning: Reversing DC power polarity to your ClearPath motor *will* permanently damage it.

Before you connect DC power to your ClearPath motor, use a voltmeter to verify that DC bus power is wired with the proper polarity. This is particularly important if the cables were not made by Teknic.

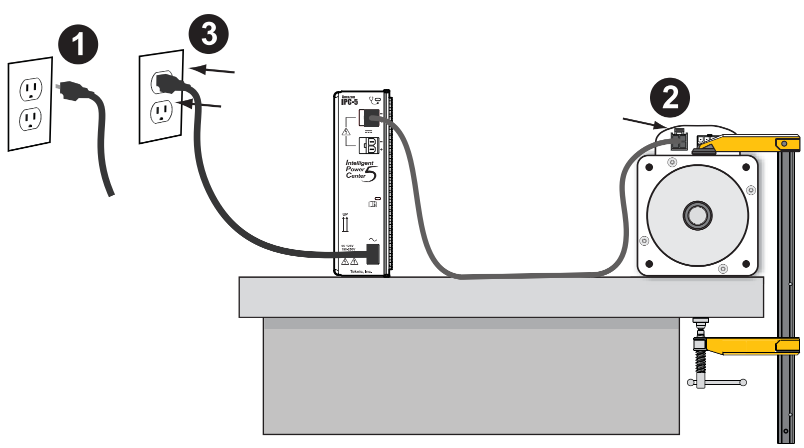
For Teknic DC power cables (PN: CPM-CABLE-PWR-MS120), test DC voltage at pins 3 and 2 as shown below (pin 3 is v+ and pin 2 is GND). This should display a positive voltage reading.



Polarity test from pin 3 (V+) to pin 2 (GND) shows a positive 75 volts

Power Up Your ClearPath

1. Begin with the power supply turned off or unplugged.
2. Connect the DC power cable from the power supply to the ClearPath motor's 4 pin connector.
3. Turn on (plug in) the power supply.

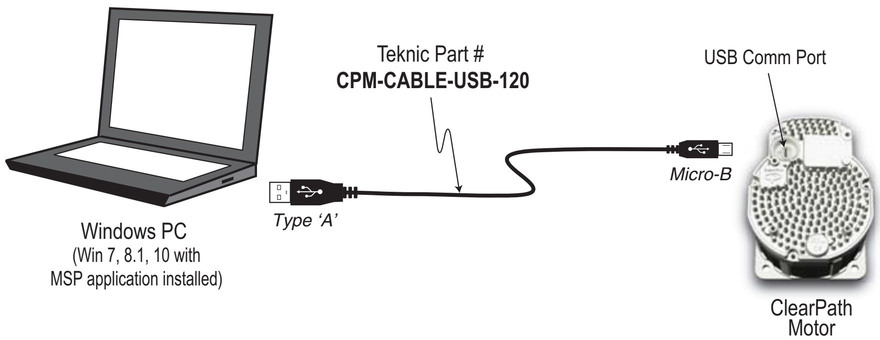


Power up sequence

CONNECT CLEARPATH TO YOUR PC

Connect ClearPath to a USB port on your PC with a high quality USB type-A to micro B cable (Teknic PN: CPM-CABLE-USB-120). If this is a first-time connection, wait for ClearPath to automatically install its driver software before proceeding. This should only take a minute or so.

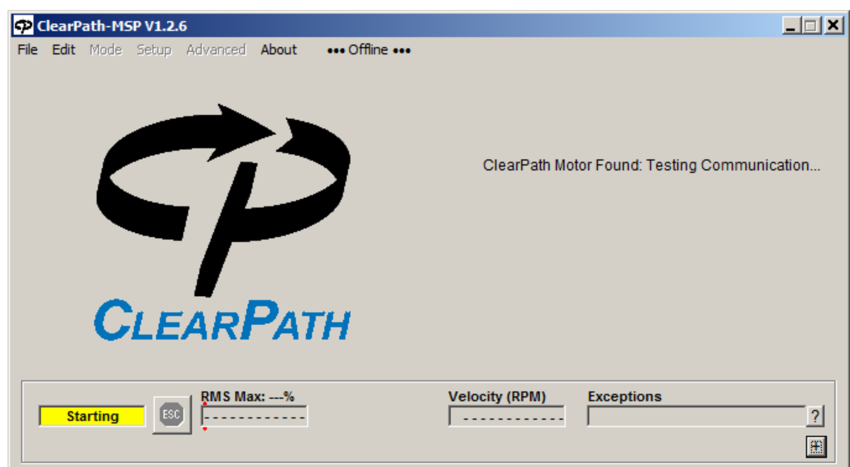
Damage Warning: Do not use USB cables of unknown origin (e.g. found in a junk drawer) with your ClearPath. Non-standard cables may be incompatible with ClearPath, and may even damage your motor.



Connect ClearPath to your PC

OPEN MSP (MOTOR SETUP PROGRAM)

After you open MSP, ClearPath will attempt to establish communication with your PC. If all is well, you will see a window like the one shown below.



Open MSP (Motor Setup Program)

SPIN YOUR MOTOR UNDER MSP SOFTWARE CONTROL

The best way to learn about a ClearPath operational mode is to try it under software control. ClearPath MSP includes simple software controls that emulate hardware inputs and outputs, so you can try different modes of operation without wiring a single switch or sensor.

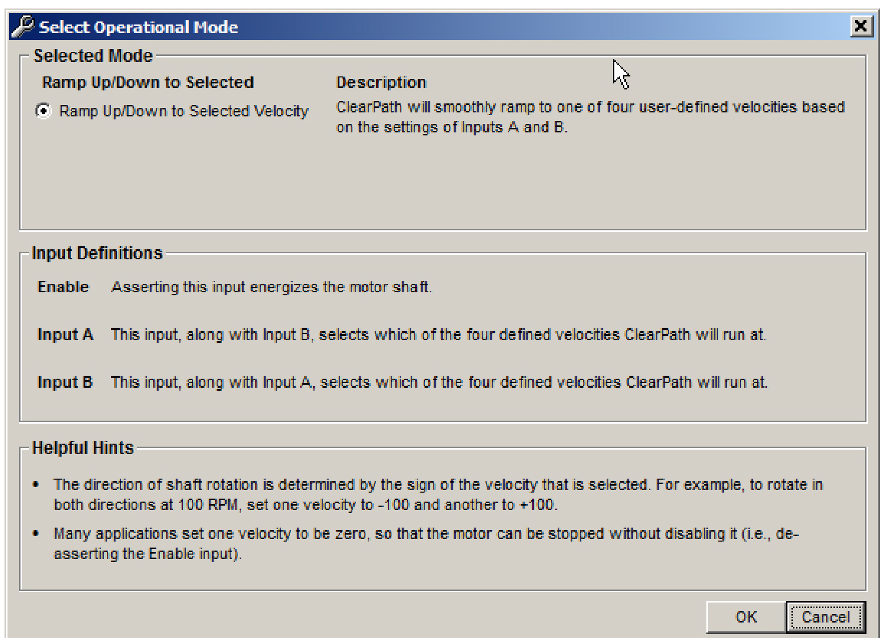
Note: ClearPath Soft Controls are great for test, development and training, but are *not meant to be used as the control system for your machine.*

SPINNING A MODEL MCPV OR MCVC

Note: Spinning models SDSK and SDHP is covered in the next section.

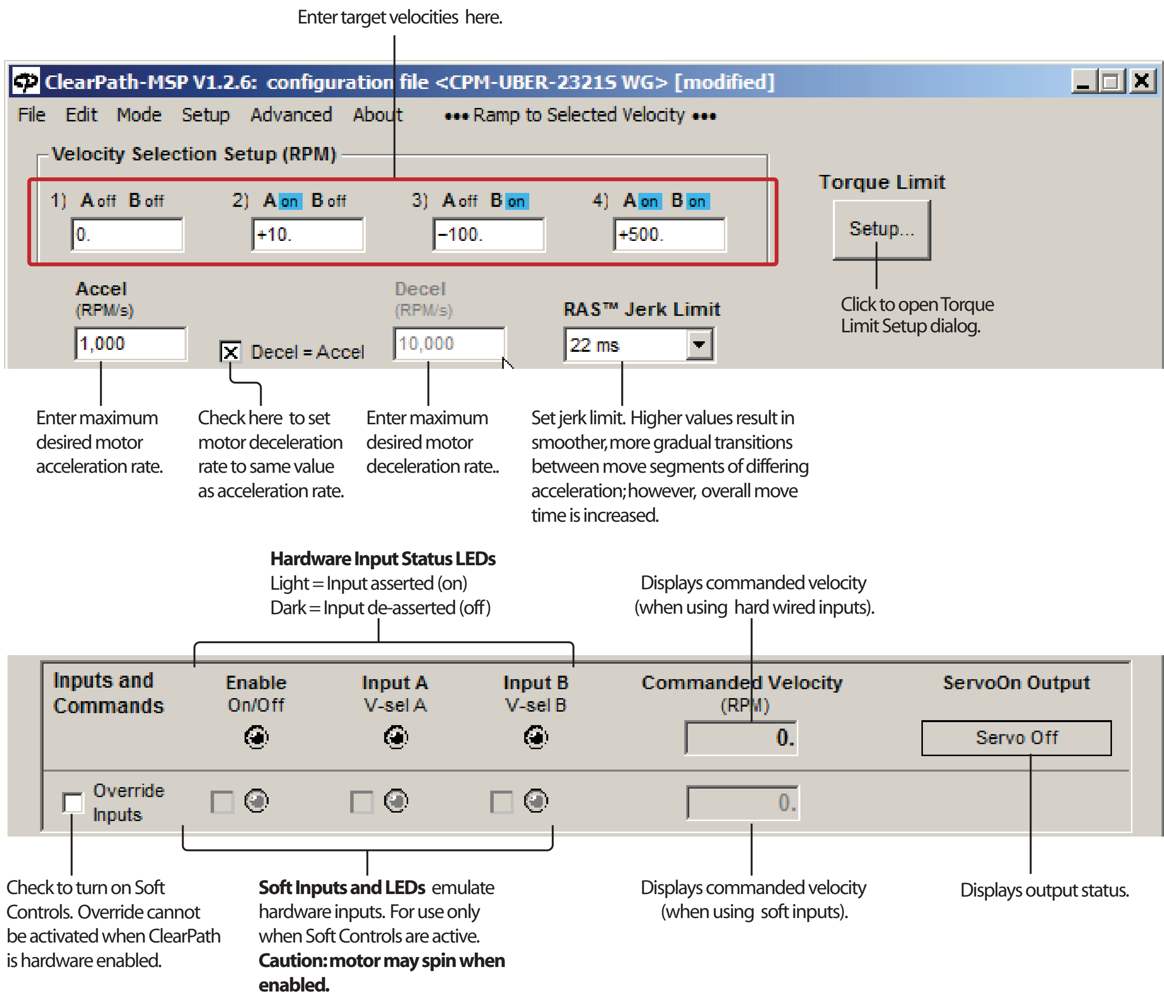
For models MCPV and MCVC we will use the mode *Ramp Up/Down To Selected Velocity*. Feel free to try any mode available in the Mode drop down menu. Each mode is described in its own section later in this manual.

1. Open MSP software.
2. From the MSP menu, select Setup>Units>Counts; RPM; RPM/s. This just tells MSP how to display distance, velocity, and acceleration.
3. Select Mode>Ramp Up/Down to Selected Velocity.
4. A dialog window will open (see below). Read all of the text presented, especially if you're unfamiliar with how the mode works. Click OK to proceed.



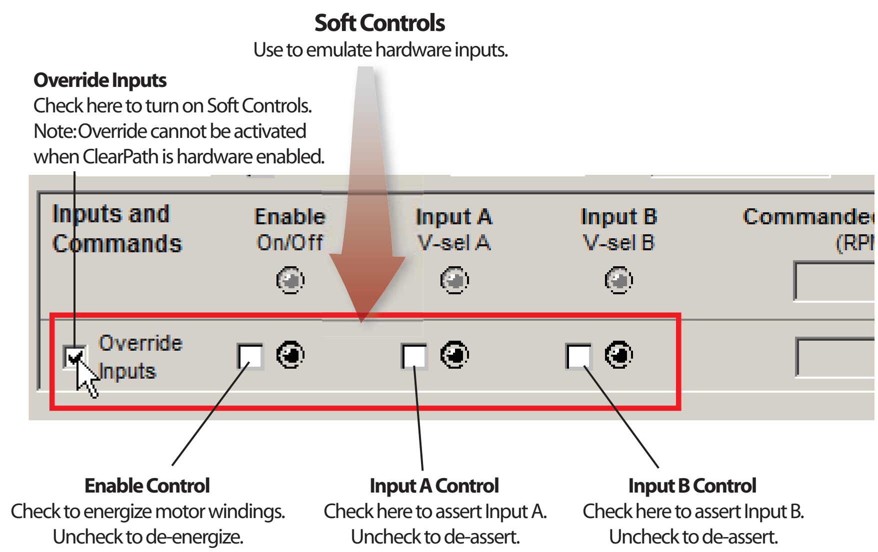
Select a mode of operation

5. The mode controls window will appear. To follow along, enter the settings as they appear below.



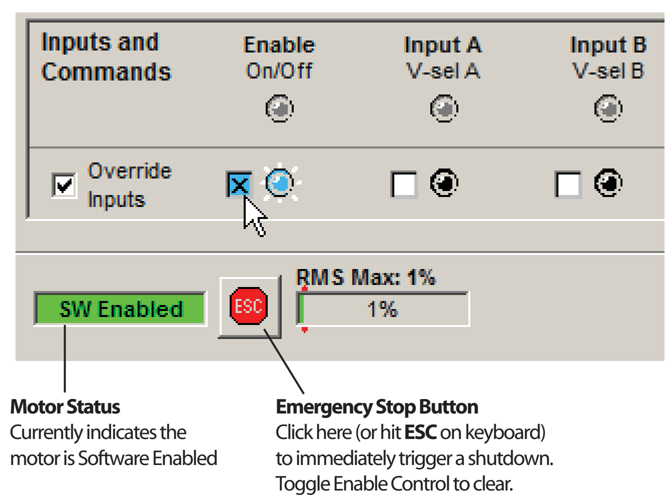
Mode setup window for Ramp to Selected Velocity

6. Click the Override Inputs checkbox. This turns on the software controls. You may notice that the other Soft Controls are no longer grayed out.



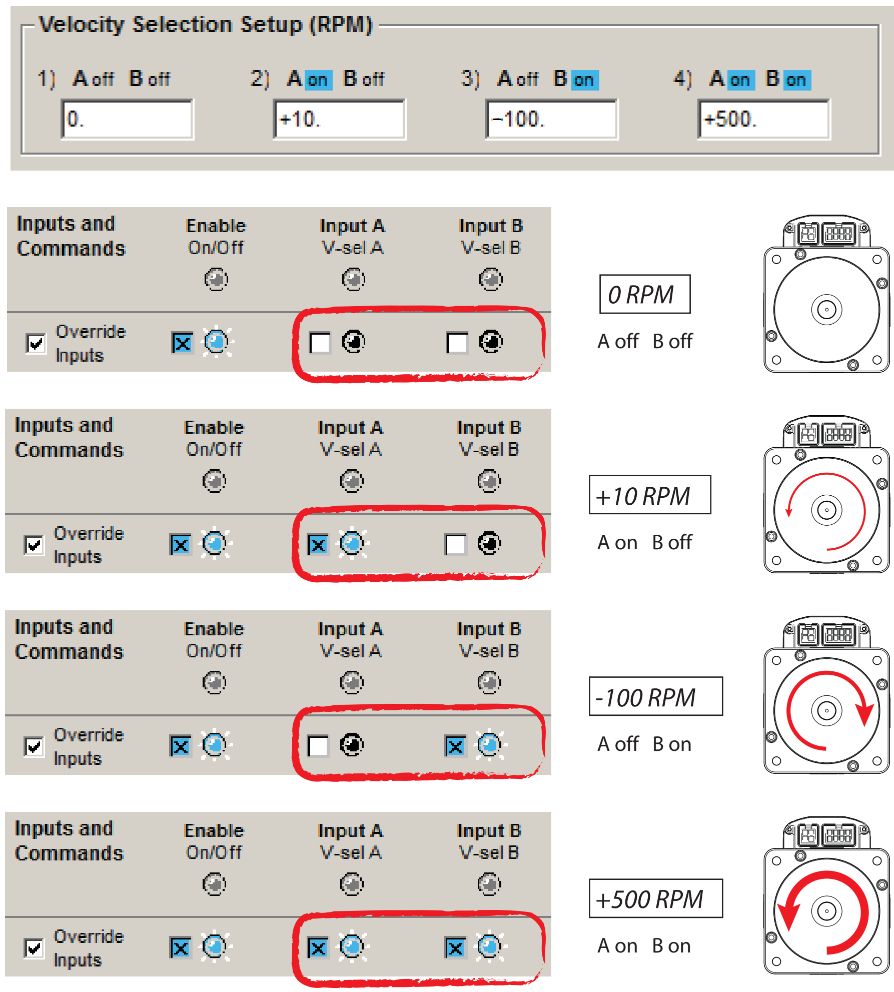
Check "Override Inputs" box to turn on Soft Controls

7. **Safety check!** Before proceeding, make sure that the motor is securely clamped down and the shaft is safely positioned away from fingers, clothing, hair, cables, etc.
8. Click the Enable Control. **Caution: the motor is now energized and capable of motion.**



Enable using Soft Controls

9. **Make some moves.** With the motor enabled, change Inputs A and B as shown below to spin at different velocities. Feel free to experiment. Try changing velocities, accelerations, and RAS settings.



Change velocity and direction by checking Inputs A and B

ADDITIONAL NOTES

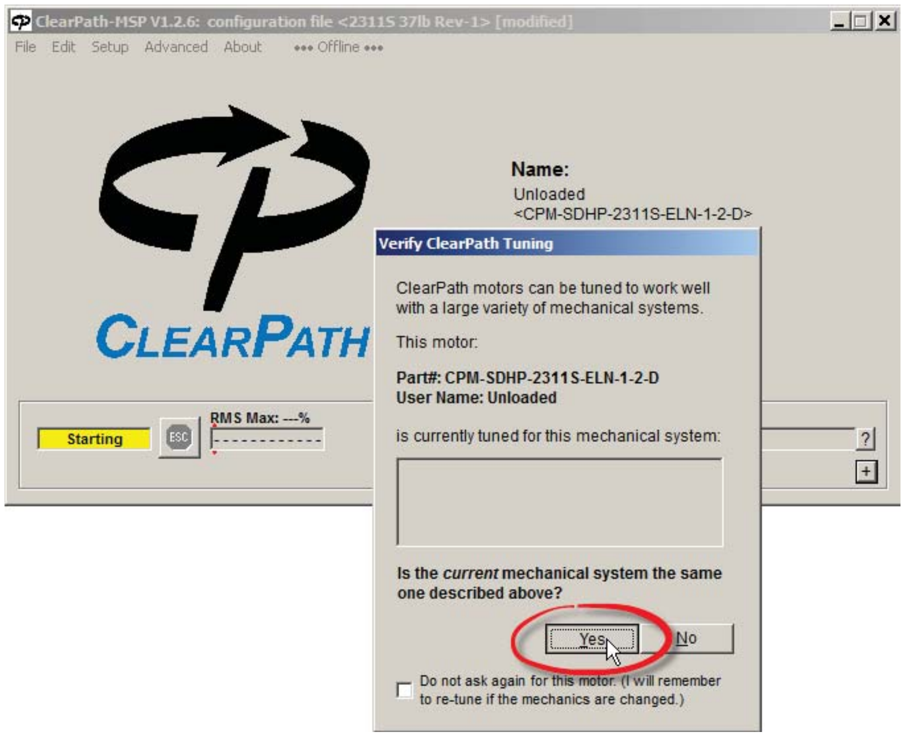
- Direction of shaft rotation is set by entering a "+" or "-" sign in front of the velocity settings (see top of figure above). "+" will cause CCW rotation, "-" will cause CW rotation.

SPINNING A MODEL SDHP OR SDSK

Note: Spinning ClearPath models MCVC and MCPV is covered in the previous section.

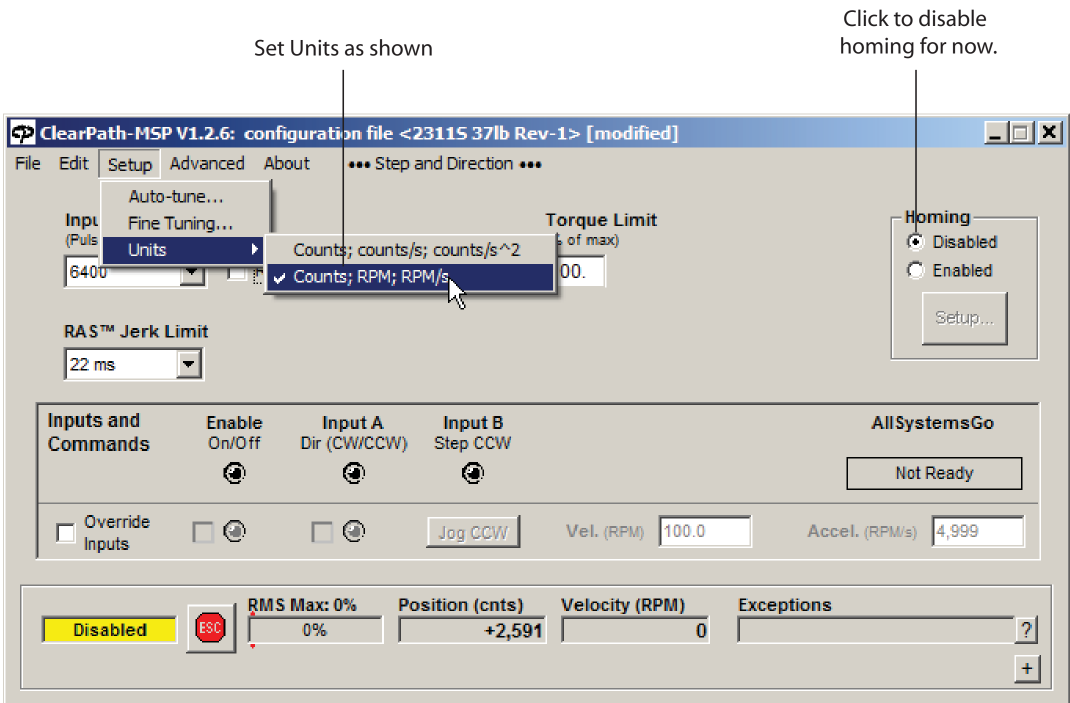
ClearPath SD models have one mode: *Step and Direction*. We'll open that mode and get the motor spinning using MSP.

1. Open MSP software.
2. After communication is established a dialog box may pop up (see figure below). Click Yes to dismiss it.

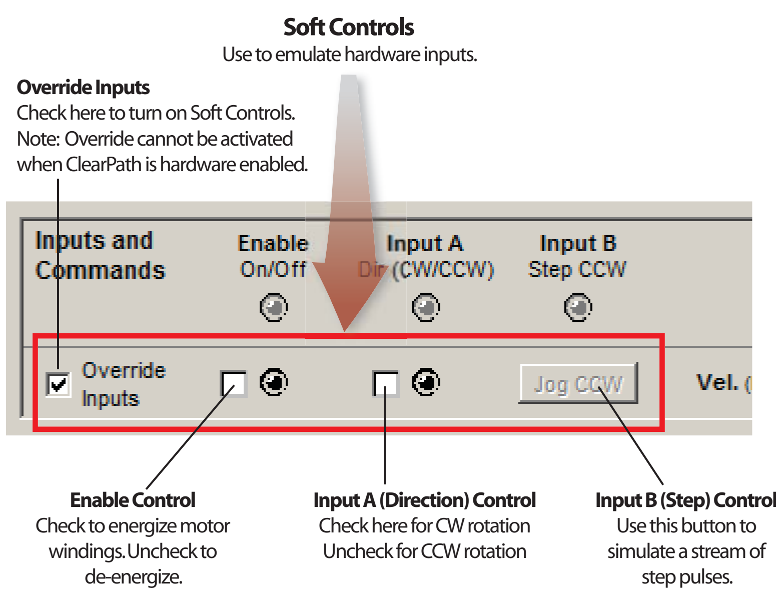


Open MSP and dismiss the dialog window

3. The Step and Direction mode controls window will open.
4. Set Units as shown in the figure below. This just tells MSP in what units to display distance, velocity, and acceleration.
5. Disable homing as shown below.

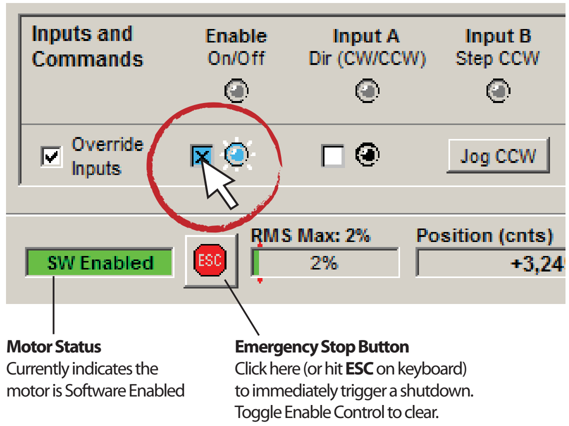


6. **Click the Override Inputs checkbox.** This turns on the software controls. You may notice that the other Soft Controls are no longer grayed out.



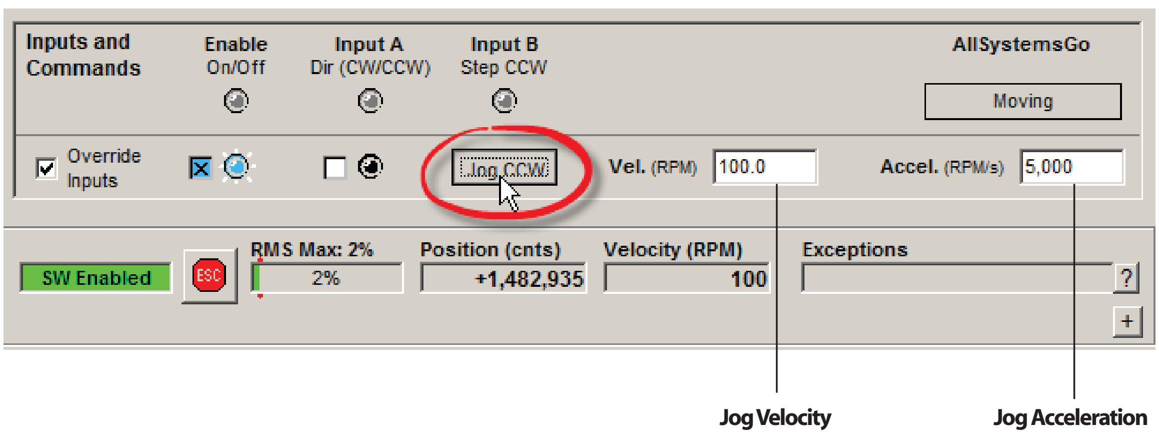
Check "Override Inputs" box to turn on Soft Controls

7. **Safety check!** Before proceeding, make sure that the motor is securely clamped down and the shaft is safely positioned away from fingers, clothing, hair, cables, etc.
8. Check the Enable control box. **Caution: the motor is now energized and capable of motion.**



Enable using Soft Controls

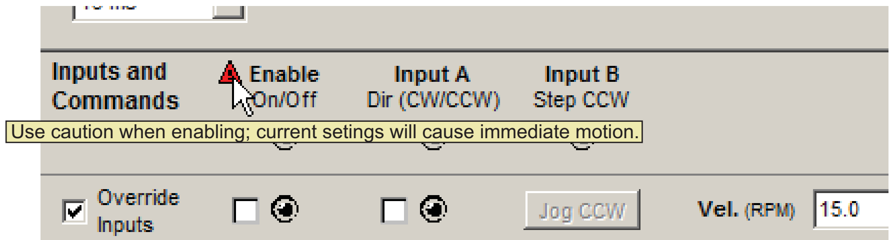
9. **Make some moves.** With the motor enabled, click the jog button. Change direction by checking Input A. Test different velocity and acceleration settings.



Spin your ClearPath-SD motor!

IF YOU EXPERIENCE A MOTOR SHUTDOWN OR WARNING

- If you see a small triangular warning icon appear in the Mode Controls section, hover your cursor over the triangle to read the warning text (it will pop up like a tool tip as shown below).



Hover cursor over "warning triangle" to read its message

- If you exceed your power supply's capability, ClearPath will tell you. You'll see warnings or shutdowns in the Exceptions field at lower right of the UI. (This does not mean that the motor is broken!) Try lowering the acceleration and/or velocity until the warning goes away.
- The majority of shutdowns are caused by weak power supplies, mechanical problems, and inappropriate settings. If your ClearPath experiences a shutdown, it is *reporting* a problem, but is not necessarily causing the problem.
- You can clear most shutdowns by toggling the Enable Input, but if you don't fix the underlying problem, you will probably continue to have shutdowns.
- IF THE STATUS LED FLASHES **RED**, your ClearPath motor has identified an internal hardware problem and needs to be returned for repair or replacement.

AUTO-TUNING

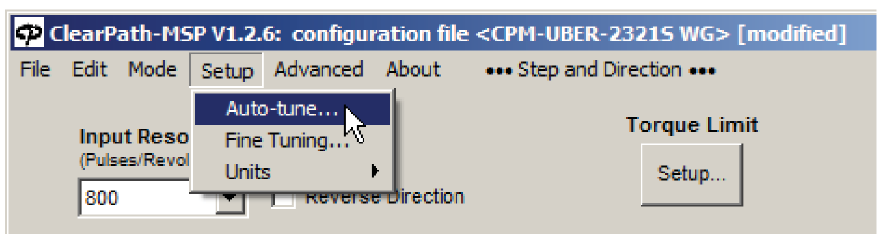
***Tuning is required** whenever you bolt your ClearPath motor to a new or different mechanical system*. The Auto-Tune feature greatly simplifies this formerly tedious and complicated process.

BEFORE YOU BEGIN THE AUTO-TUNE PROCESS:

- Disable your ClearPath.
- Recommended: Turn off your PC's sleep mode. If your PC goes into standby, sleep, or hibernation mode during Auto-Tune, the process fail.
- Tighten all couplings, fasteners, pinions, and belts to the manufacturer's specifications.
- Make sure the axis or machine frame is fully intact.
- Don't try to tune a system on wheels or on a flimsy card table.
- Use a power supply designed for use with motor drives such as Teknic's IPC-3 or IPC-5 series, or use a beefy "bulk" linear power supply with at least 10,000 microfarads of capacitance.
- Don't use a weak switching power supply.

STARTING THE AUTO-TUNER

In MSP, click **Setup>Auto-tune**.



Start the Auto-Tuner

Important: The Auto-Tune application was painstakingly designed to walk users through the tuning process in a safe, step-by-step manner. Anyone engaged in Auto-Tuning must be able to read, understand, and follow all instructions presented.

DURING THE AUTO-TUNE PROCESS

- **Be careful.** Immobilize your motor with bolts or clamps. Keep your hands, hair and clothing away from the motor shaft and mechanical system.
- **Be patient.** Auto-Tune can take up to 30 minutes (5-15 minutes is more typical).
- **Be calm.** Expect to hear humming, buzzing, clicks and clacks. Loud squeals and buzzes are perfectly normal while ClearPath explores the limits of your mechanical system.

BEFORE YOU SEEK TECHNICAL ASSISTANCE

Issue: The status LED on the motor is not lit, and my ClearPath apparently has no power.

- Connect power cable to ClearPath.
- Plug in and turn on power supply.
- Verify wall outlet is powered and no circuit breakers are tripped.
- If you accidentally reversed DC power to your ClearPath motor, it is very likely damaged and must be returned to Teknic.

Issue: The status LED is working, but my ClearPath and PC are not communicating.

- Disconnect the USB cable from ClearPath and your PC, close MSP, restart MSP, and reconnect the USB cable.
- Are you using a USB 3.0 port? Try a USB 2.0 port or a USB 2.0 hub plugged into a USB 3.0 port. ClearPath is compatible with *fully compliant* USB 3.0 ports, however there are known issues with the USB 3.0 ports made by certain manufacturers.

Issue: Auto-Tune failed to complete.

- Check to see if more than one version of MSP is installed on your computer. Always uninstall older versions of MSP before upgrading.
- If your power supply is a switcher or an underpowered “bulk” linear supply with insufficient current and/or capacitance, and cannot tolerate regenerated energy, you’ll have problems running Auto-Tune. ClearPath motors can operate between 24 and 75 VDC, but they require adequate power to Auto-Tune.

Issue: My ClearPath is getting shutdowns.

- A shutdown seldom means your ClearPath is broken or defective.
- Shutdowns with yellow or green blink codes usually mean that ClearPath is reporting a problem, but it is unlikely to be the problem. Connect ClearPath to your PC running MSP and look in the “Exceptions” field to see what’s being reported.
- Check the ClearPath User Manual (Appendix A) for blink code details, clues, and possible fixes.
- If you see a shutdown accompanied by a red flashing LED, you’ll probably have to return your ClearPath for repair or replacement. Check the Teknic website for repair/return information.

How do I restore my ClearPath to its factory default settings?

If you need to return ClearPath to its original state (i.e., configured exactly as it was when we shipped it to you), use File>Reset Config File To Factory Defaults. All parameters and settings will be over-written and ClearPath will be returned to its default factory configuration.

SAFETY WARNINGS

IMPORTANT: Read this manual before attempting to install, apply power to, or operate a ClearPath motor. Failure to understand and follow the safety information presented in this document could result in property damage, bodily injury or death.

PERSONAL SAFETY WARNINGS

- Do not wear loose clothing or unconfined long hair when using ClearPath motors. Remove ties, rings, watches and other jewelry before operating an unguarded motor.
- Do not operate a ClearPath motor if your alertness, cognitive function, or motor skills are impaired.
- Always handle, and carry a ClearPath motor by the housing (don't carry it by the shaft or cables).
- Be aware that in certain modes of operation ClearPath is designed to spin as soon as DC bus power is applied.
- Always understand how to use a mode of operation and its associated controls before attempting to power, enable, or otherwise operate a ClearPath motor.
- Install and test all emergency stop devices and controls before using ClearPath.
- Before applying DC power, secure the ClearPath motor to a stable, solid work surface and install a finger-safe guard or barrier between the user and the motor shaft.
- Provide appropriate space around the ClearPath motor for ventilation and cable clearances.
- Do not allow cables or other loose items to drape over, or rest near the ClearPath motor shaft.
- Never place fingers, hands, or other body parts on or near a powered ClearPath motor.
- Thoroughly test all ClearPath applications at low speed to ensure the motor, controls, and safety equipment operate as expected.

CE COMPLIANCE WARNINGS

- Do not open device enclosure. There are no user serviceable parts inside this product.
- Follow all instructions and use the product only as directed.
- Safety of any system incorporating this equipment is the responsibility of the system designers and builders.
- The machine designers need to recognize and incorporate required warning symbols, guards and shields for ClearPath motors that are used in applications that can result in the

external accessible parts of their machine exceeding a temperature of 65 Celsius. This is required as a method to reduce burns. A tool shall be required to remove any guards and/or shields.

- ClearPath motors require that a path exist between the motor chassis and the Protective Earth (PE) connection of the machine to which it is affixed. (Note: The PE connection is often satisfied by simply bolting the motor to the machine; however it is the users responsibility to verify the PE connection.) If an external grounding wire is required, use the same or larger wire gauge as used between the DC power supply and ClearPath Motor.
- Any maintenance or repair guide created by the user shall state that power shall be removed before the Protective Earth ground conductor is disconnected. When reconnecting power, the Protective Earth ground conductor shall be the first wire reconnected. Main power may be reconnected only after the Safety Ground connection is secure.
- When the ClearPath motor is mounted in an application where the shaft end is higher than the electrical connection end of the motor, the USB connector plug provided by Teknic must be installed. The USB plug in these installations becomes an element to prevent the spread of fire per EN 61010-1 section 9.3.2 part c.

GENERAL DISCLAIMER

The User is responsible for determining the suitability of products for their different applications. The User must ensure that Teknic's products are installed and utilized in accordance with all local, state, federal and private governing bodies and meet all applicable health and safety standards.

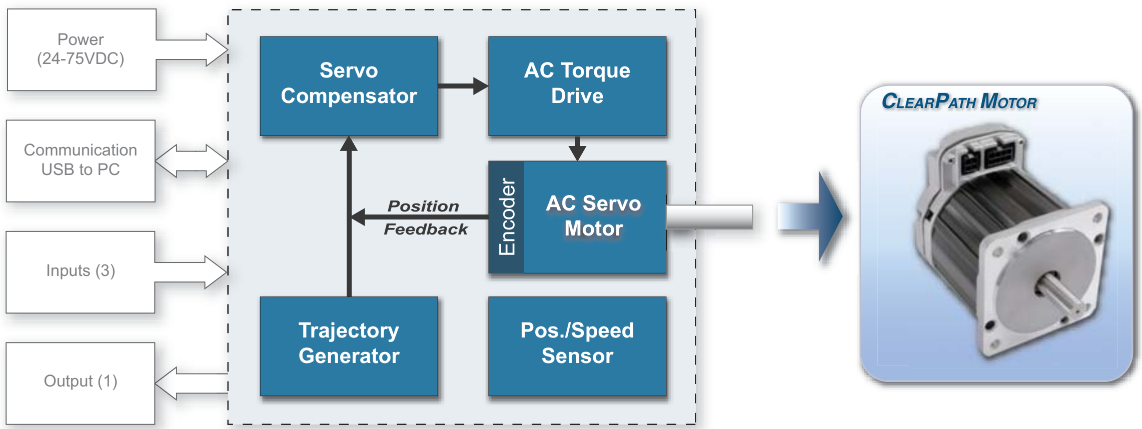
Teknic has made all reasonable efforts to accurately present the information in the published documentation and shall not be responsible for any incorrect information which may result from oversights. Due to continuous product improvements, the product specifications as stated in the documentation are subject to change at any time and without notice. The User is responsible for consulting a representative of Teknic for detailed information and to determine any changes of information in the published documentation.

If Teknic's products are used in an application that is safety critical, the User must provide appropriate safety testing of the products, adequate safety devices, guarding, warning notices and machine-specific training to protect the operator from injury.

INTRODUCTION

WHAT IS A CLEARPATH MOTOR?

ClearPath is an all-in-one servo system: a precision brushless servo motor (with encoder) combined with a powerful integrated servo drive, trajectory generator, and internal controller, in a package about the size of a servo motor alone. ClearPath brings affordable, user-friendly, precision motion control to everyone from the OEM machine builder and shop automation specialist, to the educator, artist, and maker.



ClearPath functional blocks

ClearPath is a professional level, industrial grade product. The motor subsystem is based on Teknic's Hudson family of brushless servo motors, with similar instrument grade bearings, stainless steel shaft, windings, rare earth magnets, and encoder technology. The servo drive electronics and motion control firmware employ the same state-of-the-art technology and advanced motion control algorithms as our high-end, non-integrated servo control products.

ClearPath Simplicity begins with a quick, uncomplicated setup. Install the included MSP software, connect ClearPath to your PC via USB, and configure and tune your ClearPath. Once setup is complete, disconnect ClearPath from your PC and start moving. With just three inputs and one output, sending commands and receiving feedback is simple and intuitive.

ClearPath MSP software is written in plain English with plenty of tips and annotations. Use MSP to select a mode of operation, set your move parameters and options (distance, speed, acceleration, torque) and tune the system. There's no steep learning curve with ClearPath.

Flexibility is evident in the many operating modes available. ClearPath motors can do:

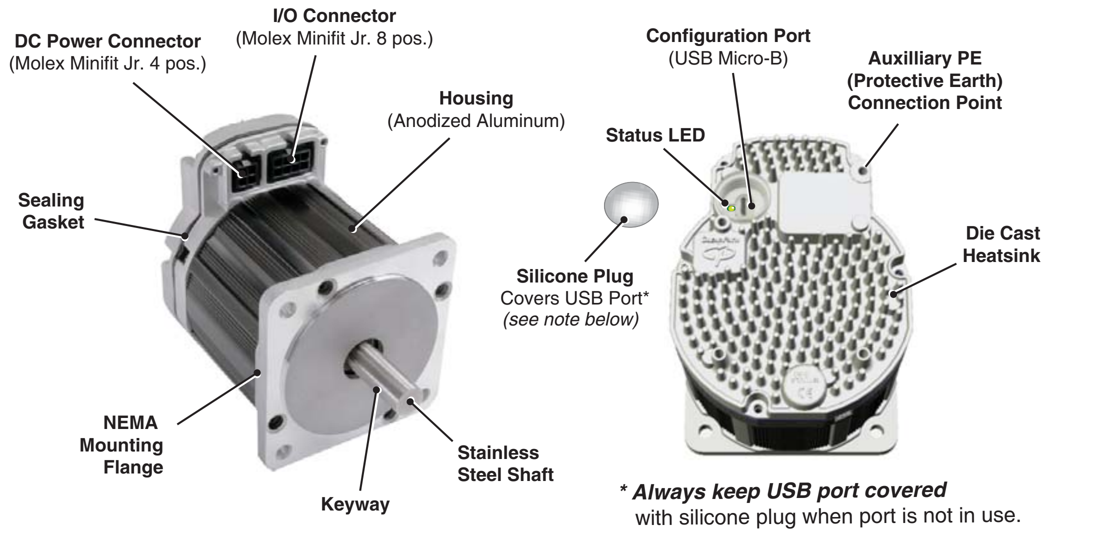
- Point-to-Point Positioning (move and settle with precision).
- Velocity Modes (spin at constant rotational speeds).
- Torque Modes (precisely control torque at the shaft).
- Stepper Emulation (use standard step-and-direction signals).

ClearPath motors are at home in applications ranging from variable speed conveyors to multi-axis positioning robots, to kinetic sculptures. And, while most ClearPath customers have a specific application in mind, it's reassuring to know that your ClearPath can be reprogrammed to perform a different job in just a few minutes.

Safety and self-protection features are standard. ClearPath will rapidly shut down if it becomes overloaded, overheated, detects a hard stop, or exceeds any of the safety or motion limits you specify.

Made in USA. Each ClearPath motor is built and tested in our New York manufacturing facility, so you can be certain you're getting a high quality, fully tested motion control product right out of the box. Additionally, Teknic backs up each ClearPath motor with a generous three year warranty.

PARTS OF A CLEARPATH MOTOR



ClearPath Motor

DC Power Connector - Apply main DC power (24-75VDC) to this 4-position Molex MiniFit Jr. connector.

I/O Connector - Access ClearPath's three inputs and one output through this 8-position Molex MiniFit Jr. connector.

Configuration Port - Use this port to connect ClearPath to a Windows PC with a standard USB (Type A to Micro-B) cable. Cover port with included silicone plug when not in use.

Status LED - Tri-color LED Indicates operational status of ClearPath device. See Appendix A for LED codes.

Auxiliary PE (Protective Earth) Connection Point - Typically used only if the motor mounting bracket or plate is not bonded to the machine's PE terminal. See Appendix E: Grounding and Shielding for complete details. To use, connect a wire between this screw boss and your machine chassis to ensure a good connection to the machine's Protective Earth terminal.

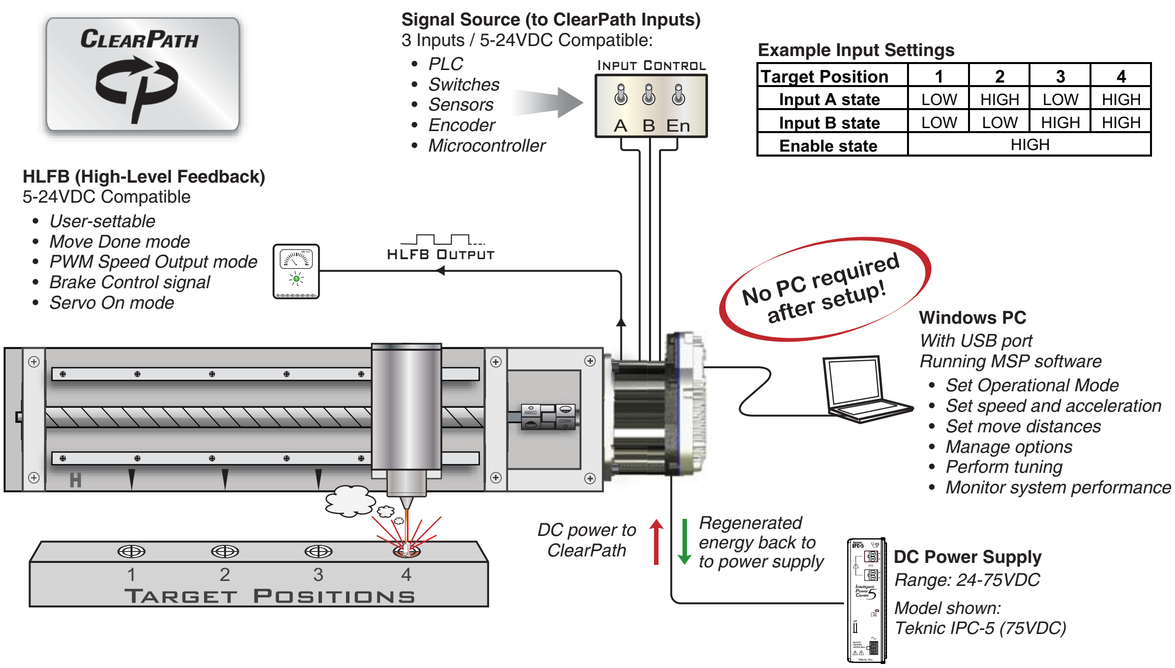
EXAMPLE APPLICATION: ABSOLUTE POSITIONING MODE

Read this section for a brief introduction to ClearPath technology and terminology through an example application. Please visit https://www.teknic.com/watch-video/ to view ClearPath application videos.

SUMMARY OF OPERATION

Note: This section describes only one example application in one mode of operation. Absolute Positioning (4-position) mode allows you to define up to four target positions and command moves between any of them simply by changing the logical states of the ClearPath inputs.

In the figure below, a ClearPath model MCPV is coupled to a ball screw positioning stage. For now, we'll say that ClearPath has already been configured and programmed via the included MSP software. This just means that the mode of operation, target positions, velocity, acceleration, and options are already stored in ClearPath memory and the motor is tuned and ready to go. ClearPath configuration and setup will be discussed later in this section.



Example Input Settings

Target Position	1	2	3	4
Input A state	LOW	HIGH	LOW	HIGH
Input B state	LOW	LOW	HIGH	HIGH
Enable state	HIGH			

ClearPath Absolute Positioning (4-Position) Mode

Getting started. To energize the motor, simply apply a DC voltage to the Enable input. Once enabled, the motor is considered "live", i.e. the motor is energized and will execute moves in response to state changes at Inputs A and B.

Caution: Depending on the exact mode and settings selected, ClearPath may automatically move upon enable *with no user changes to the inputs*.

In this particular mode, ClearPath must perform a homing operation (all of the target positions are defined in terms of distance from the "home" reference position). Setting up your homing parameters is easy, and only has to be done once (using the included MSP software).

After homing is complete, ClearPath can be commanded to move to any of the four target positions by changing the state of Inputs A and B.

EXAMPLE: MAKING A MOVE

Motion objective: Move the load platform from position#1 to position #4.

User action: Simultaneously set Inputs A and B high. This can be done with toggle switches, PLC, microcontroller, or other compatible device.

Motion result: The motor immediately begins a move based on the user's acceleration and velocity settings. The motor then decelerates and settles at position #4. Note: ClearPath will actively servo to maintain position until another move command is received, unless the system is intentionally disabled, powered down, or in a shutdown state.

The Digital Output (we call it HLFB, for High-Level Feedback) can be configured to signal when ClearPath completes a move, reaches a specified speed or torque, or shuts itself down for safety reasons. See the section on Outputs (High-Level Feedback) for more on HLFB modes.

OVERVIEW: CONFIGURING A CLEARPATH

ClearPath must be configured and tuned before it can be used in a motion application. The main configuration steps are outlined below. Each of these points is discussed in greater detail later.

1. Install ClearPath software (MSP) on a qualified Windows PC.
2. Connect your I/O devices to ClearPath (switches, PLC, microcontroller, etc.).
3. Supply DC power (24-75VDC) to ClearPath.
4. Connect ClearPath to your PC with a standard USB cable.
5. Use ClearPath MSP software to:
    a. Select a mode of operation.
    b. Set motion parameters and options (acceleration, velocity, torque, safety settings, etc.).
    c. Tune the motor to the mechanical system.
6. Test and adjust settings as needed to optimize quality of motion and overall system performance.
7. Disconnect the computer. Cover USB port with the included silicone plug, and run your application. No computer is needed once setup is complete.

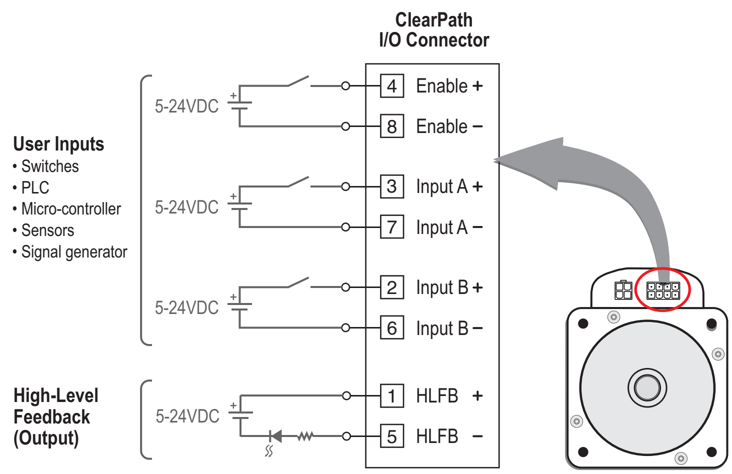
Save your settings! You can save your ClearPath settings to a motor configuration file—the file extension is .mtr—at any time. This allows you to easily test and compare various sets of tuning parameters. And, if you build many machines of the same design, you'll appreciate how quickly you can load a saved configuration file into a new ClearPath.

OVERVIEW: CLEARPATH I/O

ClearPath I/O provides a flexible high-level control interface for your ClearPath motor. There are no proprietary connectors, cables or sensors, so you decide which input devices are right for your ClearPath application.

Once the inputs are wired up, you'll be able to execute moves either by 1) changing the logical (on/off) state of the inputs or 2) by applying a pulse or PWM signal to the appropriate input. See the chapter on *Inputs and Outputs* for I/O wiring information.

Note: ClearPath inputs automatically change function based on mode of operation selected. See the Operation Mode section for input function.



Simplified overview of ClearPath inputs and output

Enable Input. Asserting the Enable input (logical 1, high, 5–24VDC) energizes the motor coils. De-asserting Enable (logical 0, low state, 0 volts) removes power from the motor coils.

Inputs A and B. Once enabled, ClearPath can respond to the state of Inputs A and B. ClearPath supports a wide range of input devices, from simple toggle switches to sensors, relays, PLC outputs, microcontroller outputs, and more can be wired to a ClearPath.

High-Level Feedback (HLFB). ClearPath's HLFB output can be set up to alert the user or control system to one of several conditions. HLFB can be configured to:

- Change state if a Shutdown occurs.
- Signal when ClearPath is running at your commanded velocity or torque.
- Signal the end of a move (based on user-defined settling requirements).
- Output a PWM signal whose duty cycle is proportional to motor speed, or torque.

POWERING A CLEARPATH SYSTEM

SELECTING A DC BUS POWER SUPPLY

ClearPath motors can be powered from 24–75VDC power supplies; however the actual minimum voltage and current required to power a ClearPath in a given application is highly dependent on the application requirements (i.e. how much torque and speed is required) as well as motor winding and magnet configuration.

Teknic power supplies have been extensively tested and widely used in ClearPath applications, but third-party (non-Teknic) power supplies can be used as well. See next page for Teknic power supply overview. Please visit the Teknic website for power supply features, specifications, and pricing.

CLEARPATH OPERATING VOLTAGE

RECOMMENDED OPERATING VOLTAGE: 24–75VDC

Note: Always operate ClearPath within the recommended operating voltage range (24VDC to 75VDC). If measuring the *actual bus voltage reaching your ClearPath motor*, probe directly on the ClearPath power connector.

The ideal ClearPath power supply...

...is capable of delivering high peak current and handling back-EMF (reverse voltage generated by the spinning motor that "cancels" a portion of the incoming supply voltage). A power supply specifically designed for motor drive power—like Teknic's "Intelligent Power Center" supplies (IPC-3 and IPC-5)—will have these features, and are ideal for servo systems like ClearPath. "Bulk" linear power supplies—basically a transformer, rectifier, and large capacitor—can also work adequately. Normal switching-mode power supplies are not generally the best choice.

Important: Thoroughly test your ClearPath application with the intended power supply *under worst case, full load conditions* to ensure sufficient power capacity and adequate operating margin.

Why you should avoid (most) switching power supplies

Switching power supplies are typically not well suited to high power servo applications because they generally have the same peak *and* continuous-current ratings. This can lead the user to purchase a large but ultimately under-worked power supply just to meet peak current requirements.

In addition, most switchers are not designed to handle the regenerated energy (back-EMF) that a decelerating motor returns to the power supply. Without special provisions, regenerated energy can cause a switching supply to reset, power cycle, shut down, or even fail.

NOTES ON LOWER VOLTAGE POWER SUPPLIES

ClearPath motors can and do work with power supplies as low as 24 volts DC, provided that the power supply has sufficient voltage, current, and capacitance to meet your application's motor torque and speed requirements. This assumes that the motor has been properly sized for the application.

IMPORTANT: An underpowered supply can result in ClearPath performance limitations and problems including the following:

- **ClearPath is unable to complete the auto-tuning process.** The ClearPath auto-tuning feature uses aggressive moves to test the limits of each mechanical system. A weak power supply (i.e. one that can't handle the peak current demands required by ClearPath) may "droop" the supply below ClearPath's minimum operating voltage, about 21.5VDC. This can cause loss of communication and/or a safety shutdown. Needless to say, if Auto-Tune cannot run to completion, you probably have an underpowered supply.
- **ClearPath completes the auto-tuning process but experiences certain warnings or shutdowns during programmed motion.** If Auto-Tune runs to completion, but you experience torque saturation, voltage saturation, or both during regular machine operation, you may be exceeding the supply's voltage and/or current capability.

If you have an underpowered supply

If you suspect your power supply is underpowered, one of these solutions may work for you:

- **Lower the commanded acceleration and/or velocity.** Sometimes lowering commanded acceleration and/or velocity can reduce the burden on a weaker power supply enough to eliminate shutdowns caused by "power starvation".
- **Upgrade to a more powerful supply.** Look for a supply with higher voltage, higher peak and continuous current ratings, and a large capacitor bank.
- **Modify your existing power supply.** In some cases adding a large capacitor and a few inexpensive components to an underpowered supply can boost the supply's output satisfactorily. Note: Consult your power supply manufacturer before making any modifications to a commercial product.

TEKNIC POWER SUPPLIES

Teknic manufactures two 75VDC power supplies designed specifically for powering motor drives—the IPC-3 and IPC-5. These supplies effectively manage peak current demand, regenerated energy, and include several built-in protective features. They are ideal for use with ClearPath motors.

Teknic IPC-3

Teknic IPC-5

Teknic 75VDC IPC family power supplies

TEKNIC MODEL IPC-3

The IPC-3 open-frame power supply can typically power one to four ClearPath motors. The actual number depends on the application—fewer when the motors are generating high torque continuously at high speeds, and more when the motors are intermittently using bursts of power like in many point-to-point positioning systems. Please visit Teknic's website (www.teknic.com) for more information, features, and specifications.

TEKNIC MODEL IPC-5

The IPC-5 fully enclosed power supply can typically power two to six ClearPath motors. The actual number depends on the application—fewer when the motors are generating high torque continuously at high speeds, and more when the motors are intermittently using bursts of power like in many point-to-point positioning systems. Please visit Teknic's website (www.teknic.com) for more information, features, and specifications.

BEFORE POWERING A CLEARPATH

- Check for proper DC power polarity before connecting power to a ClearPath. Reversing DC power polarity may damage the unit and void the warranty.
- Verify that the power supply is turned off and discharged before connecting to a ClearPath. Connecting and disconnecting the motor from a charged power supply will cause electrical arcing that can damage the connector pins over time.
- Never connect a ClearPath motor directly to an AC outlet. This will damage the ClearPath motor and void the warranty.

- It is acceptable to daisy chain power to several ClearPath motors provided that the combined current draw of the motors does not exceed 10A during operation. If total combined current draw is expected to exceed 10A, star power wiring should be used.
- When a ClearPath motor is powered on, a startup routine energizes the motor for a few milliseconds. During this startup routine it is not uncommon for a small amount of motion to occur (1° typical).

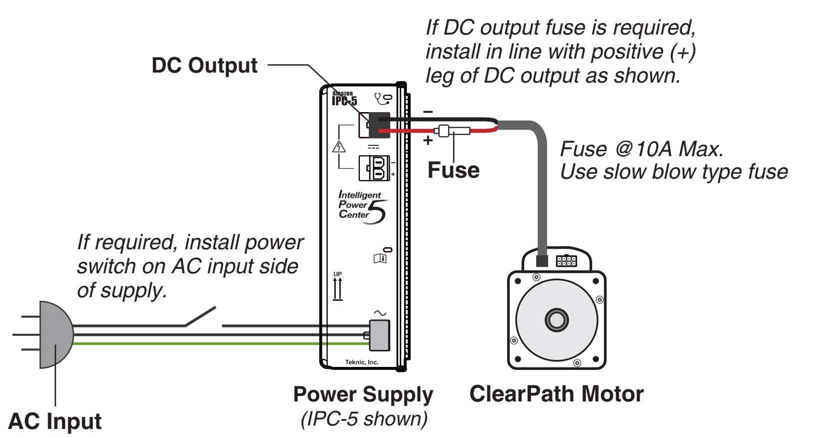
POWER SUPPLY SWITCHING AND FUSING

POWER SUPPLY CONTROL SWITCH

The power supply for a ClearPath should not be switched on and off from the DC output side. Switching the DC output side, especially with inexpensive relays, will ultimately result in poor performance (drop outs) due to pitting, corrosion and contact welding. If a power switch is required, install it such that the supply is disconnected from the AC input side (see figure below).

POWER SUPPLY FUSING

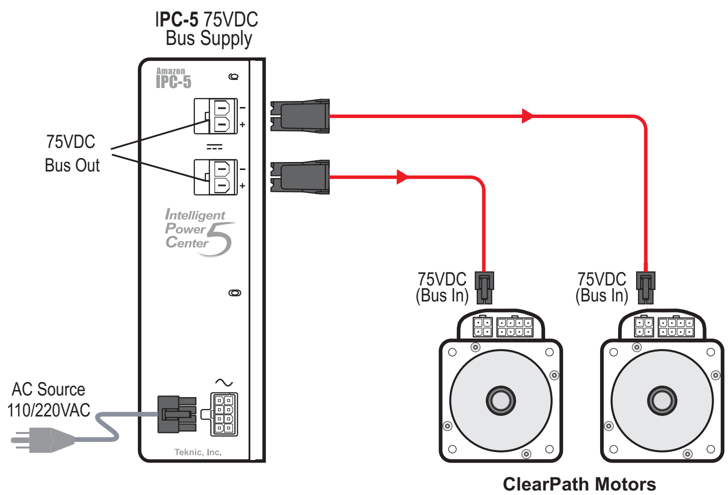
If you require an external fuse on your power supply's DC output (to meet compliance standards for example) it should be installed in line with the positive leg of the DC output wiring as shown below. Use a maximum 10A time delay fuse. Note: Teknic IPC power supplies are not internally fused on the DC output side.



Power supply switching and fusing detail

BASIC POWER CONNECTION (2 MOTORS)

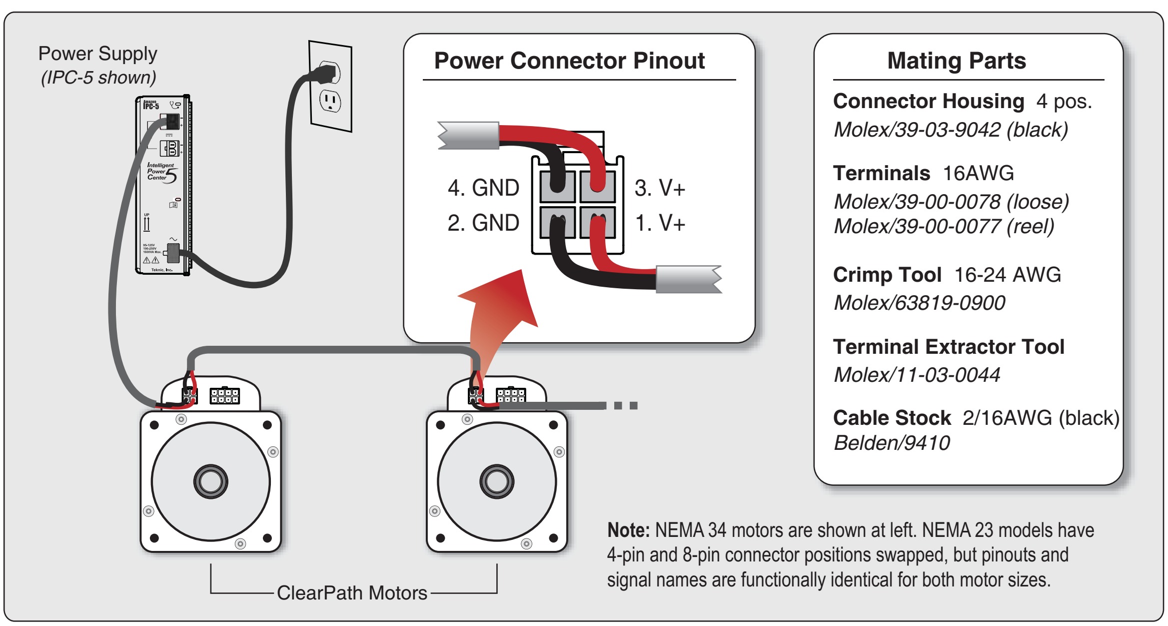
One or two motors can be connected directly to the IPC-3 or IPC-5 power supply as shown below. To connect more than two motors, consider chaining power or using the optional Power Hub board.



Direct Connection

POWER CHAINING (MULTIPLE MOTORS)

For applications with several ClearPath motors, chaining power from motor to motor may be preferable. You will have to fabricate power cables as shown below to chain power from motor to motor.



ClearPath Power Supply Connection

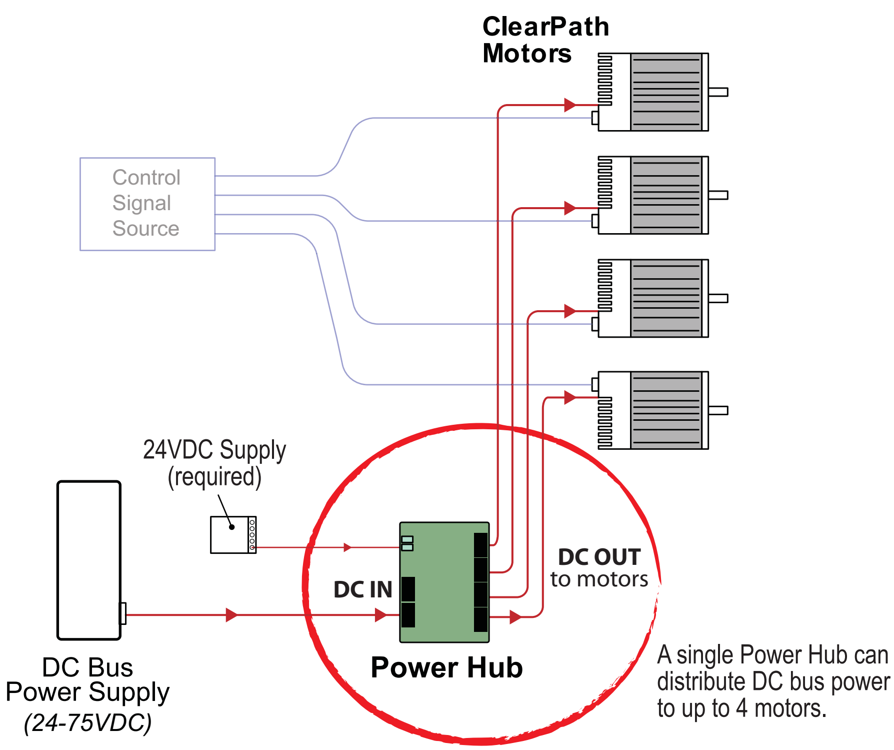
USING A POWER HUB (MULTIPLE MOTORS)

The Power Hub (Teknic PN **POWER4-HUB**) is an optional ClearPath accessory board that:

1. Distributes DC bus power to as many as four ClearPath motors per hub, thus eliminating the need for special "power chaining" cables.
2. Delivers low voltage backup power to keep your ClearPath motors' electronics "alive" should main DC bus power be lost. The benefit is uninterrupted communication, status, and position tracking.

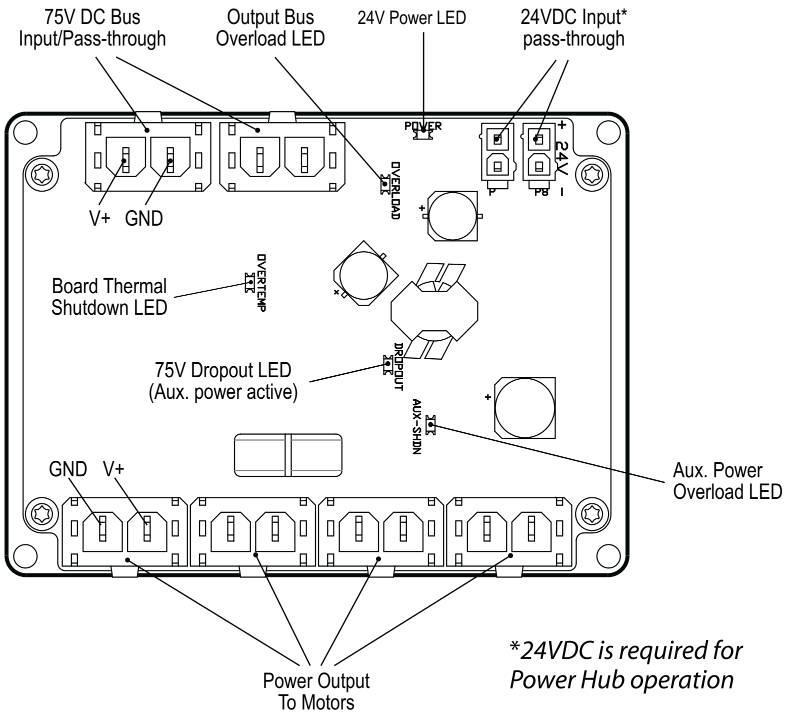
Note: You will be unable to spin your motors when using only low voltage backup power. Low voltage backup power will keep the motor electronics alive, but is not designed nor intended to replace main DC bus power.

POWER HUB OVERVIEW DIAGRAM



Power Hub in a ClearPath system

PARTS OF A POWER HUB



Power Hub with parts called out

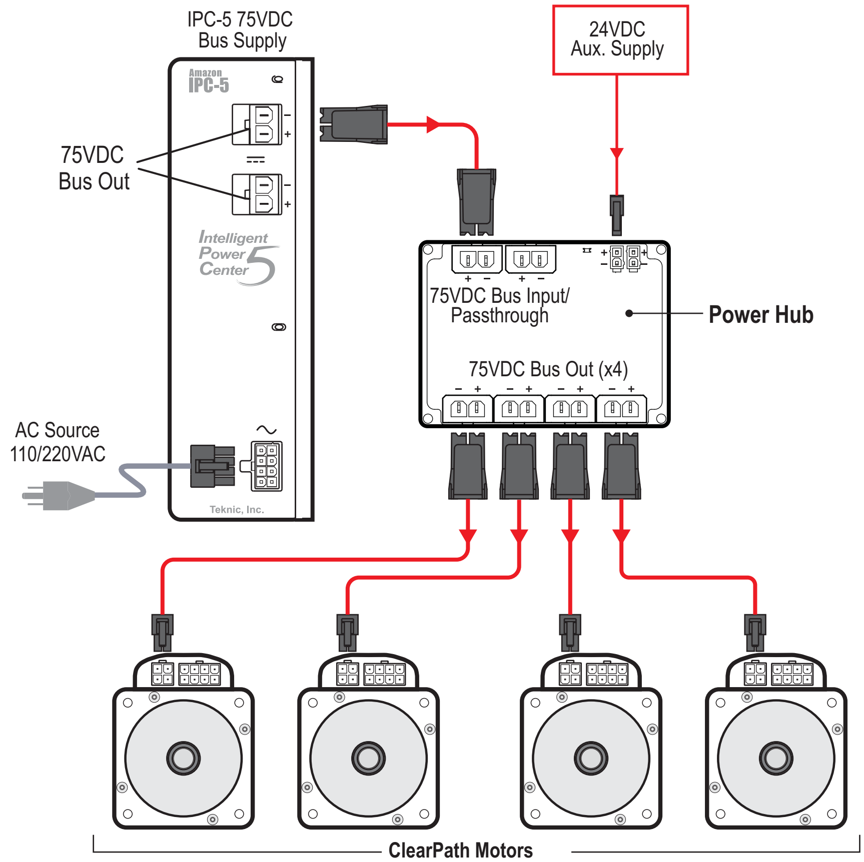
DC Bus Power Input/Passthrough (Qty. 2) - Supply 24-75VDC power from your DC Bus Supply to either of these connectors (they are wired in parallel). The other connector can be used to bring bus power to a second Power Hub if desired, or left unconnected.

DC Bus Power Outputs (Qty. 4) - These four connectors supply bus power to your ClearPath motors. In addition, if power is dropped, they carry aux. power to keep maintain motor communication to the host application. They are fully short-circuit protected.

Aux. 24VDC Input/Passthrough (Qty. 2) - Supply low power 24VDC from your aux. supply to either of these connectors (they are wired in parallel). The other connector can be used to supply aux. power to a second Power Hub.

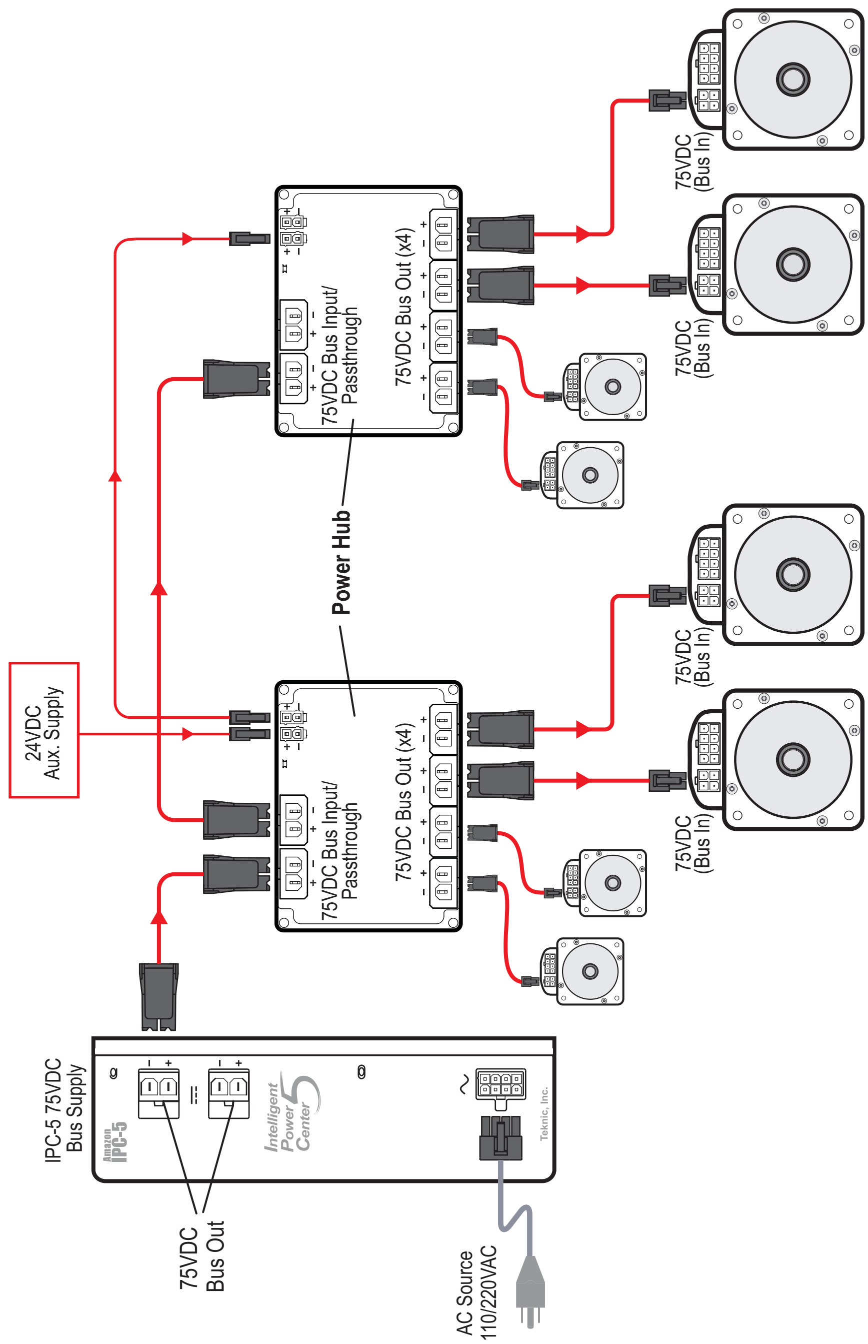
Power Hub LEDs - There are 5 LEDs (light emitting diodes) on a Power Hub. Please refer to the section "Power Hub LEDs" (in a few pages) for complete information on what the LED indicators indicate.

CONNECTIONS FOR A SINGLE POWER HUB SYSTEM



Single Power Hub System

CONNECTIONS FOR A DUAL POWER HUB SYSTEM



Two Power Hubs powering 8 ClearPath motors

AUXILIARY (24V) POWER SUPPLY

The Power Hub requires a 24VDC auxiliary power supply to function. The auxiliary supply need only deliver enough current (typically 1-2 amps). See below for auxiliary supply current requirements.

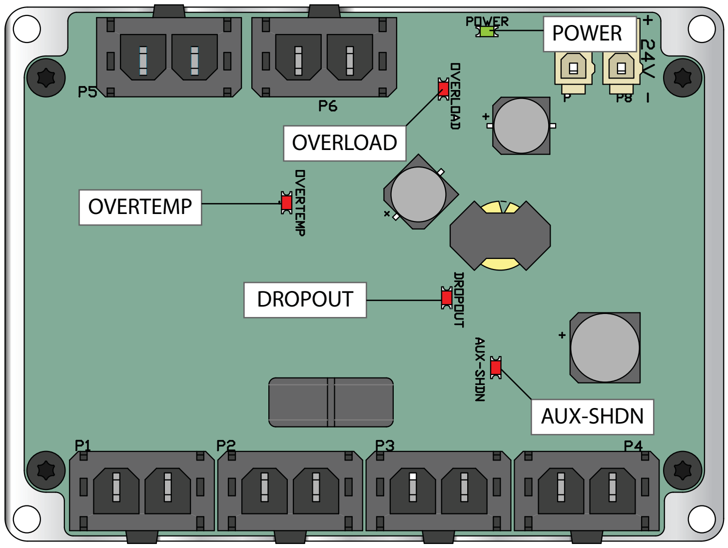
AUXILIARY SUPPLY MINIMUM CURRENT REQUIREMENT

For your 24DC supply, budget current as follows:

- 80mA per Power hub
- 80mA per motor

If you intend to power one Power Hub and four motors, budget at least 400mA total (80mA for the Power Hub plus 80mA per motor). Budget additional current if other devices share the aux. supply.

POWER HUB LED CODES



Power Hub LEDs

LED Name	Color	LED On Indicates	LED Off Indicates
POWER *24V Power*	Green	Normal operation. Aux. 24V supply voltage detected.	Aux. 24V supply voltage not detected. Hub not functional.
OVERLOAD *Output Bus Overload*	Red	Short (or near short) circuit at bus output. Power Hub electronically disconnects bus input from bus output in this case as a protective measure.	Normal operation.
OVERTEMP *Board Thermal Shutdown*	Red	Board temperature has exceeded 105°C. (Note: After an overtemp event, LED will turn off when board temp falls below 95°C.)	Normal operation. (Board temp is < 105°C.)
DROPOUT *75V Dropout LED*	Red	Bus supply has "dropped out", meaning the DC Bus has fallen below 18.2 VDC. Aux. power is active.	Normal operation.
AUX-SHDN *Aux. Power Overload*	Red	Motor bus has dropped out and aux. supply is in an overloaded state. (The motor load has exceeded 1000mA for >20mS.) This is a latching shutdown. You must cycle the aux. power supply to clear.	Normal Operation

POWER HUB: THINGS TO KNOW

- **Reversing DC bus power polarity to the Power Hub DC input will permanently damage the Power Hub.** Use a meter to verify correct DC bus power polarity before connecting the power supply to the Power Hub.

- **Do not "hot swap" power connectors.** Verify that the DC bus power supply is turned off before connecting a motor to the Power Hub. Connecting and disconnecting the motor from a live power supply will cause electrical arcing that will damage the connectors over time.

- **Do not connect more than four motors to a Power Hub.**

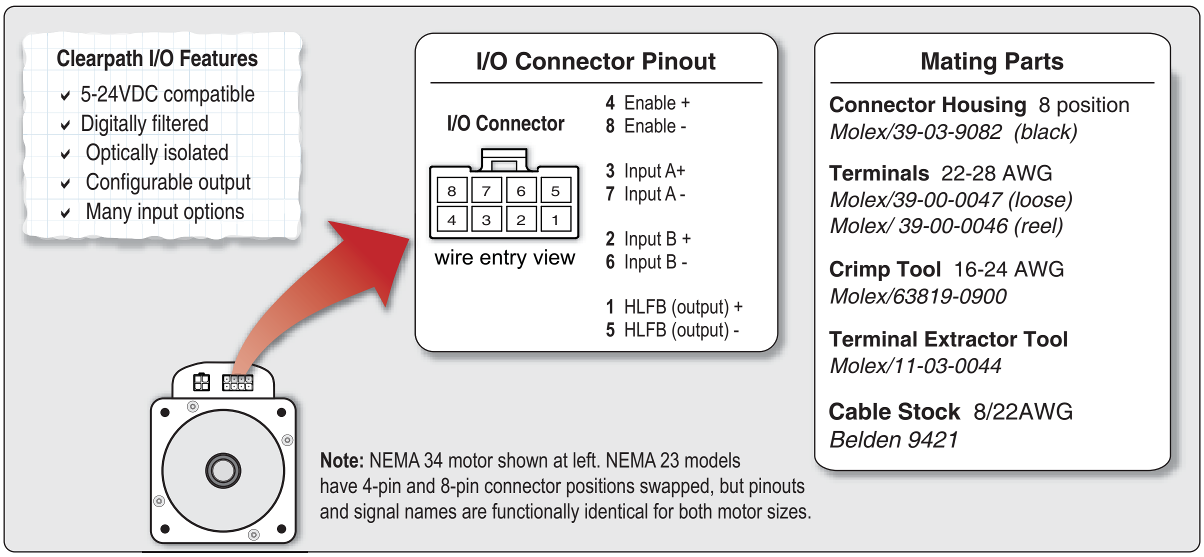
- **Do not connect more than two Power Hubs to a power supply.** Continuous and peak current usage must not exceed the power supply's specifications.

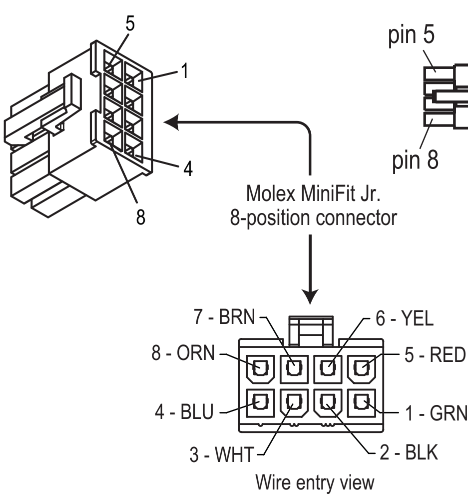
Important: While it is acceptable to chain two Power Hubs together, it is the user's responsibility to ensure that the DC bus power supply has sufficient continuous and peak power to meet his or her application requirements.

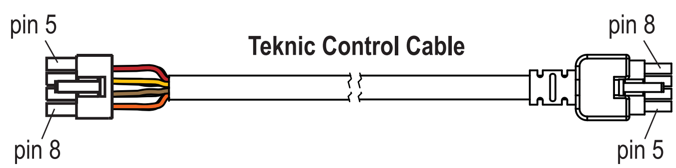
INPUTS AND OUTPUTS

ClearPath inputs and output (I/O) allow the user to send and receive control signals from a ClearPath motor. There are a total of three digital inputs and one digital output accessible through the 8-position Molex MiniFit Jr. connector. Refer to the diagram below for a list of I/O connector mating parts readily available through most electronic component suppliers.

I/O CONNECTOR PARTS AND PINOUT







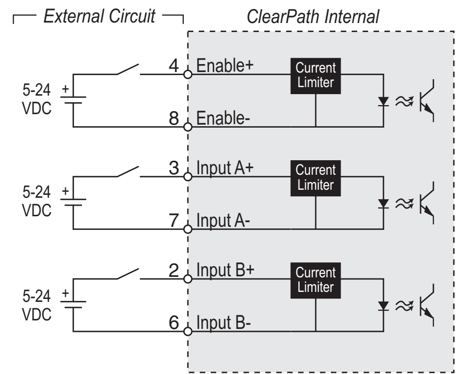
Teknic Control Cable Pin Assignments

Pin	Color	Name
1	GRN	HLFB +
2	BLK	Input B +
3	WHT	Input A +
4	BLU	Enable +
5	RED	HLFB -
6	YEL	Input B -
7	BRN	Input A -
8	ORN	Enable -

ClearPath I/O connector and mating parts

INPUT ARCHITECTURE

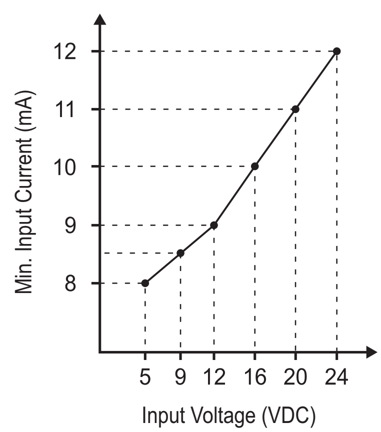
The three inputs, designated *Enable*, *Input A*, and *Input B*, are designed for use with 5-24VDC logic levels and pulses from a wide variety of signal sources and devices including PLCs, microcontrollers, and even mechanical switches, with no external resistors required.



ClearPath Inputs shown with simple switches

INPUT CURRENT DRAW

The table and graph below illustrate the maximum current draw by the ClearPath input circuits for the range of acceptable input voltages.



Voltage at ClearPath Input	Minimum Input Current Required
5 VDC	8 mA
12 VDC	9 mA
24 VDC	12 mA

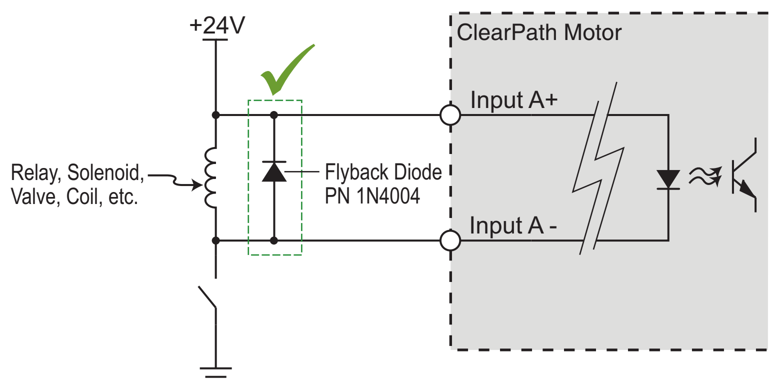
Maximum input current draw at given input voltages

WARNING: INDUCTIVE LOADS AND CLEARPATH I/O

When power is suddenly removed from an inductive load, the inductor is left with residual stored energy that, if discharged into a circuit without surge suppressing components, can weaken, damage, or destroy susceptible components in the discharge path.

Therefore, if you connect an inductive load across a ClearPath Input, you must also add a common diode (such as part number **1N4004)** to the circuit to prevent the inductor's back EMF from destroying the ClearPath input circuit. Note: when a diode is used in this manner it is often called a flyback diode, snubber, suppression diode, or catch diode.

Information on the Web: For more information search Wikipedia: "Flyback Diode" for an article that explains how a circuit with an inductive load across it can be damaged (and how a flyback diode can solve the problem).



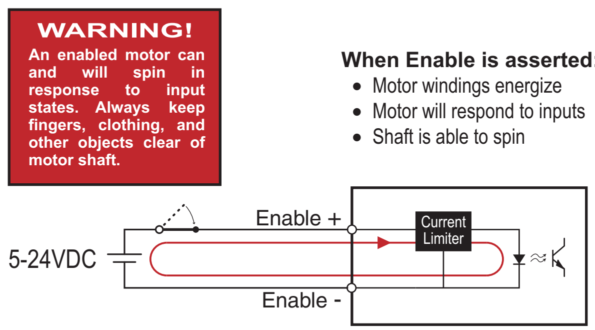
Add a diode as shown if you have an external inductive load across a ClearPath input

The Enable Input

The **Enable Input** controls power to the motor coils. When a ClearPath is powered up and the Enable Input is asserted (i.e. 5–24VDC is present at the Enable Input) the motor windings energize and ClearPath is able to respond to control signals at Inputs A and B.

When Enable is de-asserted power to the motor coils is removed and the motor cannot respond to user inputs[2].

Safety Note: The Enable Input is not designed for safety compliance use. Main power must be removed to ensure safety.



ClearPath Enable Input

Caution: When ClearPath is in “Spin on Power-Up” mode, it can spin as soon as main DC power is applied. All inputs, *including the Enable Input*, are ignored in this mode. For safety reasons, ClearPath motors never ship configured in "Spin on Power-Up" mode.

Enable-With-Trigger function. In a few ClearPath modes, the Enable input also serves as a trigger input. In these modes, briefly pulsing the Enable input low (and immediately back high again) causes ClearPath to perform a predefined action, such as execute a move, change direction of rotation, or change velocity. See individual operation modes for trigger mode details.

Inputs A and B: The Control Inputs

Inputs A and B are the main user control inputs. Their function changes automatically based on the ClearPath mode of operation you choose. In some modes simply apply a PWM signal to control velocity or torque. In other modes, set the inputs high or low to move a preset distance, ramp to a target velocity, change direction, or move until a sensor trips. For ClearPath SD models, apply standard step and direction signals to the inputs to create your own motion profiles.

Tip: Input A and Input B functions are defined at the beginning of each operational mode section.

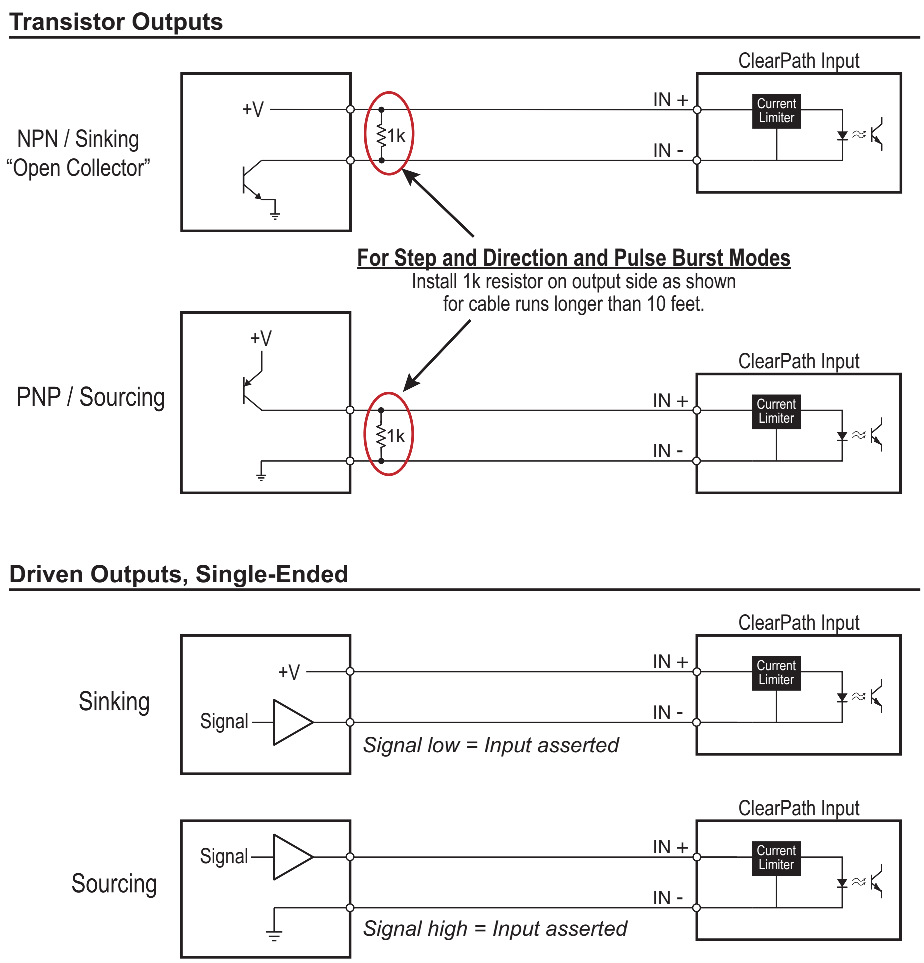
Engineer’s Note: In all ClearPath motors, the input signals are electrically isolated from the DC power bus and motor output circuits, as

[2] **Exception:** when ClearPath is set to “Spin on Power Up” mode, the motor shaft can move as soon as main DC power is applied, regardless of the state of the Enable Input. ClearPath motors never ship configured in this mode.

well as from the motor case. This design feature ensures that control signals will not be compromised due to induced currents from the motor, power supply, or other sources of common mode noise or ground loops.

INPUT WIRING

ClearPath inputs are compatible with standard digital output formats including open collector transistor, and driven outputs from PLCs, sensors, signal generators, microcontrollers and more.



Interfacing digital outputs to ClearPath Inputs

Engineer's Note: 5V differential outputs are not directly compatible with ClearPath I/O because differential drivers' guaranteed output voltage swing is typically not guaranteed to meet the ClearPath input minimum input voltage requirements.

While differential drivers may work initially, they may fail over time as the environment changes, i.e. the motor heats up, components age, and so forth. This can result in erratic operation that is difficult to debug.

OVERVIEW: THE CLEARPATH OUTPUT (HLFB)

ClearPath has one, user settable, multi-purpose, digital output called the HLFB Output (HLFB stands for High-Level Feedback).

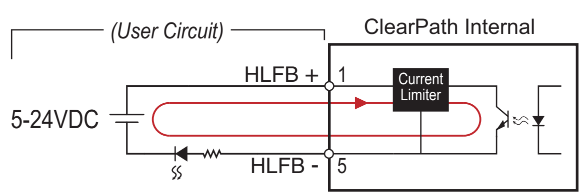
HLFB can provide one of several types of motion-related feedback to your PLC, microprocessor, or other device. Even a simple resistor and LED can be hooked to the HLFB output to create a quick visual indicator.

The HLFB can be used to signal:

- If the servo drive is enabled or in a shutdown (Servo On)
- When the commanded move is complete and settled to your specifications (ASG-Position)
- How well the motor is following your positioning or velocity commands (In Range)
- Motor speed, via PWM output (Speed Output)
- Motor torque, via PWM output (Torque Output)

HLFB is configured by connecting your ClearPath motor to MSP and navigating to the *Advanced> High-Level Feedback* drop down menu.

Note: The HLFB circuit is not internally powered; it requires an external 5–24VDC power supply capable of sourcing/sinking at least 1mA, non-inductive. In typical HLFB applications, power is supplied by the PLC, control board, or an external supply. See Appendix D for complete HLFB specifications.



High-Level Feedback circuit (shown driving a LED)

HLFB OUTPUT MODES

Note: Not all HLFB modes are available in all ClearPath op modes. HLFB modes will appear grayed out on the menu if unavailable.

SERVO ON

In Servo On mode, the HLFB output asserts (conducts) when ClearPath is enabled and not in a shutdown state. This signal is often used to monitor ClearPath for shutdowns or as the control signal for an external brake.

ASG (ALL SYSTEMS GO)

This HLFB mode is actually three modes (it automatically changes function based on the ClearPath operational mode your motor is running in).

For example, if you were using a ClearPath positioning mode, such as *Move to Incremental Position*, and you selected All Systems Go(ASG) from the HLFB menu, the HLFB output would automatically be set to **ASG-Position** (described below). If you were using a velocity mode, HLFB would be set to **ASG-Velocity**, and if you were in a torque mode, HLFB would be set to **ASG-Torque**.

ASG-POSITION

ASG-Position mode is typically used as a “move done” signal. In this mode, the HLFB output asserts (conducts) when ClearPath is enabled *and* settled within X counts of the target position, for at least Y milliseconds (you set X and Y in MSP via the Move Done Criteria dialog).

ASG-VELOCITY

ASG-Velocity mode signals when ClearPath has reached commanded peak velocity. In this mode, the output asserts (conducts) when ClearPath is enabled *and* running within a tolerance band of the commanded velocity[3]. This output can be used to signal when a conveyor or rotary tool has reached full operating speed. Note: HLFB is de-asserted during periods of acceleration and deceleration (i.e., when not at speed).

ASG-TORQUE

In ASG-Torque mode, the HLFB output asserts (conducts) when the ClearPath is enabled and motor torque is within a tolerance band of commanded torque.

SPEED OUTPUT

In Speed Output mode, HLFB outputs a 45 Hz PWM waveform whose duty cycle varies in proportion to actual motor speed. This signal can be used as the input to a simple speedometer or tachometer. Note: The user

[3] In All Systems Go-Velocity mode, the output asserts when actual motor velocity is within +/- 3% of the commanded velocity or within 24RPM of the commanded velocity, whichever value is greater.

must supply an appropriate device or circuit to read/interpret the PWM output signals.

IN RANGE

The HLFB In Range mode signals when the motor shaft is within a user-defined range of the commanded position or commanded velocity. This mode is available in positioning or velocity op modes and changes automatically based on the ClearPath op mode you are currently using.

In Range-Position

You must be in a ClearPath positioning mode and select **In Range** from the HLFB menu. During operation, the HLFB output asserts when actual motor position is within X counts of commanded position. You set the X value (i.e., the range) via the *Advanced>MoveDone Criteria* dialog in MSP.

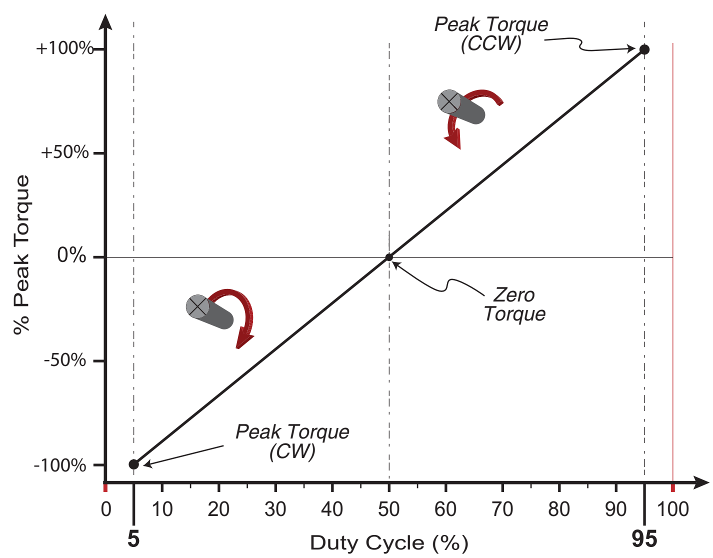
In Range-Velocity

You must be in a ClearPath velocity mode and select **In Range** from the HLFB menu. During operation, HLFB asserts when actual motor velocity is within X% of commanded velocity. You set the X value (range) via the *Advanced>MoveDone Criteria* dialog in MSP.

TORQUE

In this mode, the HLFB output produces a 45Hz PWM waveform that varies in duty cycle between 5% and 95% to indicate direction and magnitude of motor shaft torque as follows:

- 5% duty cycle = 100% peak torque, CW direction
- 50% duty cycle = zero torque
- 95% duty cycle = 100% peak torque CCW direction



HLFB Torque: Graph of PWM duty cycle vs. Peak Torque

TORQUE/ASG

The HLFB output produces a 45Hz PWM waveform that varies in duty cycle between 5% and 95% to indicate direction and magnitude of motor shaft torque as follows (previous diagram applies):

- 5% duty cycle = 100% peak torque, CW direction
- 50% duty cycle = zero torque
- 95% duty cycle = 100% peak torque CCW direction

In addition:

- The output asserts (100% "on") when the motor meets ASG conditions (based on current ClearPath op mode).
- If the motor gets a shutdown, or is disabled, HLFB de-asserts (100% "off").

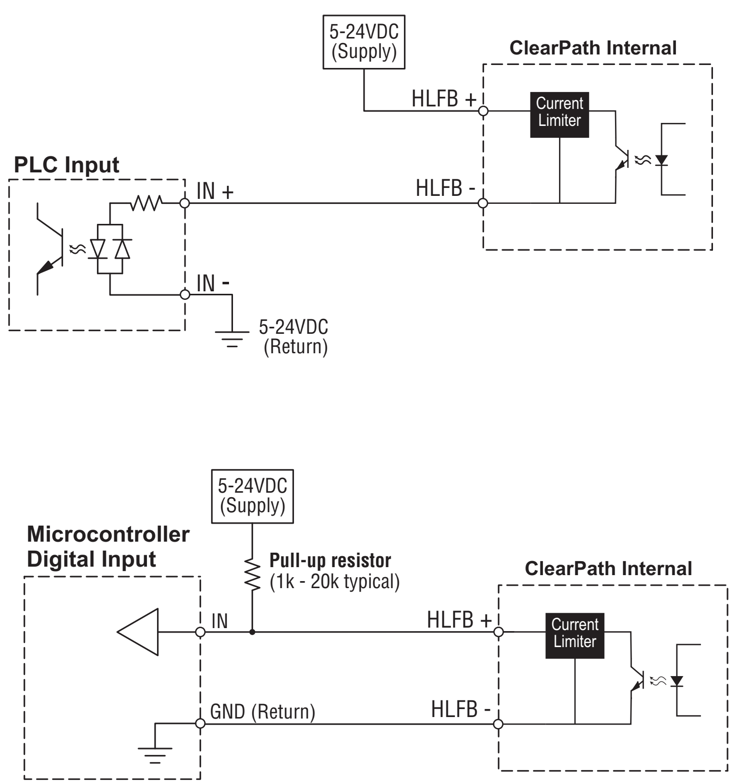
Tech Note: HLFB and Signal Noise

In most applications, the machine controller either samples the HLFB binary signal, or, when HLFB is set as a PWM output, filters it and reads it as an analog signal. If, however, in your system, you plan to use a digital timer to directly measure the duty cycle of the HLFB signal, it is possible that the common mode noise rejection of the opto-coupler used in the HLFB output circuit, and the high impedance of the HLFB output when it is off, will cause your controller to experience noise as the HLFB output transitions.

If you experience this problem, there are several possible remedies: (1) use a low value pull-up, e.g., a 2k ohm resistor is recommended in a 5V system; (2) Use a Schmitt trigger input to read the HLFB output; (3) turn on I/O pin digital filtering (available in some microprocessors); (4) construct a non-linear filter in software to remove any unreasonable readings.

HLFB OUTPUT WIRING EXAMPLES

HLFB Output Wiring Examples



Tips on microcontroller inputs

- Check your microcontroller documentation to see if the inputs already have internal pull-up resistors before adding an external pull-up. Most Arduinos, for example, let you "turn on" or "turn off" internal pull-up resistors with a simple line of code. See link below for more information on Arduino inputs.

- To learn more about pull up resistors and digital circuits, Google search: *pull up resistor for digital input*.

Arduino on the Web

For more information related to Arduino digital inputs and pull-up resistors, check out the following link:

https://www.arduino.cc/en/Tutorial/DigitalPins

SOFTWARE (CLEARPATH MSP)

SECTION OVERVIEW

This section includes information on the following topics:

- ClearPath MSP System requirements
- Installing ClearPath MSP software
- Communicating with ClearPath
- Tour of ClearPath MSP
- Overview of ClearPath advanced features

MINIMUM SYSTEM REQUIREMENTS

Operating System:	Win 7, 8.1, 10
Processor:	1 GHz or faster
Memory:	512 MB
HD Free Space:	512 MB
Monitor:	1280 x 1024 pixels or higher
Other:	Sound card with speakers (optional)

INSTALLING MSP

Launch the MSP installer and follow the on-screen prompts. Please contact Teknic if you have problems with software installation.

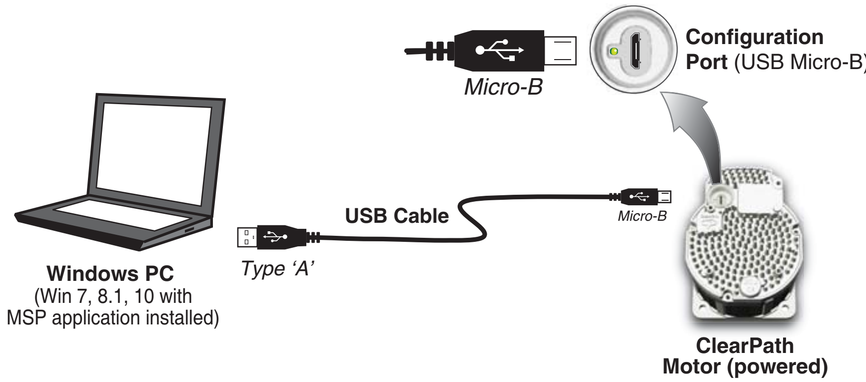
COMMUNICATING WITH CLEARPATH

After ClearPath MSP is installed on your PC, follow the directions below to establish a communication link between your ClearPath and PC.

Note: Establishing a ClearPath communication link is required for setting operational modes, defining move parameters and options, tuning the motion system, and using the MSP Scope to analyze system performance.

ITEMS REQUIRED FOR COMMUNICATION SETUP

- A ClearPath motor
- A DC power supply (24–75VDC nominal) and cables
- A PC running Windows 7, 8.1, 10 with ClearPath MSP installed
- A USB cable (Type A to Micro-B)



ClearPath Communication Setup

FIRST-TIME COMMUNICATION SETUP

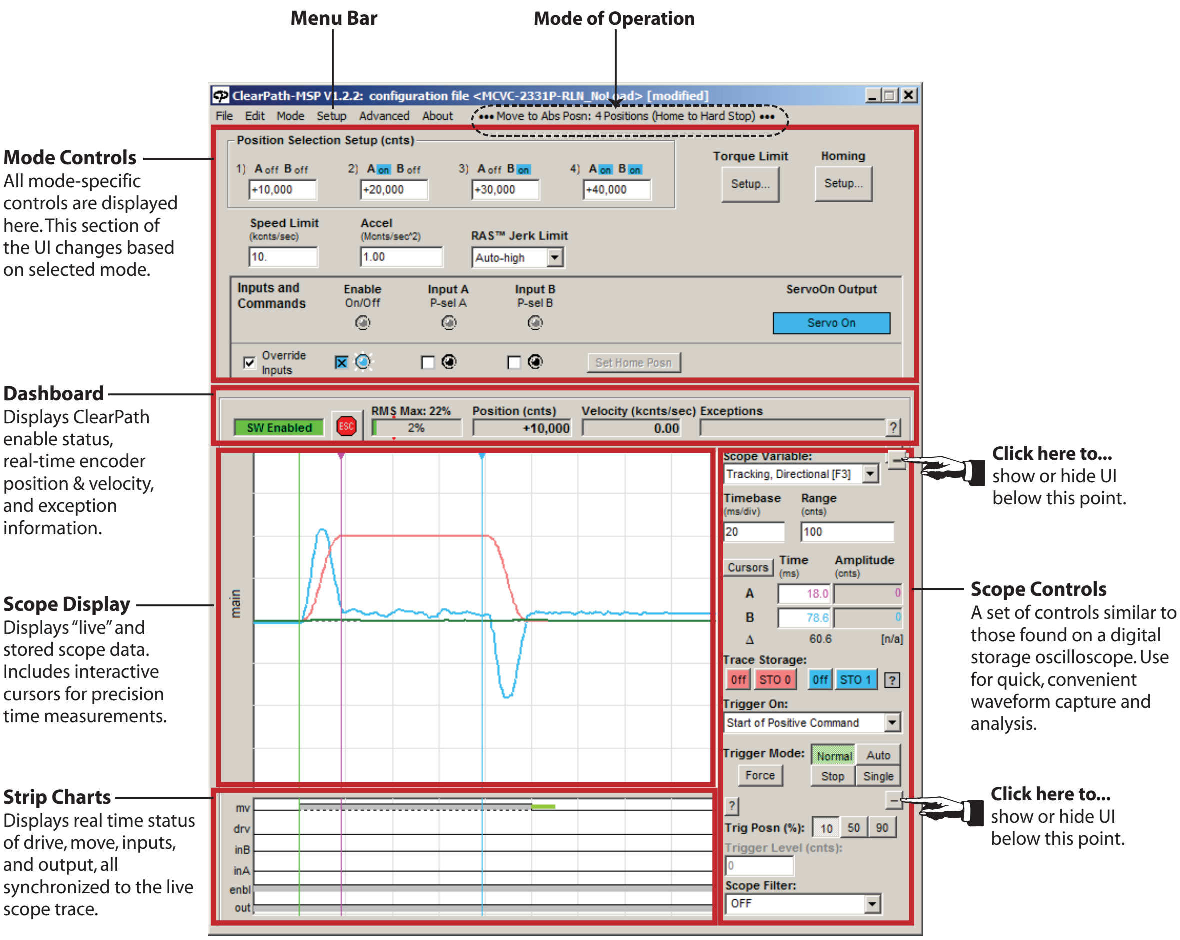
1. **Install MSP** software on a qualified Windows PC. See previous page for Minimum System Requirements.
2. **Power up ClearPath.** Apply 24-75VDC to the power input connector. Note: A lab power supply can be used for basic communication and *low power, low speed* testing.
3. **Connect ClearPath to your PC** with a USB Type A to Micro-B cable. Use a high quality cable.
4. **Wait!** In most cases Windows will detect the connected ClearPath and install the correct USB driver software automatically. This step can take a few minutes to complete. Proceed only after Windows reports the device is installed and ready for use.
5. **Launch MSP** software by double clicking the desktop icon or selecting from the Programs menu: Teknic>ClearPath MSP> ClearPath MSP Setup Program.

Communication Notes

- MSP can communicate with only one ClearPath at a time.
- Before tuning a ClearPath, the motor must be powered up, connected to a PC running MSP, and enabled.
- The host PC can be disconnected after configuration and tuning are complete. And, while ClearPath does not need a PC connection during normal operation, you *can* connect your ClearPath to a PC at any time to use MSP for manual control, system analysis, diagnostic and troubleshooting tasks.

TOUR OF CLEARPATH MSP SOFTWARE

MAIN UI OVERVIEW



ClearPath MSP User Interface

MODE CONTROLS

The Mode Controls section is the user input area of MSP. This part of the UI changes based on the mode of operation selected. The Mode Controls are used to:

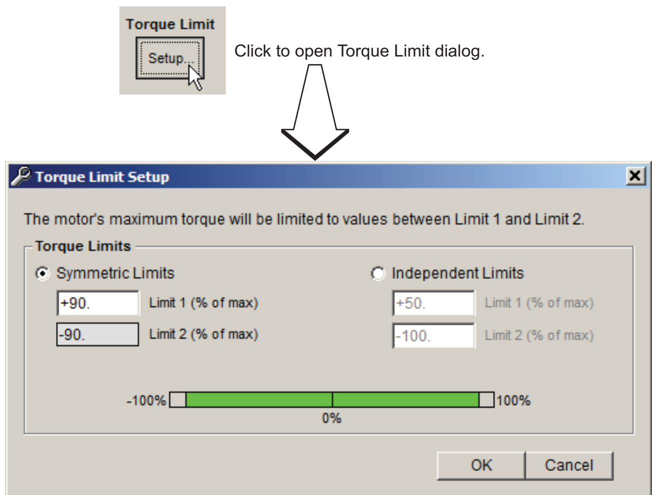
- **Enter motion parameters and settings** related to the currently selected mode, including position, acceleration, velocity, torque, and homing parameters.
- **Access Soft Controls.** Soft Controls allow you to spin your ClearPath with no hardware inputs connected. With just MSP and a powered up ClearPath, you can enable the motor, turn the inputs on and off, command motion, and monitor the output state. Soft Controls are designed for configuration, testing, and troubleshooting tasks.

- **Set optional homing parameters**. Because homing settings vary from mode to mode, homing is discussed in each operating mode section later in this manual.
- **Set Torque limits.** The Torque Limits dialog is explained in greater detail below.

Torque Limit Setup

The Torque Limit Setup allows you to set the maximum amount of torque that your motor is able to apply in either or both directions of travel. Click the Torque Limit Setup button to open a dialog window like the one shown below.

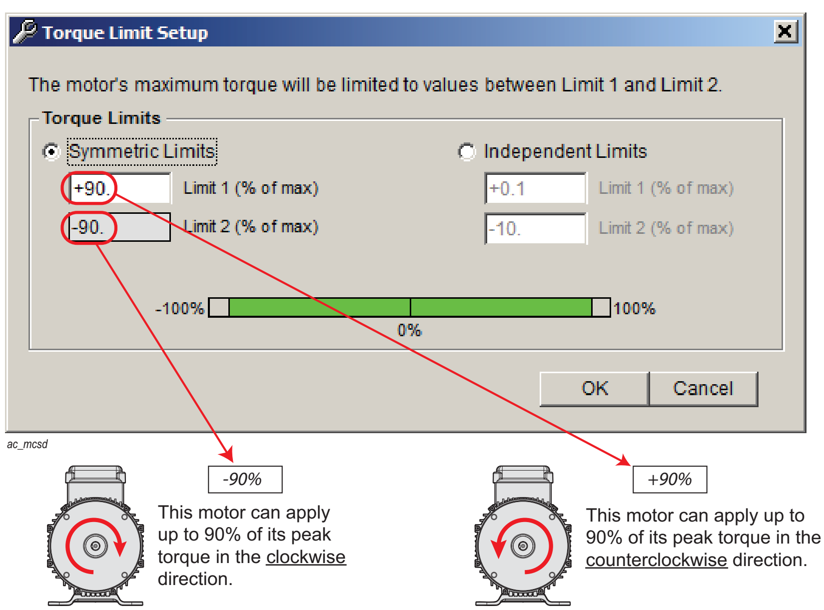
Note: By ClearPath convention, a plus (+) sign denotes torque applied in the counterclockwise direction (looking into the motor shaft). A minus (-) sign denotes torque applied in the clockwise direction.



Torque Limit Setup dialog window

Symmetric Torque Limits

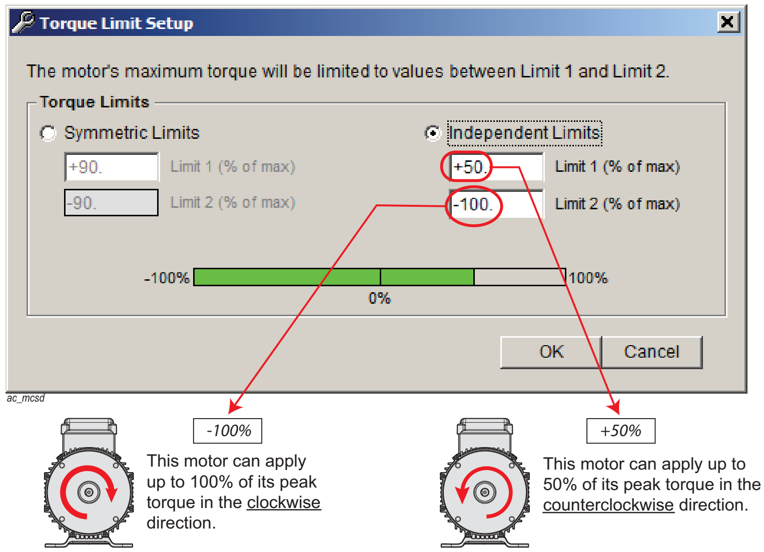
Select "Symmetric Limits" and enter a single value (90% in the example above). Click OK and torque is effectively capped at 90% of the motor's peak torque in both the CW and CCW directions of travel.



Symmetric torque limits

Independent Torque Limits

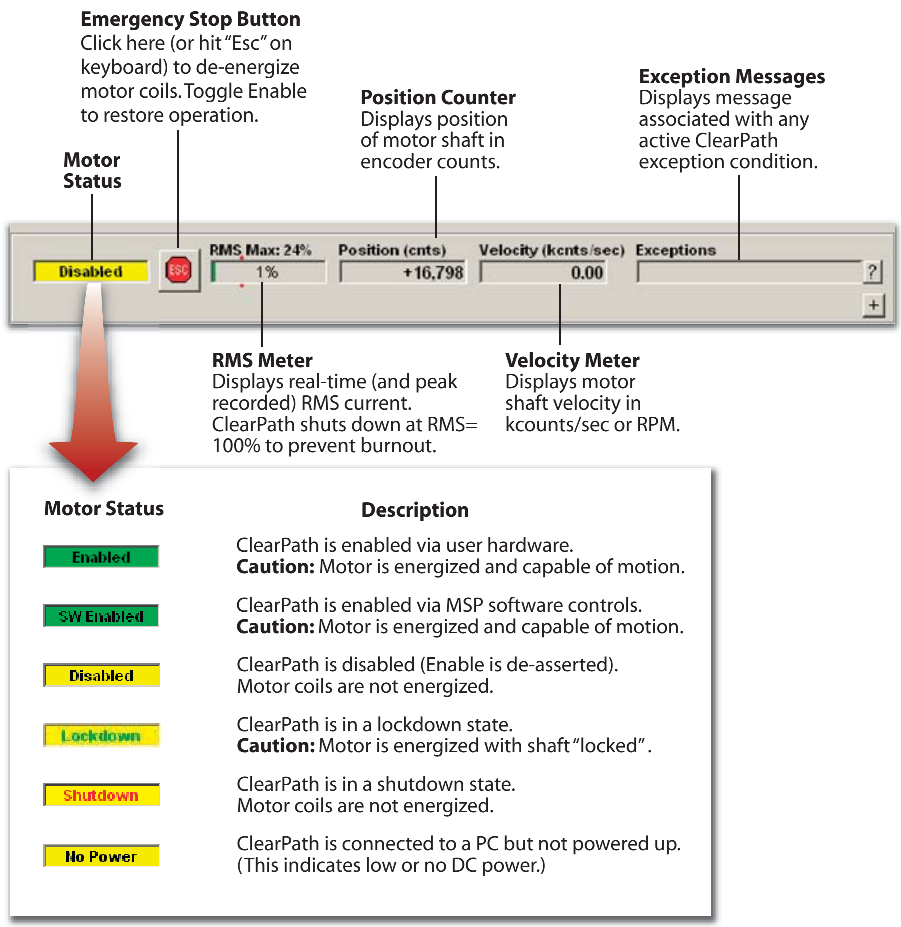
Select "Independent Limits" if you need to set a different torque limit for each direction of travel.



Independent torque limits

DASHBOARD

The Dashboard section of the UI contains various gauges and readouts related to your ClearPath motor's performance and operational status.



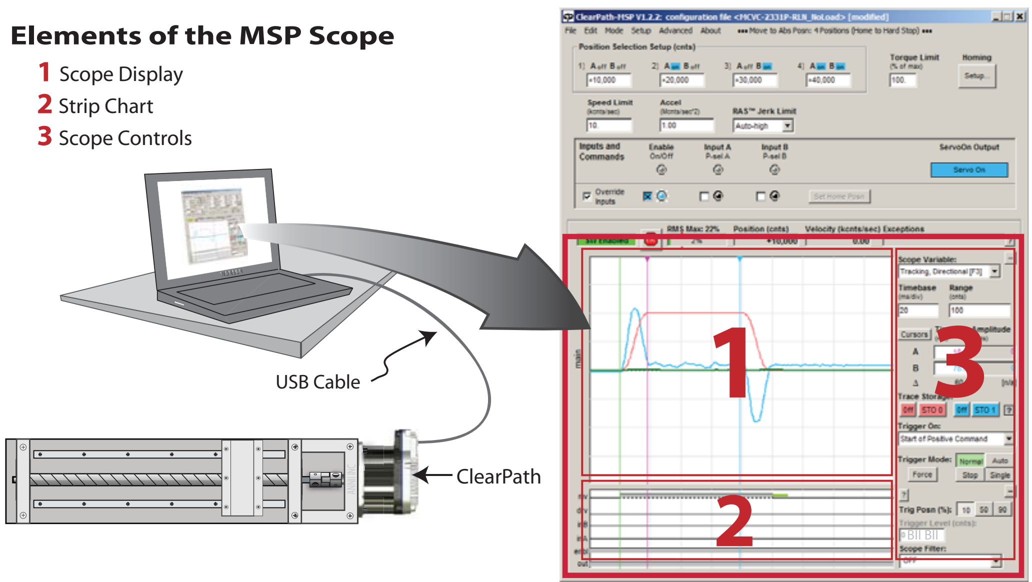
MSP Dashboard

MSP Scope

OVERVIEW

The MSP Scope takes real-time streaming data from ClearPath and plots it on the Scope Display to provide a dynamic picture of motor performance. The scope can be used to display your motor's current torque output, tracking error, commanded velocity, acceleration, and more. Feedback from the scope is critical for motor tuning, servo gain refinement, and in the analysis and troubleshooting of electrical, mechanical, and motion-related problems.

The MSP Scope consists of three main sections: the Scope Display (1), Strip Chart (2), and Scope Controls (3). These components, taken together, emulate much of the functionality of a digital storage oscilloscope and data analyzer.



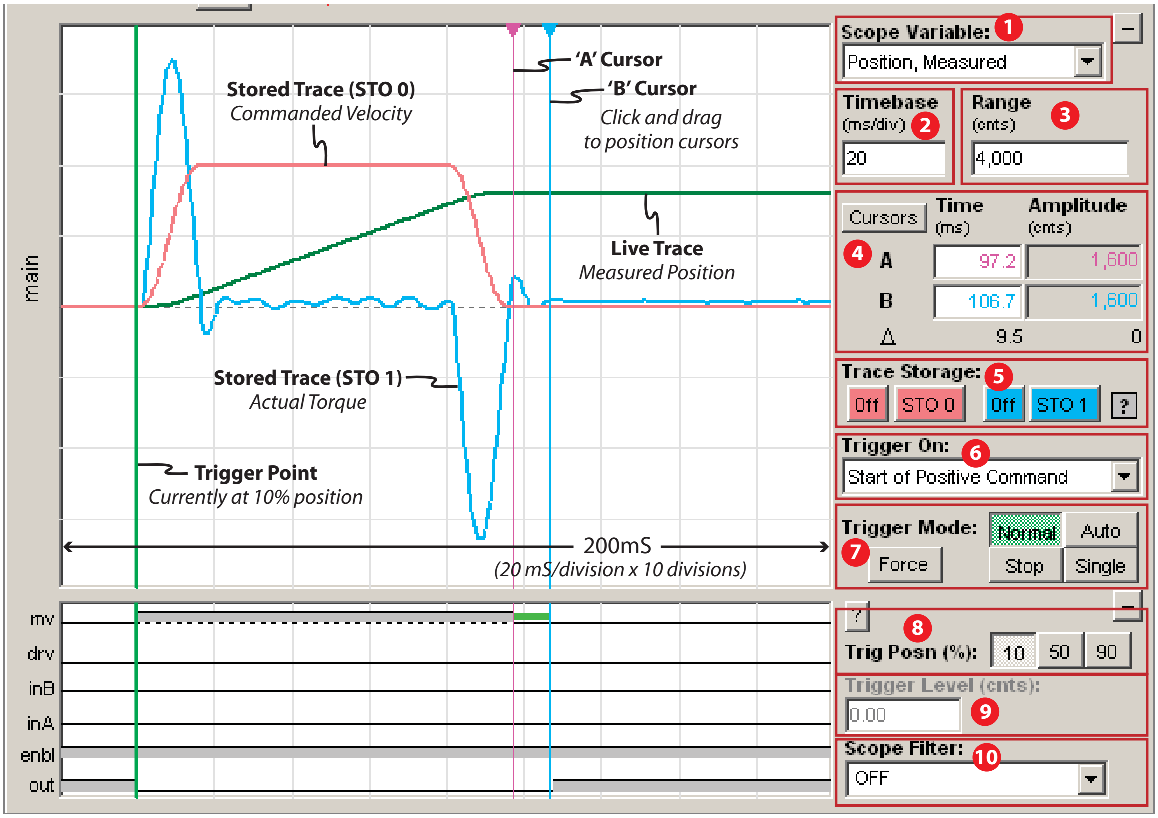
MSP Scope Overview

SCOPE FEATURES

- 14 scope variables.
- Four trigger modes.
- Adjustable time base, range, and trigger position.
- Two stored traces + one live trace.
- Twelve trigger source presets.
- Click-and-drag cursors for precise time and amplitude measurements.
- Strip Charts that conveniently display synchronous move, drive, and I/O event timing.

SCOPE DISPLAY AND SCOPE CONTROLS

The MSP Scope display is modeled after that of a typical hardware oscilloscope; as such, it has 10 major vertical divisions on the time axis and 8 major horizontal divisions on the amplitude axis.



MSP Scope

1 The Scope Variable drop down menu lets you select any of 12 ClearPath motion control variables to display. These variables include Tracking Error, Commanded Velocity, Actual Torque, Actual Velocity, Velocity Error, Commanded Torque, SGN (sign of velocity), Measured Position, Commanded Jerk, Commanded Acceleration, Max Phase Voltage, and Torque Error.

2 The Timebase text box lets you adjust the scale of the time axis (think Cartesian X-axis) in units of mS/division. This allows you to control how a waveform fits horizontally on the Scope Display. For example, if the Timebase is set to 20mS per division (as in the figure above) the full horizontal range of the scope is 200mS (10 divisions x 20mS/division).

3 The Range text box lets you change the scale of the amplitude axis (think Cartesian Y-axis). This allows you to control how a waveform fits vertically on the Scope Display. For example, in the figure above the green trace represents Measured Position and the Range is set to 4000 counts. This means the center horizontal line represents 0 counts, the top horizontal line represents (+)4000 counts, and the bottom line represents (-)4000 counts.

4 Cursor controls allow you to drag the two vertical cursors around on the main scope display and view time and amplitude measurements in real time. The delta function automatically displays the difference between cursor values.

5 **Trace Storage controls** allow you to save and display two traces on the scope display. Just capture a waveform and click either the STO0 or STO1 button (Storage 0 and Storage 1). The selected trace is then stored and displayed in either pink (STO0) or blue (STO 1). Hide or show either stored trace by clicking its associated On/Off button.

6 **The Trigger Source ("Trigger On")** drop down menu lets you choose what condition(s) must be met before scope data collection begins (is triggered). The following Trigger Source options are available:

If Trigger Source is set to:	MSP Scope will:
Start of Positive Command	Trigger at the start of any positive move; useful for tuning.
Start of Negative Command	Trigger at the start of any negative move; useful for tuning.
Start of Any Command	Trigger at the start of any move (positive or negative); useful for assessing bi-directional tuning performance.
End of Positive Command	Trigger at the end of any positive move; useful for assessing settling performance.
End of Negative Command	Trigger at the end of any negative move; useful for assessing settling performance.
End of Any Command	Trigger at the end of any move (positive or negative); useful for assessing bi-directional settling.
End of Positive Settled Move	Trigger at the end of any positive move after Move Done criteria are met; useful for assessing settling performance.
End of Negative Settled Move	Trigger at the end of any negative move after Move Done criteria are met; useful for assessing settling performance.
End of Any Settled Move	Trigger at the end of any move (positive or negative) after Move Done criteria are met; useful for assessing settling performance.
Voltage/Torque/Speed Limit	Trigger on first occurance of saturation (voltage *or* torque) or upon speed limiting; useful for determining which moves (or segments of moves) exceed these thresholds.
Drive Shutdown or Exception	Trigger on the assertion of an exception or safety shutdown; useful for determining the operational status at the time of a fault.
Rising Slope	Trigger on the rising edge of the active waveform.
Falling Slope	Trigger on the falling edge of the active waveform.

7 **Trigger Mode** settings allow you to select exactly when data acquisition begins and ends. These controls are analogous to the trigger modes found on a digital storage oscilloscope.

- **Normal -** Causes scope data collection to occur whenever a valid trigger source is detected.
- **Single -** Works the same as *Normal* mode, except it captures only a single data set when a valid trigger source is detected.

After the single sweep capture, data collection automatically stops.

- **Auto -** This is the rolling, "always on" setting. Data is continuously collected, refreshed, and displayed regardless of the trigger source settings.
- **Force -** Forces the scope to trigger immediately, regardless of trigger source setting. As with Single mode, only one data set is collected and displayed; then data collection stops.
- **Stop** – Causes scope data collection to stop. It does *not* clear previously captured data from the scope display.

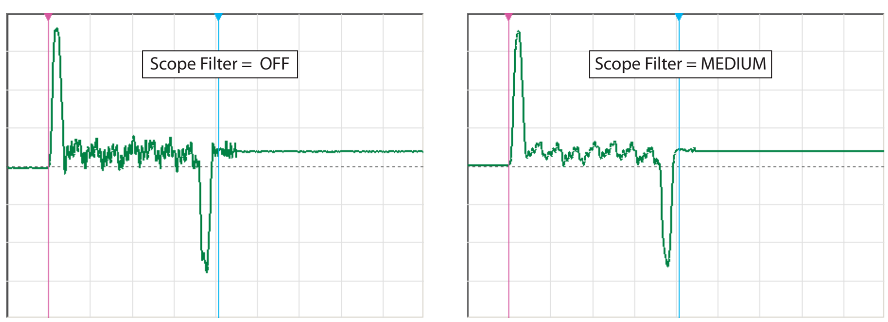
8 **Trigger Position** buttons allow you to position the trigger point on the left (10%, as shown in the previous figure), middle (50%), or on the right side (90%) of the scope display grid. This is useful for viewing events on the scope that occur before, during, or after the trigger point.

9 **The Trigger Level** lets you select the amplitude at which the scope will trigger.

Note: Trigger Level can only be used when Trigger Source is set to "Rising Slope" or "Falling Slope".

Tip: Use Trigger Level when the Trigger Mode is set to "Normal" or "Single" to facilitate waveform display at a fixed trigger point.

10 **The Scope Filter** "cleans up" or smoothes the appearance of the displayed trace by removing higher frequency data content. This has an averaging effect on the displayed waveform that can help mitigate the effect of noise (or just unnecessary visual clutter) on the displayed signal.



Effect of Scope Filter on trace display

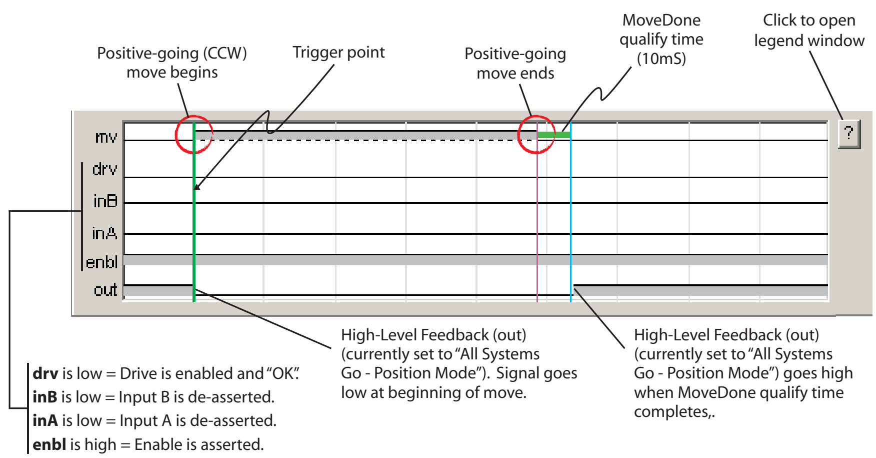
Note: The Scope Filter has no effect on motor performance. *It changes only how scope data is displayed*.

Note: Higher filter setting may filter out meaningful data points from the display (peaks in particular).

Tip: In most cases Scope Filter can be left "OFF" or at the lowest setting.

STRIP CHART

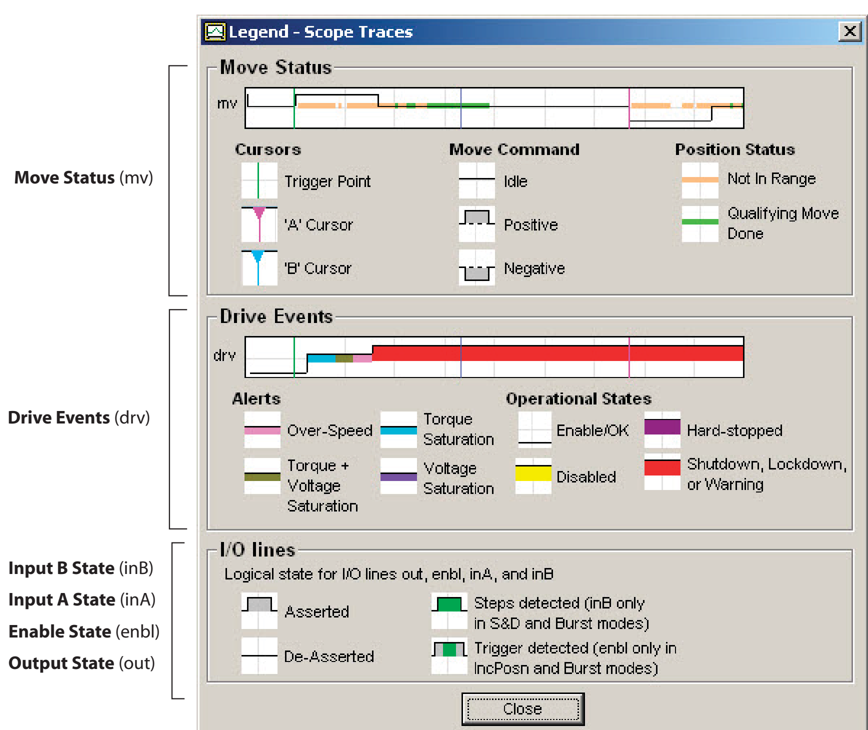
The Strip Chart can display a number of additional events and conditions that occur in sync with the primary waveform capture. Using the Strip Chart you can view move status (mv), drive events (drv), and I/O states in real time. And, because the Strip Chart display is always auto-synchronized to the main scope trace, there are no settings to deal with.



MSP Strip Chart display

Strip Chart Legend

MSP includes a helpful reference chart to help you interpret what's happening on the strip chart. To open the legend window click the ? symbol to the right of the strip chart display.



MSP Strip Chart Legend

MSP MENUS

FILE MENU

Load Configuration (Ctrl+0). Use this command to load saved ClearPath configuration files (extension .mtr) to your ClearPath.

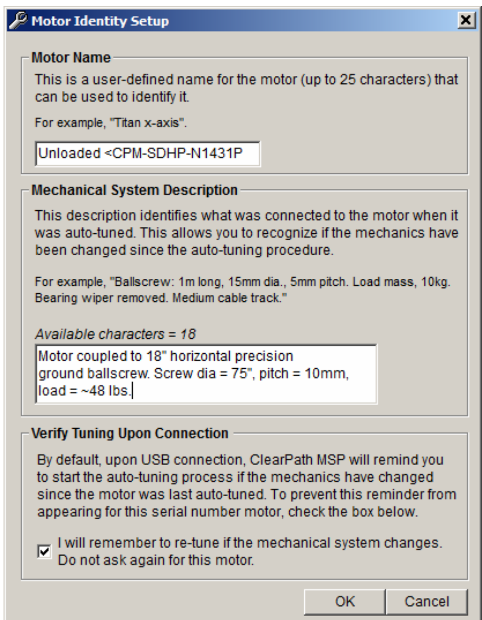
Save Configuration (Ctrl+s). Use this command to save your ClearPath configuration settings to a .mtr file.

Reset Config File to Factory Defaults. This command restores ClearPath to its factory default configuration.

EDIT MENU

Cut (Ctrl-x), Copy (Ctrl-c), and Paste (Ctrl-v) are the standard Windows Edit commands.

Motor ID. Opens a window that lets you enter a name and brief description for your ClearPath if desired.



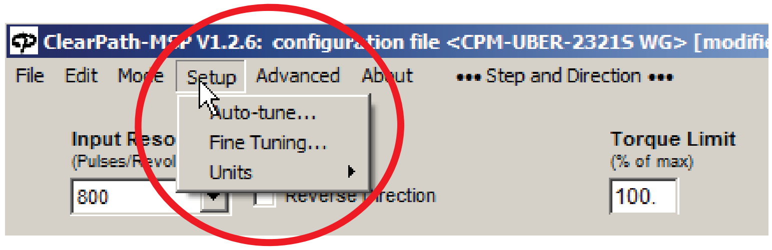
Zero Position (Ctrl+0) Sets the Position Counter to zero. Note: In certain modes, double-clicking the Position Counter directly in the UI will also zero the counter.

Reset RMS Peak Note: This applies to the RMS Meter in the Dashboard section of MSP. Click this menu item to reset *RMS Max* (this is the maximum RMS value recorded since last reset).

MODE MENU

Select ClearPath operating modes from this drop down menu. Note: number of available modes varies by model.

SETUP MENU

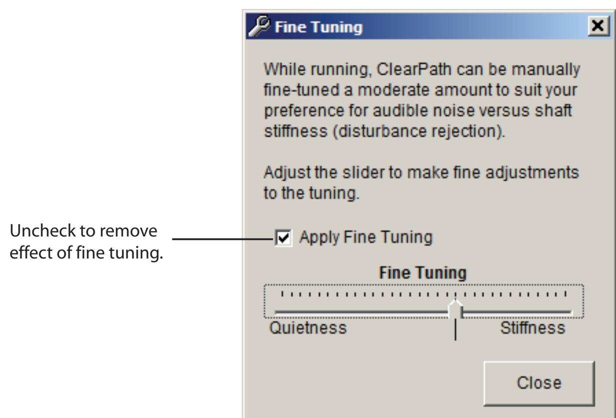


Setup Menu

Auto-tune. Select this menu item to begin an Auto-tuning session. The software is designed to walk you through the Auto-tuning process in a safe, step-by-step manner.

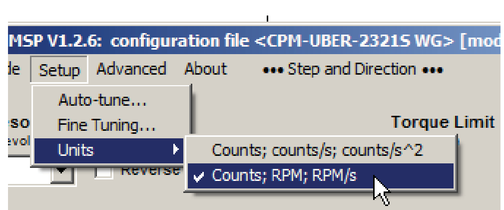
Important: To avoid personal injury, crashes, and machine damage, carefully read and follow all on-screen instructions presented during the Auto-tune process.

Fine Tuning. This menu item provides a convenient way to "touch up" tuning performance. Turn on the control by checking Apply Fine Tuning. Move the slider left for quieter performance, move it right for increased dynamic stiffness. Uncheck to turn it off.



Fine Tuning Controls

Units. Use this menu item to tell MSP which units to display for velocity and acceleration. Velocity and acceleration can be based on encoder counts or RPM. Distances are always displayed in encoder counts.



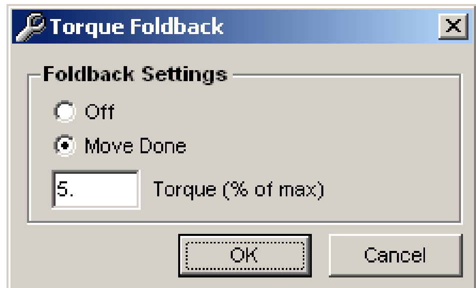
Units selection menu

ADVANCED MENU

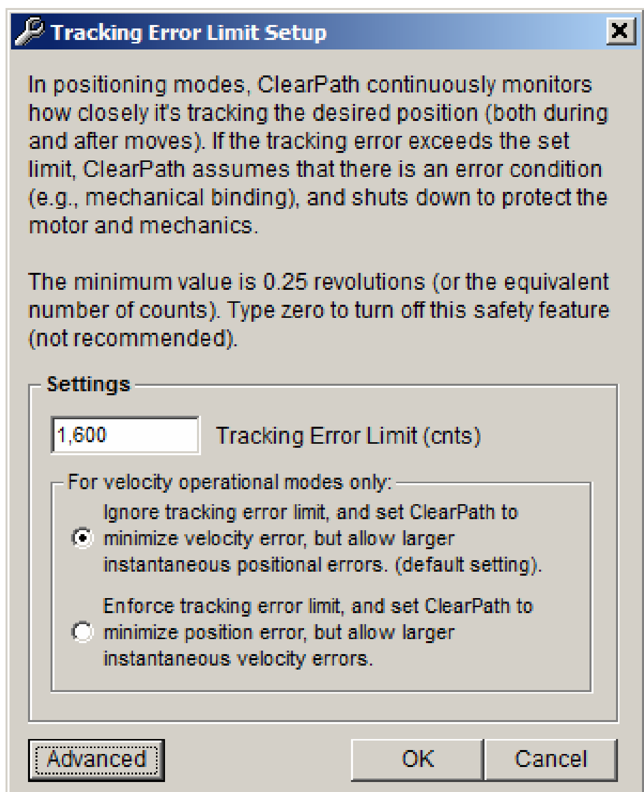
The Advanced menu gives you access to additional specialized features and settings. Advanced Menu item are listed below.

Torque Foldback

This feature automatically limits maximum available torque to the user-specified value whenever the Move Done criteria are met. See *Move Done Criteria* (next page) for details.



Tracking Error Limit



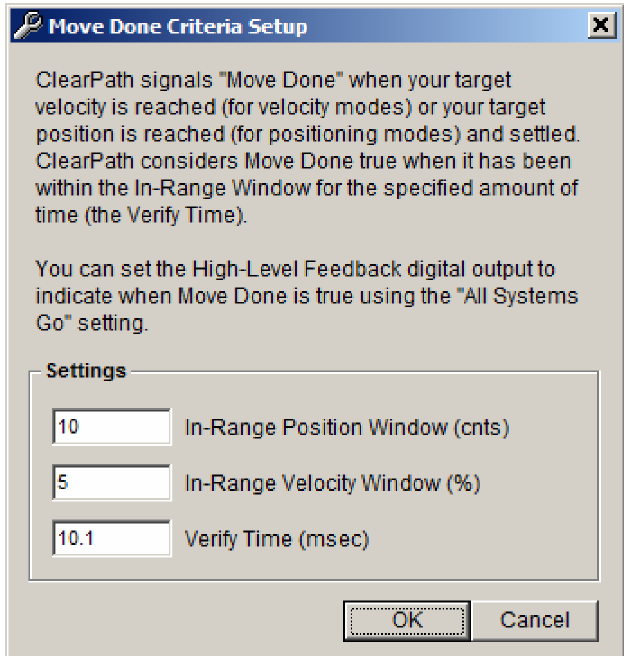
Tracking Error Limit Setup

High-Level Feedback

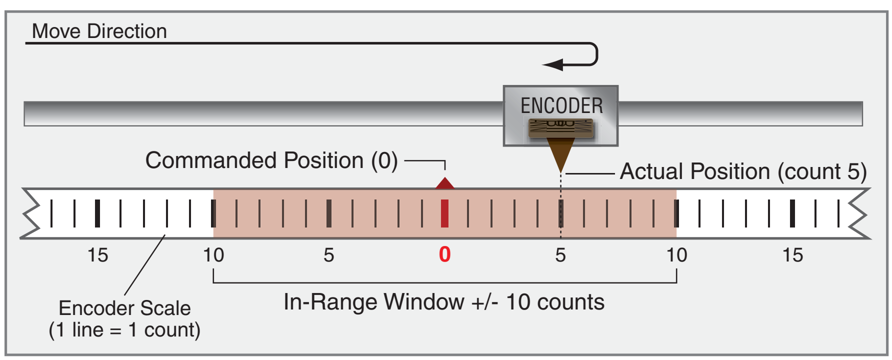
Use this to set the HLFB output mode. Refer to the chapter *Inputs and the HLFB Output* for full information.

Move Done Criteria

Move Done status is used to determine when the All Systems Go-Position signal should be asserted at the HLFB output. The Move Done Criteria consist of two parameters: the "In-Range Window" and the "Verify Time". These parameters are explained in the screen capture, taken from MSP, below.



Move Done Criteria Setup



How Move Done Works

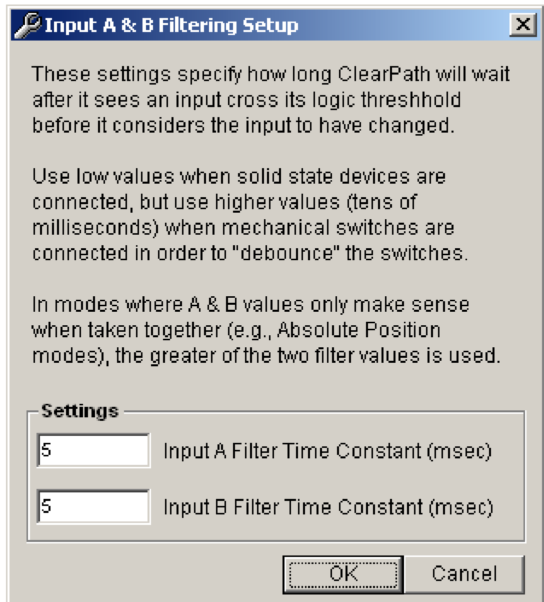
Move Done status is achieved when the Move Done criteria are met. In the above figure, Move Done occurs when the motor is within +/-10 encoder counts of the commanded position (the In-Range Window) for a minimum of 10.1 milliseconds (the Verify Time).

Note: If the encoder leaves the In-Range window during the time qualification period, the Move Done timer automatically resets. The timer will begin a fresh countdown as soon as the motor comes back in range.

Because encoder resolution, mechanical systems, and settling performance requirements vary by application, you may need to experiment a bit to determine appropriate values for the In-Range Window and Verify Time.

Input A & B Filtering Setup

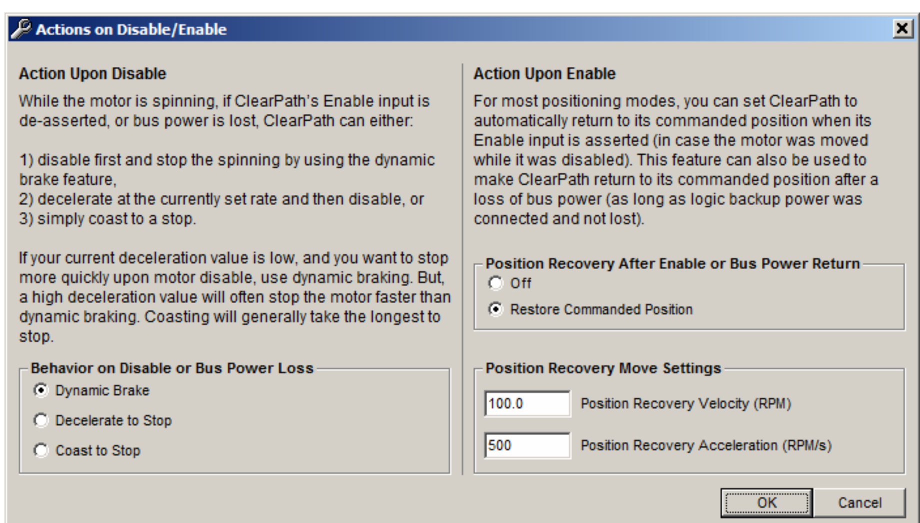
This dialog lets you independently set digital filtering for the two ClearPath inputs. This can be particularly helpful when dealing with "bouncy" mechanical switches. This feature is not selectable in Step and Direction, Pulse Burst, or for PWM modes.



Input Filtering Setup

Actions on Disable/Enable

This dialog lets you tell ClearPath whether to use dynamic braking, powered deceleration, or just coast when a disable or bus power loss event occurs. It also gives you the option of using Position Recovery feature upon enable.

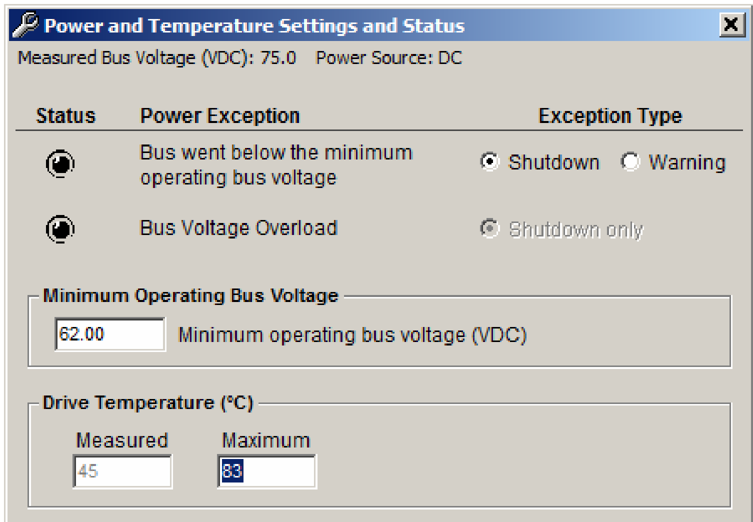


Actions on Disable/Enable

Power and Temperature Settings and Status

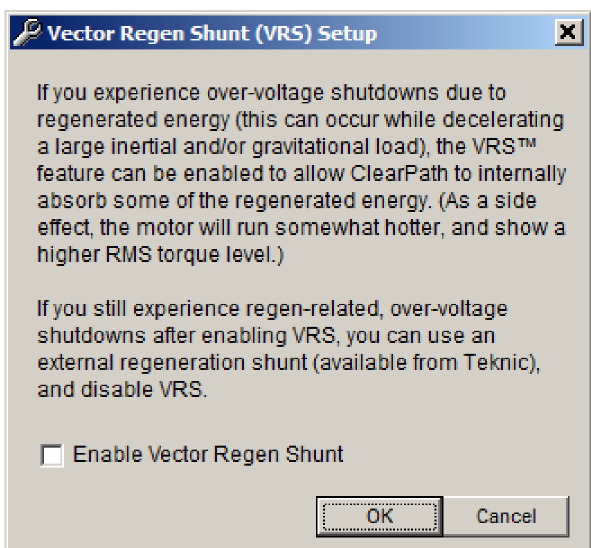
Use this dialog to:

- Define how ClearPath responds to DC bus voltage droop.
- View the temperature of your ClearPath board.
- Set the temperature threshold at which ClearPath throws an over-temperature shutdown. This should typically remain at the default setting.



Power and Temperature Settings and Status

Vector Regen Shunt (VRS) Setup



Vector Regen Shunt (VRS) Setup

Operational Modes: MCVC and MCPV

MCVC and MCPV Mode Table

Operation Mode	Model		Description
	MCVC	MCPV	
Velocity Control Modes			
Spin On Power Up	✓	✓	Just turn on power and smoothly ramp to your preset velocity. For when all you need is reliable, constant velocity from a brushless motor, and a bare minimum of wiring. It doesn't get any easier than this.
Manual Velocity Control	✓	✓	Fine control of velocity from zero to max velocity at the turn of a knob. Remembers your last set velocity or resets to zero velocity when motor is enabled.
Ramp Up/Down to Selected Velocity	✓	✓	By changing digital inputs (from your PLC, switches, etc.), ClearPath will smoothly ramp to one of four preset velocities.
Follow Digital Velocity Command Bipolar PWM Command	✓	✓	Connect a digital waveform (PWM or frequency) from your PLC or other device, and ClearPath will run at a velocity proportional to the waveform. Or, use the PWM output from an H-bridge driver of a brushed motor setup and ClearPath becomes a high-performance drop-in replacement.
Follow Digital Velocity Command Bipolar PWM Command with Variable Torque	✓	✓	
Follow Digital Velocity Command Unipolar PWM Command	✓	✓	
Follow Digital Velocity Command Frequency Command	✓	✓	
Torque Control Modes			
Follow Digital Torque Command Bipolar PWM Command	✓	✓	ClearPath will apply a variable torque (or force or tension) in proportion to a digital command (PWM or frequency) supplied to the inputs.
Follow Digital Torque Command Unipolar PWM Command	✓	✓	
Follow Digital Torque Command Frequency Command	✓	✓	
Position Control Modes			
Move to Sensor Position	✓	✓	Use ClearPath digital inputs to spin the shaft CW or CCW. Wire your position sensors or switches in series with the inputs to make an inexpensive, precision two position actuator.
Move to Absolute Position (2 Positions)	✓	✓	Command ClearPath to move to one of two preset locations. Perfect for replacing air cylinders that move between two positions.
Move to Absolute Position (4 Positions)	✗	✓	Command ClearPath to move to one of four preset locations. Perfect for replacing air cylinders where more power and finesse is needed, and in cases where you want to move to more than two positions.
Move Incremental Distance (2 Distances)	✗	✓	Trigger ClearPath to move a user-defined distance (one of two) from its current position. You can also send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any of its user-defined distances in one smooth move.
Move Incremental Distance (4 Distances)	✗	✓	Trigger ClearPath to move a user-defined distance (one of four) from its current position. You can also send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any of its user-defined distances in one smooth move.
Pulse Positioning Mode			
Pulse Burst Positioning	✗	✓	Use a timer/counter on your PLC (or a simple circuit) to send a burst of pulses to ClearPath, and it will move a distance proportional to the number of pulses sent, at your preselected velocity and acceleration. This mode gives you most of the flexibility of a "step & direction" motion controller without the cost and added complexity.

SPIN ON POWER UP

Available on
MCVC + MCPV

MODE SUMMARY

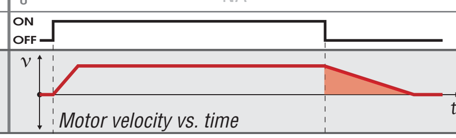
This is ClearPath's simplest mode of operation. Just turn on power and ClearPath smoothly ramps to your preset velocity. Use this mode for applications that require reliable constant velocity and a bare minimum of wiring.

HOW IT WORKS

Apply main DC power and ClearPath immediately ramps up to your target velocity (target velocity and acceleration are defined by the user during setup). ClearPath spins at the target velocity until power is removed. All inputs are ignored, but the output (High-Level Feedback) is functional.

Note: When power is removed, ClearPath may stop abruptly or coast a short distance depending on the application and motor winding configuration. Carefully test your loaded ClearPath application for stopping behavior before deploying.

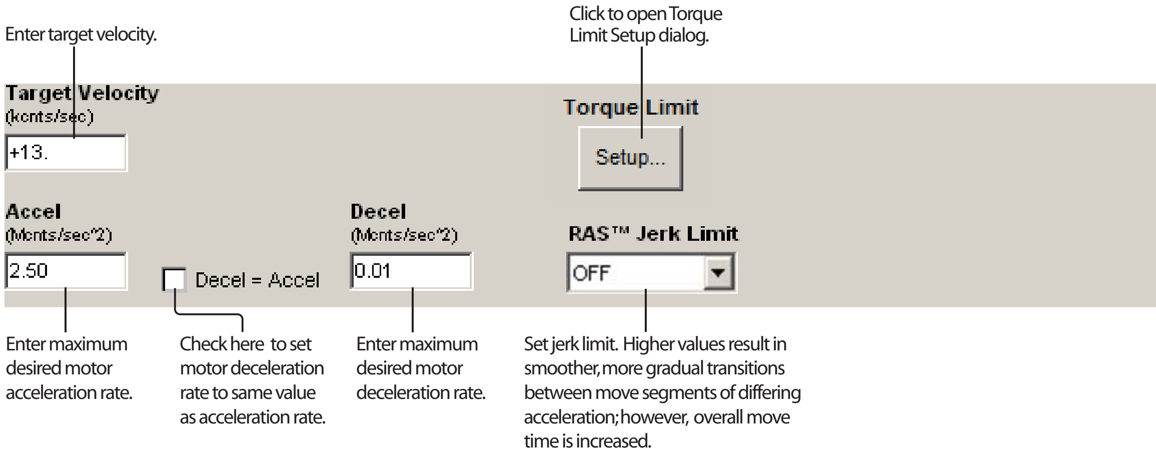
Velocity Control Spin On Power Up

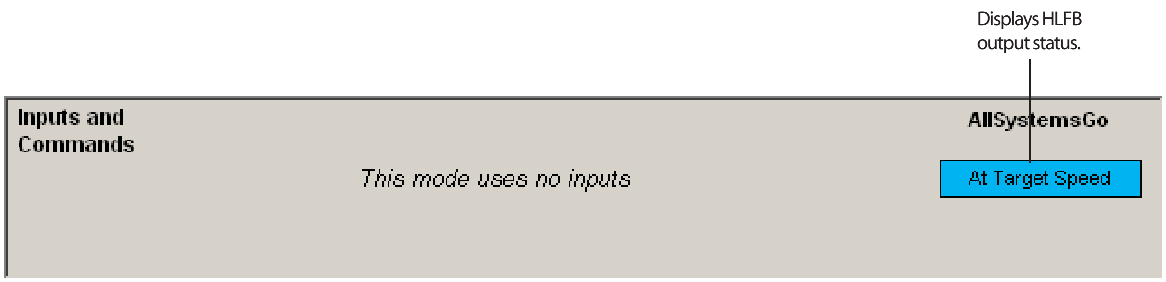
Signal	Function	Input Type	Example Timing
Input A	Disabled	NA	NA
Input B	Disabled	NA	NA
Enable	Disabled	NA	NA
Main DC Power			ON / OFF
Caution! Motor shaft may spin as soon as main DC power is applied. **Notes:** All inputs are ignored in this mode. High-Level Feedback is available. Motor will free-wheel when DC power is removed, unless external braking force is applied. Motor may stop abruptly depending on load conditions.			

Motor free-wheeling

Spin-On-Power-Up Mode: Inputs and Timing Diagram

MODE CONTROLS





MANUAL VELOCITY CONTROL

Available on
MCVC + MCPV

MODE SUMMARY

This mode offers fine velocity control from zero to a user defined maximum at the turn of a quadrature output device (such as a quadrature output encoder). Turn in one direction to increase CW motor velocity; turn in the other direction to increase CCW velocity. When enabled, ClearPath can either resume running at its last set speed *or* start at zero speed (and stay at zero speed until commanded to move).

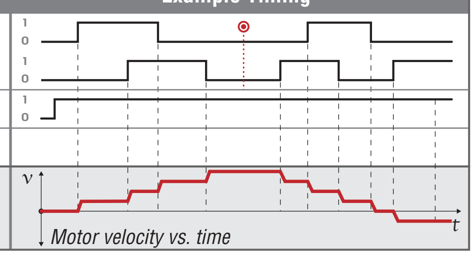
HOW IT WORKS

Assert the Enable Input to energize the motor. Then, control motor velocity by sending quadrature signals to ClearPath Inputs A and B. Each quadrature signal transition (or "tick") received by ClearPath causes an incremental increase or decrease in motor velocity, depending on which direction the encoder is turned (i.e. whether phase A leads B or B leads A).

Velocity Control **Manual Velocity Control**

Signal	Function	Input Type
Input A	Velocity Control A	Quadrature
Input B	Velocity Control B	Quadrature
Enable	Enable	Logic: High=Enable Low=Disable
Trigger	NA	NA
Notes:		

Example Timing



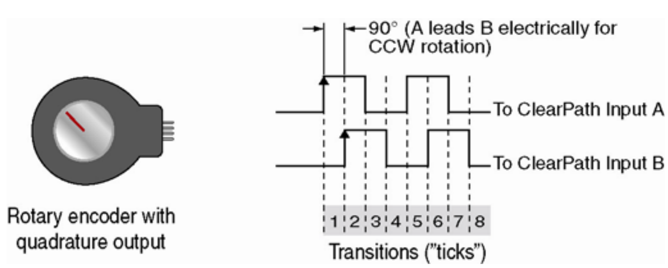
Manual Velocity Control: Inputs and Timing Diagram

Notes:

- Disable time = 10 mS

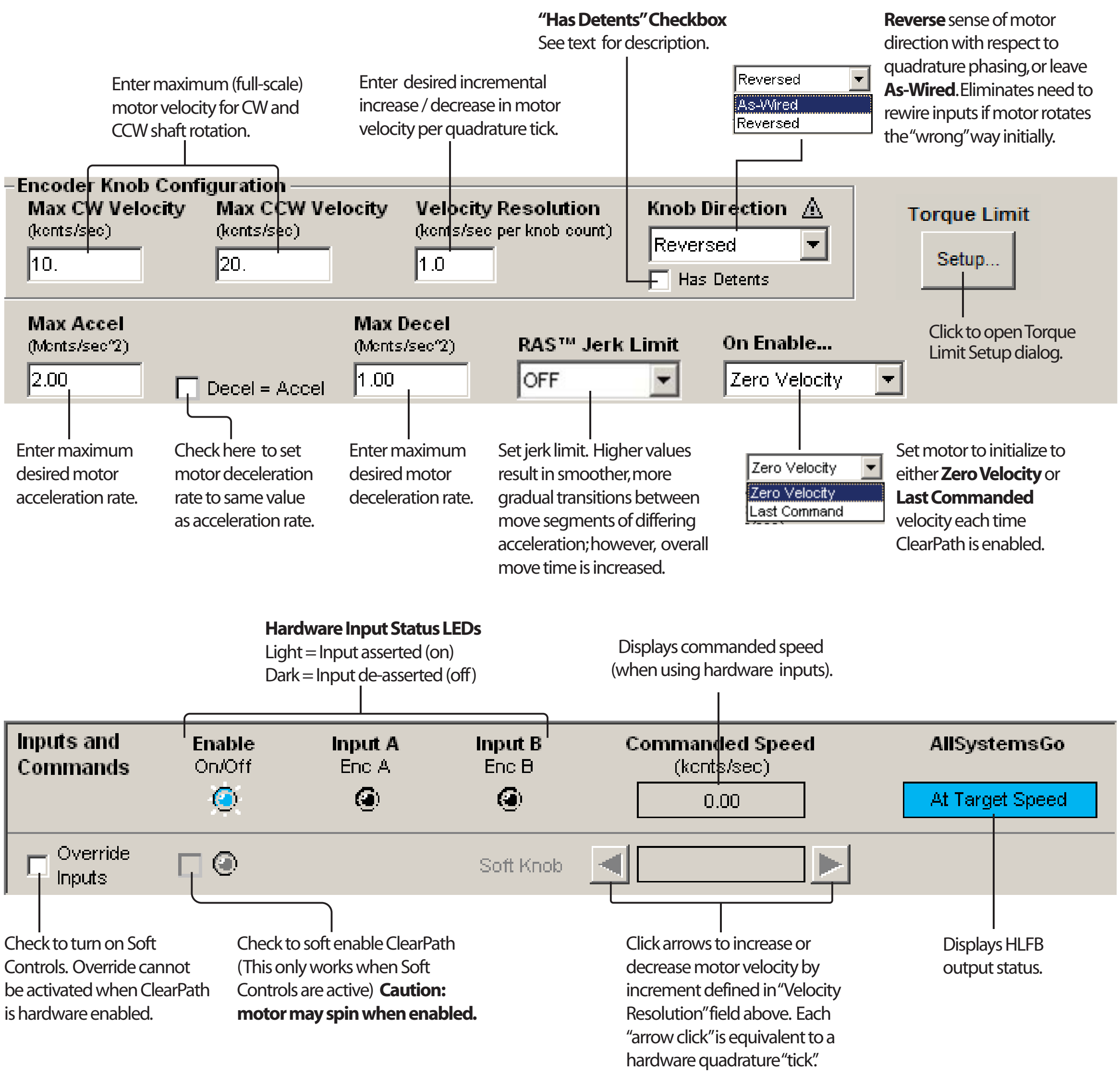
QUADRATURE SIGNAL SOURCE

To use this mode you'll need a device that can generate quadrature signals in the 5-24VDC range. Many users choose an optical or mechanical incremental encoder for this task, but a microcontroller or digital signal generator will work as well. Note: mechanical quadrature encoders are generally the least expensive option.



Quadrature output from a rotary encoder, aka "the knob"

Mode Controls



Description of Encoder/Knob Settings

Max CW Velocity

This setting defines the maximum motor shaft velocity that can be reached when the quadrature knob is turned in the direction that elicits CW shaft rotation.

Max CCW Velocity

This setting defines the maximum shaft velocity that can be reached when the quadrature knob is turned in the direction that elicits CCW shaft rotation.

Velocity Resolution

This setting defines exactly how much (i.e., by what increment) motor velocity will increase or decrease per quadrature "tick".

Knob Direction

These setting allow the user to reverse the motor's sense of direction with respect to the quadrature device phasing.

"Has Detents" Checkbox

When unchecked, ClearPath treats each quadrature transition it sees as a single "tick". (Remember, each tick causes an incremental change in motor speed.)

When checked, ClearPath treats every 4^{th} quadrature transition it sees as one "tick". (Remember, each "tick" causes an incremental change in motor speed.) Check this box when using an encoder that has one detent point per full quadrature cycle or if you want to divide your quadrature resolution by four.

RAMP UP/DOWN TO SELECTED VELOCITY

Available on
MCVC + MCPV

MODE SUMMARY

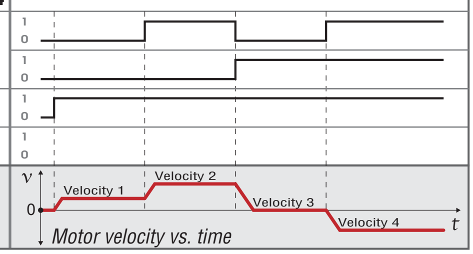
Changing the digital inputs on ClearPath (using your PLC, switches, etc.) causes ClearPath to smoothly ramp between any of four user defined velocities.

HOW IT WORKS

Assert the Enable Input to get started. Once enabled, ClearPath reads the state of Inputs A and B and immediately accelerates to the target velocity indicated. For example, if **Input A is high** and **Input B is low** ClearPath will ramp to "Velocity 2". Change to a different velocity by changing Inputs A and B

Velocity Control Ramp Up/Down to Selected Velocity (4 Velocity Programmable)

Signal	Function	Velocity Settings (logic levels)				Example Timing
		Velocity 1	Velocity 2	Velocity 3	Velocity 4	
Input A	Velocity Select A	LOW	HIGH	LOW	HIGH	
Input B	Velocity Select B	LOW	LOW	HIGH	HIGH	
Enable	Enable	Logic: High=Enable Low=Disable				
Trigger	NA	NA				
Tip: Setting one of the programmable velocities to zero (Velocity 3 in the example at right) provides a convenient way to stop the motor via the ClearPath inputs.						



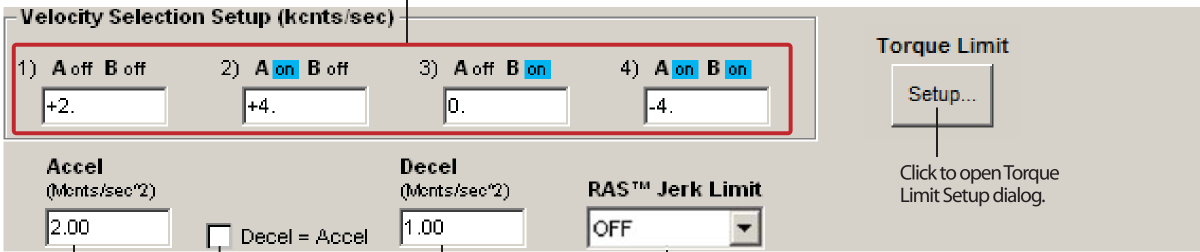
Ramp Up/Down to Selected Velocity Mode: Inputs and Timing Diagram

Notes:

- As soon as a new velocity command is received by ClearPath—as happens when Inputs A and/or B are changed—ClearPath immediately ramps to the new target velocity without delay.
- For a convenient way to command ClearPath to stop, set one of the velocity settings to zero. We did this with "Velocity 3" in the table above.
- Disable time = 10 mS

MODE CONTROLS

Enter target velocity for each input state here.



Click to open Torque Limit Setup dialog.

Enter maximum desired motor acceleration rate.

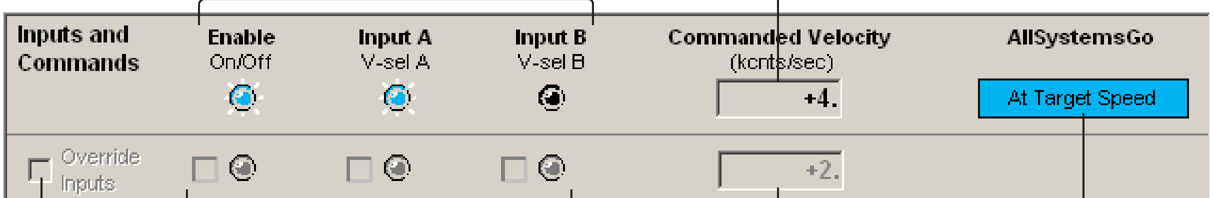
Check here to set motor deceleration rate to same value as acceleration rate.

Enter maximum desired motor deceleration rate..

Set jerk limit. Higher values result in smoother, more gradual transitions between move segments of differing acceleration; however, overall move time is increased.

Hardware Input Status LEDs
Light = Input asserted (on)
Dark = Input de-asserted (off)

Displays commanded velocity (when using hard inputs).



Check to turn on Soft Controls. Override cannot be activated when ClearPath is hardware enabled.

Soft Inputs and LEDs emulate hardware inputs. For use only when Soft Controls are active. **Caution: motor may spin when enabled.**

Displays commanded velocity (when using soft inputs).

Displays HLFB output status.

FOLLOW DIGITAL VELOCITY COMMAND (BI-POLAR PWM INPUT)

Available on
MCVC + MCPV

MODE SUMMARY

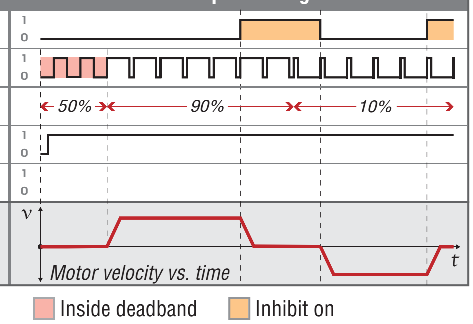
Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a velocity proportional to the duty cycle of that waveform. Or, use the PWM output from an H-bridge driver of a brushed motor setup and ClearPath becomes a high-performance drop-in replacement.

HOW IT WORKS

Assert the Enable Input to energize the motor. Control motor speed and direction by modulating the duty cycle of the PWM signal. Assert the Inhibit signal (Input A) to immediately ramp to zero velocity. See figure below and read text for timing and PWM requirements.

Velocity Control **Follow Digital Velocity Command (Bi-Polar PWM Command)**

Signal	Function	Input Type	Example Timing
Input A	Inhibit (optional)	Logic: High=Inhibit on Low=Inhibit off	
Input B	Speed/Direction	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes: Asserting Inhibit Input causes immediate ramp to zero speed. See text for information on deadband set up and application.			



Follow Digital Velocity Command (Bi-Polar PWM Control): Inputs and Timing Diagram

Notes:

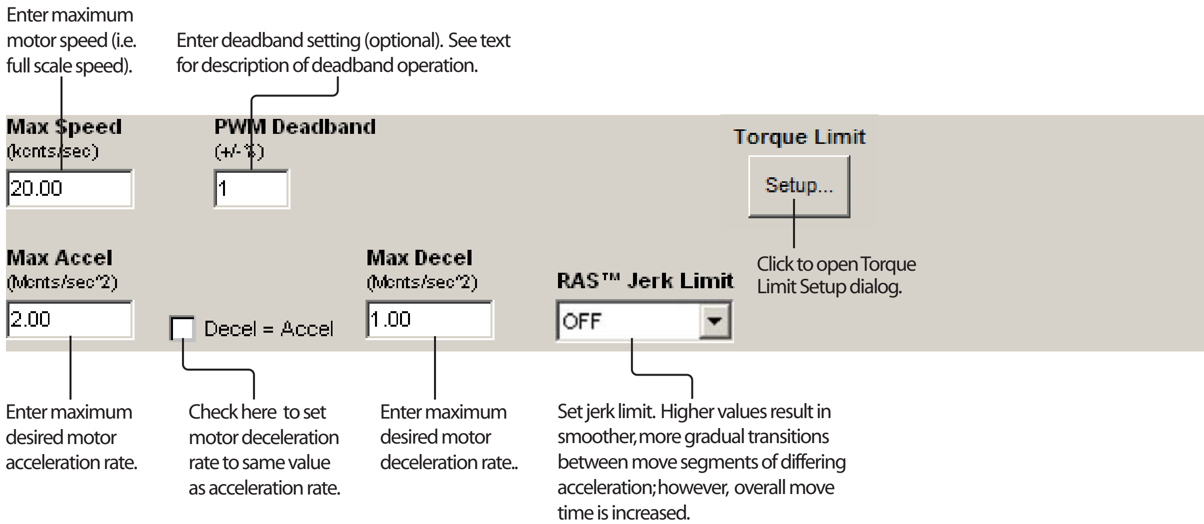
- PWM input frequency range: 20 Hz up to 30 kHz.
- If the PWM signal is off for 50mS or more the PWM input is considered off. This is interpreted by ClearPath as a zero-velocity command.
- Disable time = 10 mS
- Ramp to a stop by asserting Input A (the "Inhibit Input"). De-assert Input A to resume normal operation.

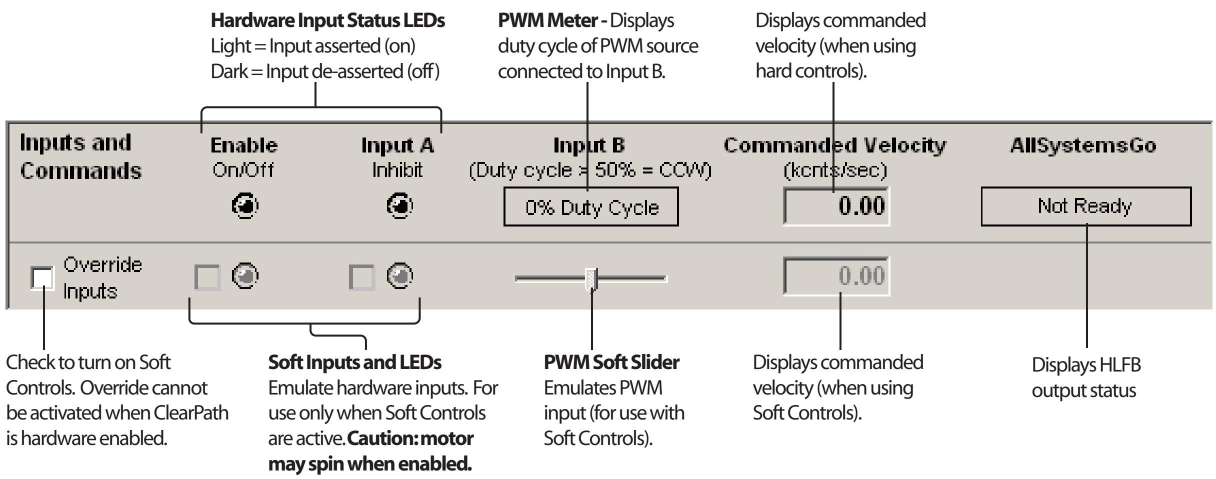
  or

  Set a PWM deadband to reliably command zero velocity. Read text for details on deadband setup.

- PWM Input, especially at higher frequencies, tends to have more inherent inaccuracy. If a very high level of velocity accuracy is important for your application, consider using Frequency Input mode.

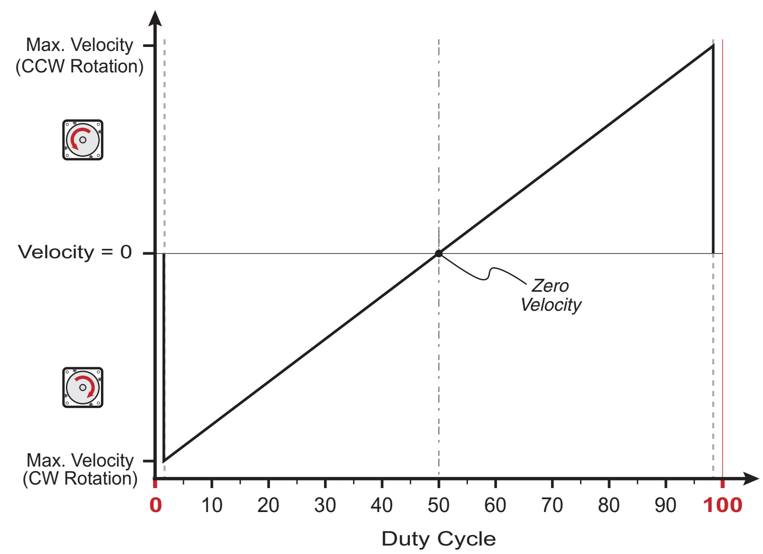
Mode Controls





Relationship of PWM duty cycle to motor velocity

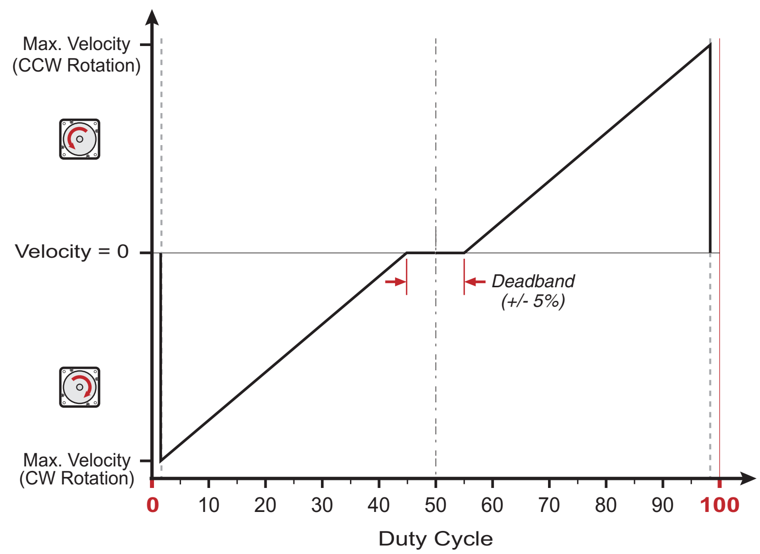
- Shaft velocity increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft velocity increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50%—from either direction—motor velocity approaches 0.
- In practice, O% and 100% (static low and static high conditions) are not valid PWM states. ClearPath treats these cases as zero-velocity commands.
- PWM minimum on time and minimum off time = 300nS.



Graph of PWM duty cycle vs. motor velocity

SETTING A PWM DEADBAND (OPTIONAL)

The deadband expands the range about the 50% PWM mark that is interpreted as the "zero-velocity setting" by ClearPath. This gives the user a reliable way to ensure that motor velocity ramps to zero when the PWM duty cycle is set at (or "close enough" to) 50%.



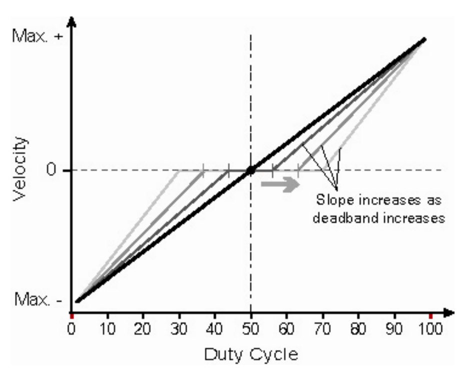
+/- 5% PWM dead band setting

Why use a deadband?

In bi-polar mode, stopping the motor (i.e. commanding "zero velocity") is achieved, in theory, by applying a 50% duty cycle PWM signal to Input B. However, it can be technically challenging to set a perfect 50% duty cycle. In fact, some very low speed motion may still be observed at the motor shaft *even when duty cycle is apparently set to 50%*. A deadband helps to ensure that actual motor velocity is zero (with no drift) when you expect it to be.

Example: If the user sets a +/- 5% dead band, any PWM signal with a duty cycle between 45% and 55% will be interpreted as a zero-velocity command by ClearPath. See figure above.

Note: As size of deadband setting increases, the slope of velocity vs. duty cycle increases as illustrated below.



FOLLOW DIGITAL VELOCITY (BIPOLAR PWM COMMAND WITH VARIABLE TORQUE LIMIT)

Available on
MCVC + MCPV

MODE SUMMARY

Control velocity and maximum torque independently [concurrently] with this mode. Connect a digital PWM waveform from your PLC or other device to Input B, and ClearPath will run at a velocity proportional to the duty cycle of that waveform. Connect a separate digital or PWM signal to Input A to independently vary your motor's torque limit.

HOW IT WORKS

Assert the Enable Input to energize the motor.

Velocity Control (Input B). Motor velocity is controlled by sending a PWM signal to Input B. Velocity is commanded as follows:

- Shaft velocity increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft velocity increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50%—from either side—motor velocity approaches 0.
- In practice, O% and 100% (static low and static high conditions) are not valid PWM states. ClearPath treats these cases as zero-velocity commands.
- All changes in velocity occur at the user-defined acceleration rate.
- Set a PWM deadband to help reliably command zero velocity.
- PWM minimum on time and minimum off time = 300nS.

Torque Limit Control (Input A). Vary your motor’s maximum torque between the "standard" Torque Limits and the Alternate Torque Limits using either digital or PWM control methods.

For **digital torque limit control**, toggle between the Torque Limits and Alternate Torque Limits by changing the state of Input A as follows:

- De-assert input A to operate using purely the "standard" Torque Limits.
- Assert input A to operate using purely the Alternate Torque Limits.

For **PWM torque limit control**, you can vary the active torque limit linearly between the two torque limit settings by varying the PWM duty cycle sent to Input A as follows:

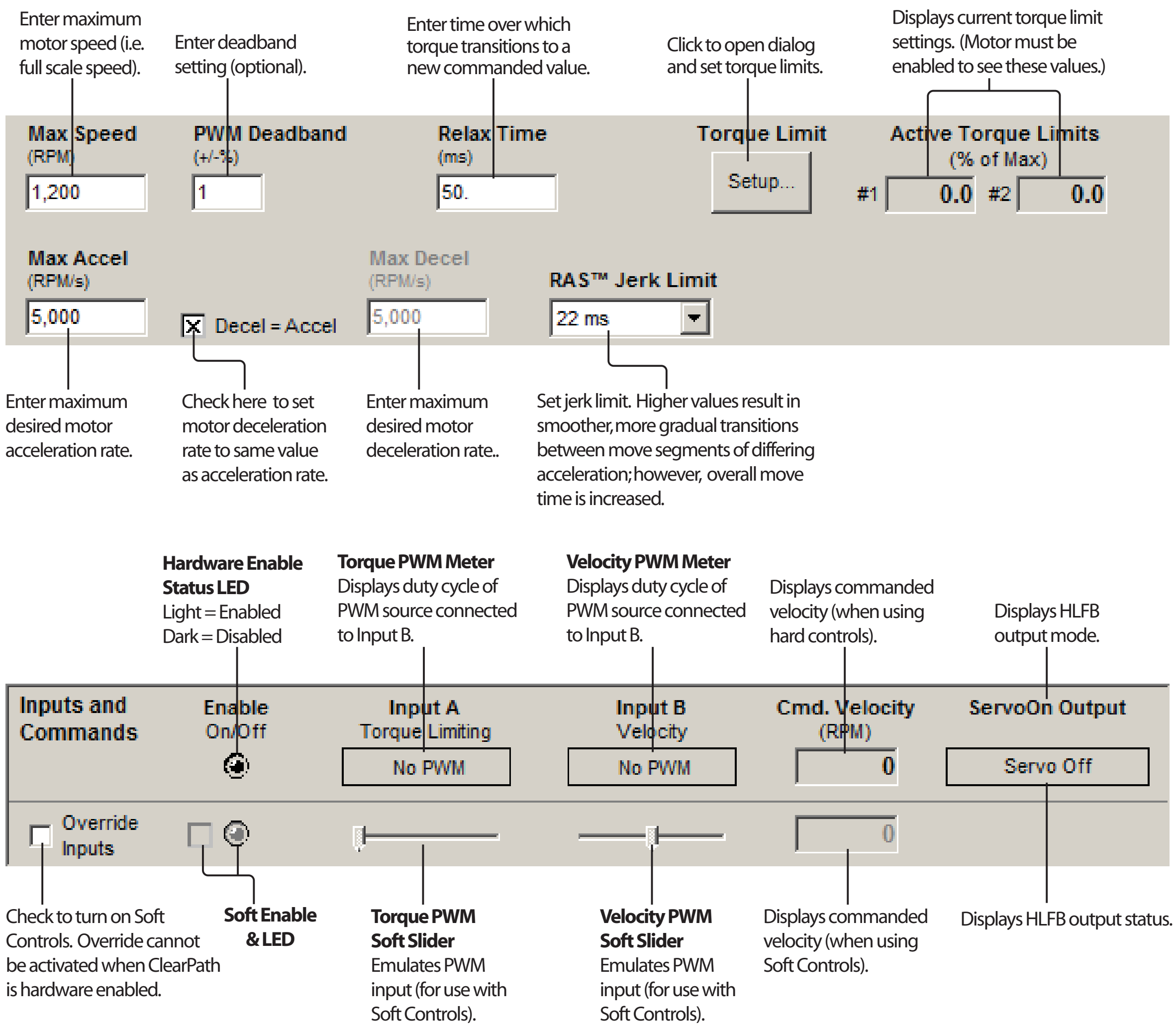
- Apply a 0% duty cycle (static low) to operate using purely the "standard" Torque Limits.
- Apply a 100% duty cycle (static high) to operate using purely the Alternative Torque Limits.

- Apply a duty cycle anywhere in between 0% and 100% to create a linear combination of the two limits.

Additional Notes:

- PWM input frequency range: 20 Hz up to 30 kHz.
- If the PWM signal is off for 50mS or more the PWM input is considered off.
- Disable time = 10 mS.

Mode Controls



Follow Digital Velocity Command (Unipolar PWM Input)

Available on
MCVC + MCPV

Mode Summary

Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a speed proportional to the duty cycle of the PWM waveform.

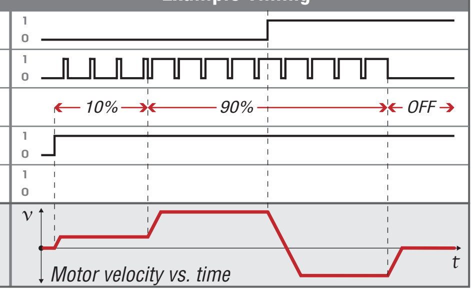
How it Works

Assert the Enable Input to energize the motor. Once enabled, motor velocity is controlled by sending a PWM signal to Input B. 0% PWM duty cycle commands zero velocity, and 100% (minus a little) duty cycle commands full-scale velocity. Changes in velocity occur at the user-defined acceleration rate.

Direction of travel (CW/CCW) is controlled by the state of Input A. See Inputs and Timing table below.

Velocity Control **Follow Digital Velocity Command (Unipolar PWM Command)**

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Velocity	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

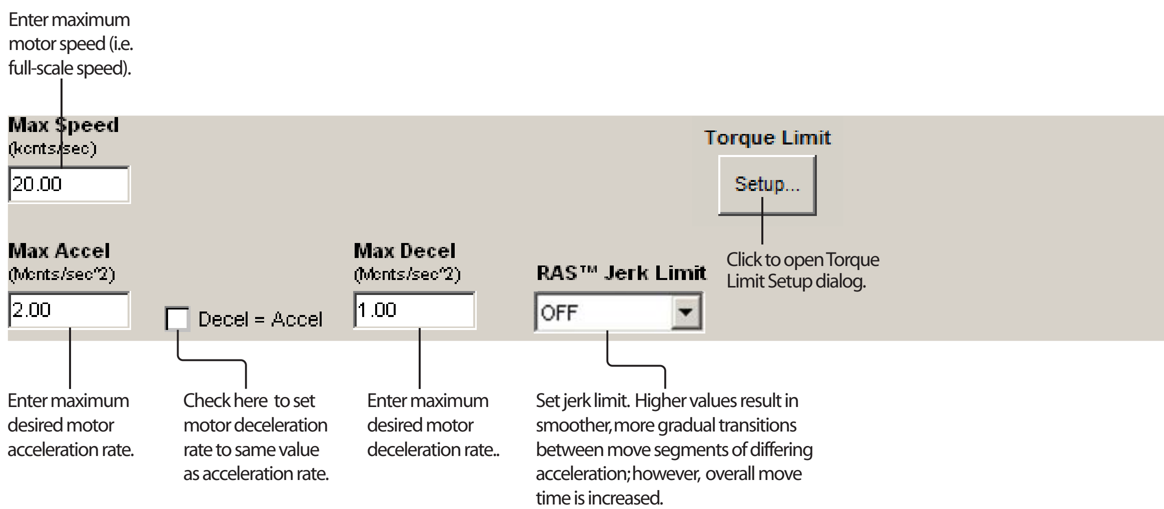


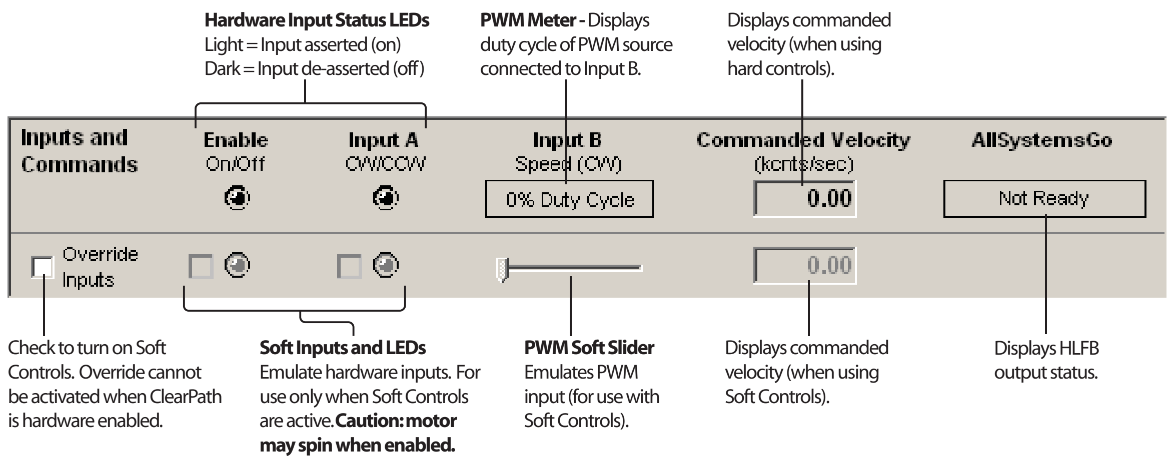
Follow Digital Velocity Command (Unipolar PWM Control): Inputs and Timing Diagram

Notes:

- PWM input frequency range: 20 Hz up to 30 kHz.
- If the PWM signal is off for 50Ms or more the PWM input is considered off. This is interpreted by ClearPath as a zero-velocity command.
- Disable time = 10 mS
- PWM Input, especially at higher frequencies, tends to have more inherent inaccuracy. If a very high level of velocity accuracy is important for your application, consider using Frequency Input mode.

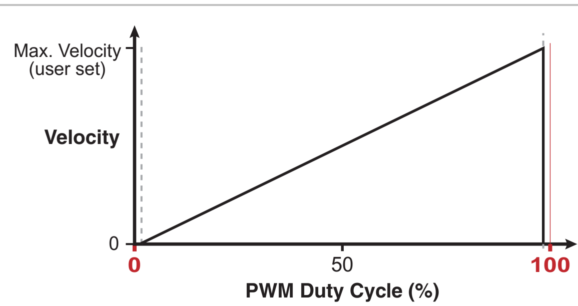
MODE CONTROLS





Motor velocity vs. PWM duty cycle :

- Motor velocity is proportional to PWM duty cycle (velocity increases as duty cycle increases). See figure below.
- In practice, 0% and 100% duty cycle signals (static low and static high respectively) are invalid PWM states, interpreted by ClearPath as "PWM turned off". This is the equivalent of a zero-velocity command.



- For CW shaft rotation, set Input A high. For CCW shaft rotation, set Input A low.
- PWM minimum on time and minimum off time = 300nS

FOLLOW DIGITAL VELOCITY COMMAND (FREQUENCY INPUT)

Available on
MCVC + MCPV

MODE SUMMARY

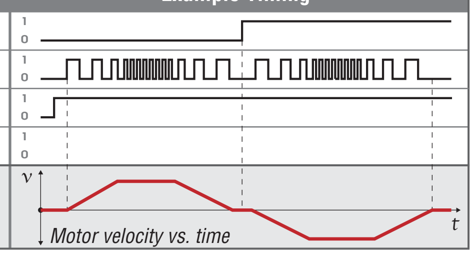
Connect a digital variable frequency waveform from your PLC or other device, and ClearPath will run at a velocity proportional to the frequency of the waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Then, control velocity by applying a variable frequency pulse train to Input B. Pulse frequency is proportional to commanded velocity. Direction of travel (CW/CCW) is controlled by the state of Input A. See Inputs and Timing diagram below.

Velocity Control **Follow Digital Velocity Command (Frequency Input Control)**

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Velocity	Pulse: Variable Frequency	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

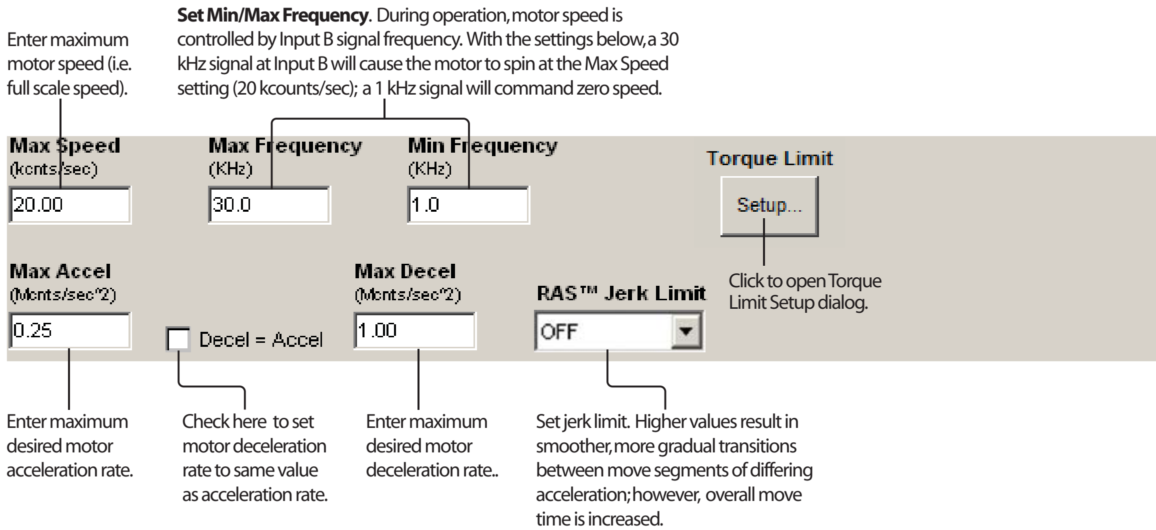


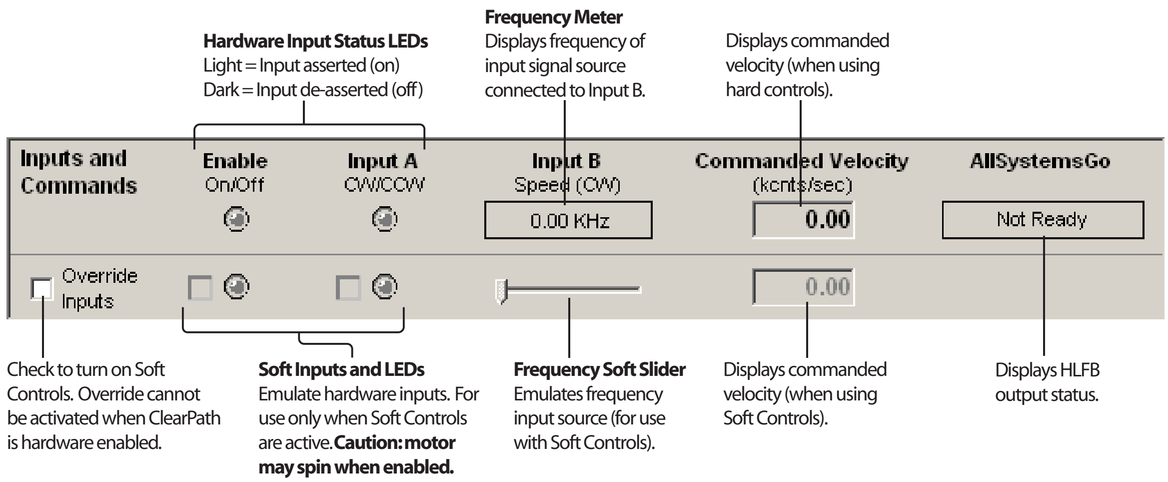
Follow Digital Velocity Command (Frequency Input Control): Inputs and Timing Diagram

Notes:

- Input frequency range: 20 Hz to 500 kHz.
- Actual motor speed in RPM is given by the following equation [(Input Freq. - Min Freq.) / (Max Freq. - Min Freq.) * User Defined Max Velocity. For **Example,** a 120 kHz pulse train with 100 kHz Min Frequency and 200 kHz Max frequency will result in a rotational speed of 20% of the user-defined Max Velocity.
- If the frequency signal is off interrupted for 50mS or more the input is considered off. This is interpreted by ClearPath as a zero-velocity command.
- Disable time = 10 mS

MODE CONTROLS





FOLLOW DIGITAL TORQUE COMMAND (BI-POLAR PWM INPUT)

Available on
MCVC + MCPV

MODE SUMMARY

Connect a digital PWM waveform from your PLC or other device, and ClearPath will produce torque proportional to the duty cycle of the PWM waveform.

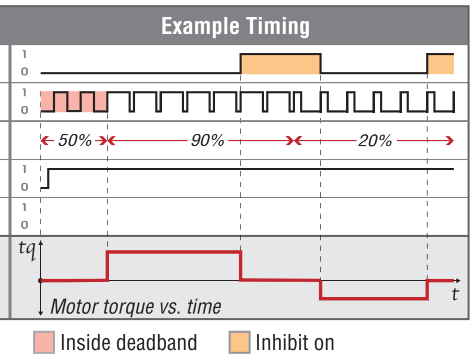
HOW IT WORKS

Assert the Enable Input to energize the motor. Control motor torque by applying a PWM signal to Input B. Motor torque changes in proportion to the duty cycle of the applied PWM signal. Assert the Inhibit signal (Input A) to immediately turn off torque. See figure below and read text for timing and PWM requirements.

Torque Control **Follow Digital Torque Command (Bi-Polar PWM Command)**

Signal	Function	Input Type
Input A	Inhibit (optional)	Logic: High=Inhibit on Low=Inhibit off
Input B	Torque/Direction	Pulse: Variable PWM
		Duty cycle of applied PWM signal (%)
Enable	Enable	Logic: High=Enable Low=Disable
Trigger	NA	NA

Notes: Asserting Inhibit Input causes immediate jump to zero torque. See text for information on deadband set up and application.



Follow Digital Torque Command (Bi-polar PWM Control): Inputs and Timing Diagram

Notes:

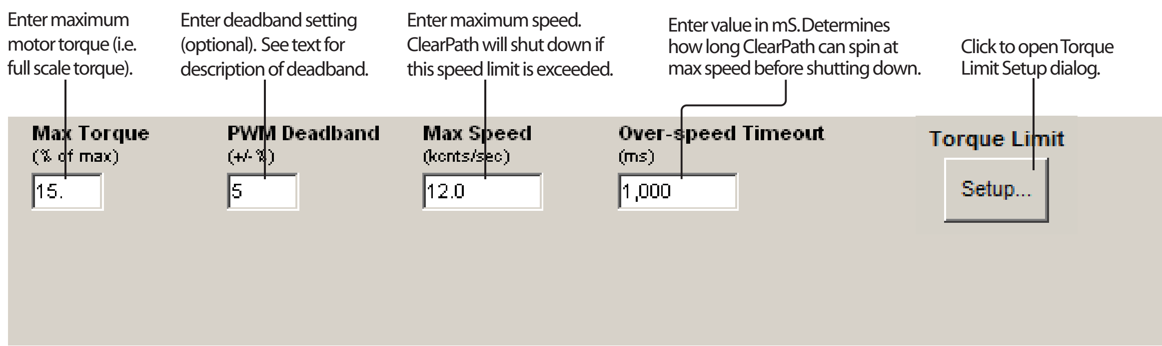
- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

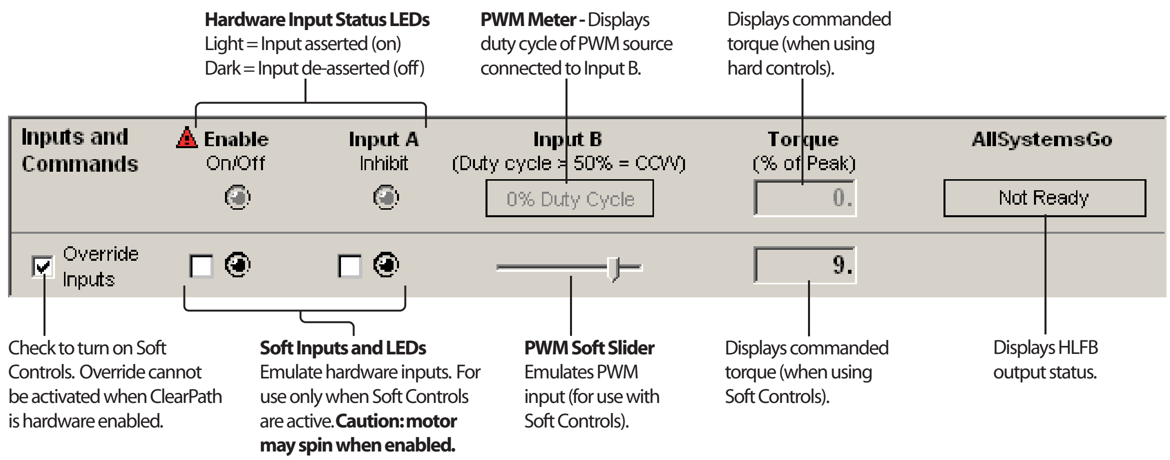
- To command ClearPath to zero torque, assert the Inhibit): Input (Input A). De-assert Input A to resume normal operation.

or

- Set a PWM deadband: to help reliably command zero torque. Refer to text on following pages for details on deadband setup.

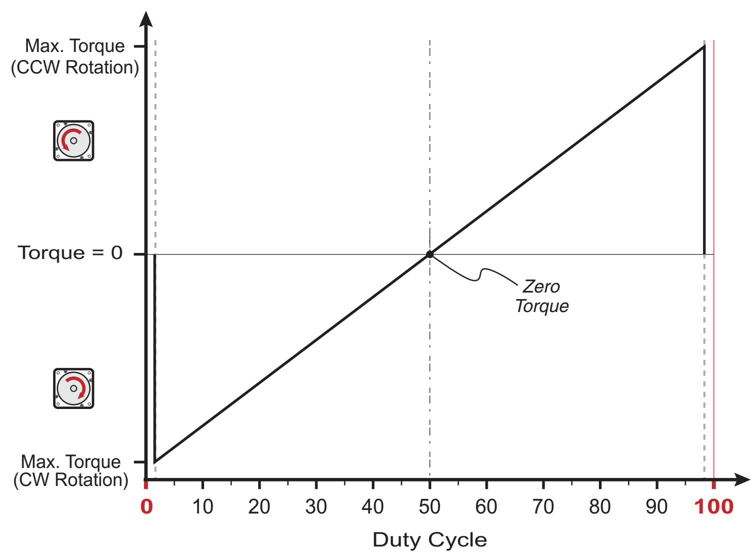
Mode Controls





Relationship of PWM duty cycle to motor torque

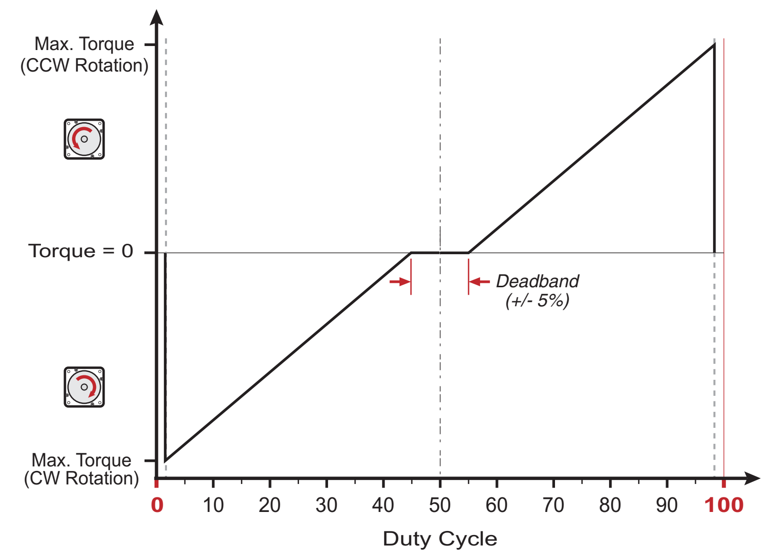
- Shaft torque increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft torque increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50% from either direction, motor torque approaches 0.
- O% and 100% duty cycle (static low and static high conditions) are not valid PWM states. ClearPath interprets these values as zero-torque commands.
- PWM minimum on time and minimum off time = 300nS.



PWM duty cycle vs. motor torque

SETTING A PWM DEADBAND

The deadband expands the range about the 50% PWM mark that is interpreted as the “zero torque setting” by ClearPath. This gives the user a reliable way to ensure that motor torque is completely turned off when the PWM duty cycle is set at (or “close enough” to) 50%.



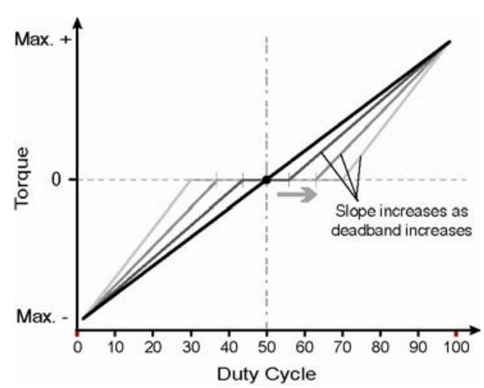
+/- 5% PWM deadband setting

Why use a deadband?

In bi-polar mode, turning off torque is achieved, in theory, by applying a 50% duty cycle PWM signal to Input B. However, it can be difficult to set a perfect 50% duty cycle. In fact, a very small amount of torque may still be produced by the motor, *even when duty cycle is apparently set to 50%*. A deadband helps guarantee torque is fully off when you expect it to be.

Example: If the user sets a +/-5% deadband, any PWM signal with a duty cycle between 45% and 55% (i.e., in the deadband) is interpreted as a zero-torque command by ClearPath.

Note: As deadband setting increases, the slope of torque vs. duty cycle increases as illustrated below.



FOLLOW DIGITAL TORQUE COMMAND (UNIPOLAR PWM INPUT)

Available on
MCVC + MCPV

MODE SUMMARY

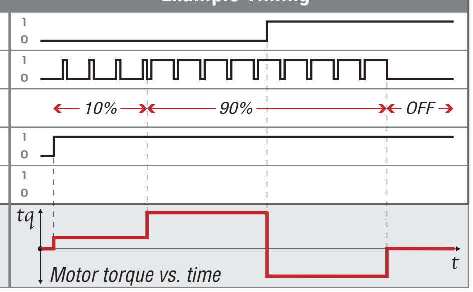
Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a speed proportional to the duty cycle of the PWM waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Motor torque is controlled be applying a variable PWM signal to Input B. 0% PWM duty cycle commands zero torque, and 100% duty cycle commands full-scale torque. Changes in speed occur at the user-defined acceleration rate. Direction of shaft rotation is controlled by the state of Input A. See Inputs and Timing table below.

Torque Control **Variable Torque With Unipolar PWM Input Control**

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Torque	Pulse: Variable PWM	
		Duty cycle of applied PWM signal (%)	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

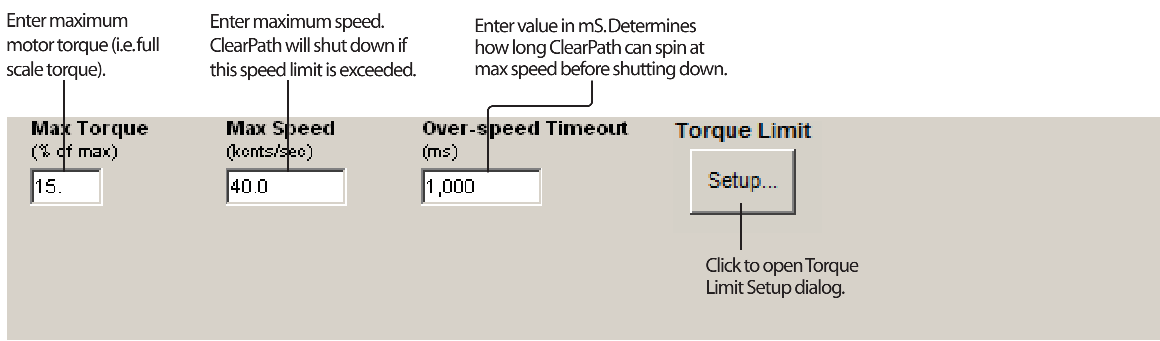


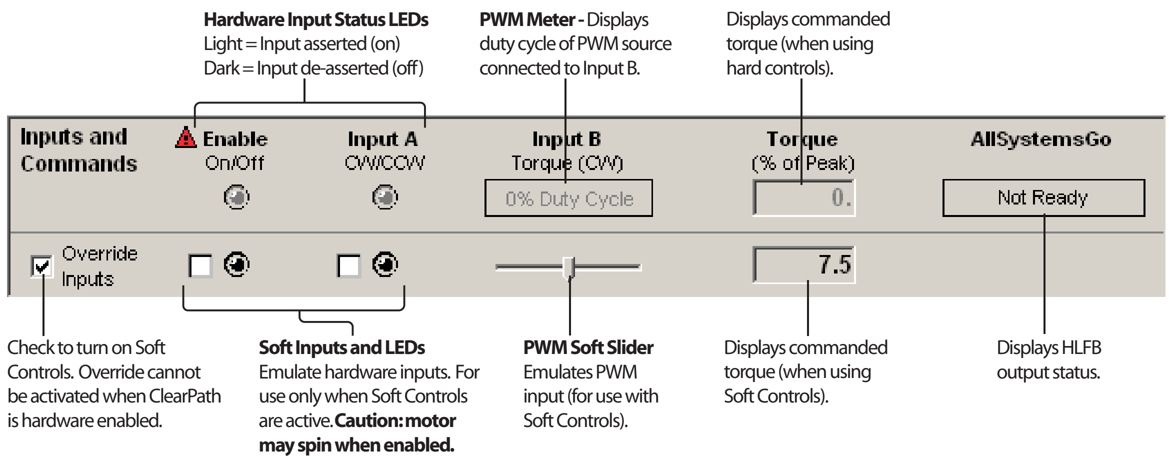
Variable Torque Mode (Unipolar PWM Control): Inputs and Timing Diagram

Notes:

- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

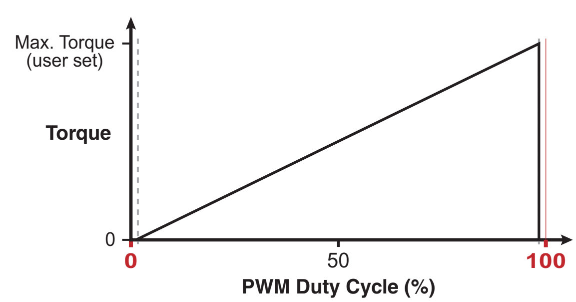
MODE CONTROLS





Motor torque vs. PWM duty cycle:

- Motor torque is proportional to PWM duty cycle (i.e. torque increases as duty cycle increases). See figure below.
- 0% and 100% duty cycle signals (static low and static high respectively) are invalid PWM states, interpreted by ClearPath as “PWM turned off”. This is the equivalent of a zero-torque command.



PWM duty cycle vs. torque

- For CW torque, set Input A high. For CCW torque, set Input A low.
- PWM minimum on time and minimum off time = 300nS

FOLLOW DIGITAL TORQUE COMMAND (FREQUENCY INPUT)

Available on
MCVC + MCPV

MODE SUMMARY

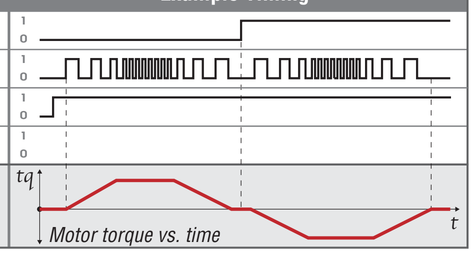
Connect a digital variable frequency waveform from your PLC or other device, and ClearPath will produce torque that is proportional to the frequency of the waveform.

HOW IT WORKS

Assert the Enable Input to energize the motor. Control torque by applying a variable frequency pulse train to Input B. Pulse frequency is proportional to commanded torque. Direction in which torque is applied (CW/CCW) is controlled by the state of Input A. See Inputs and Timing table below.

Torque Control **Variable Torque With Frequency Input Control**

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Torque	Pulse: Variable Frequency	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes:			

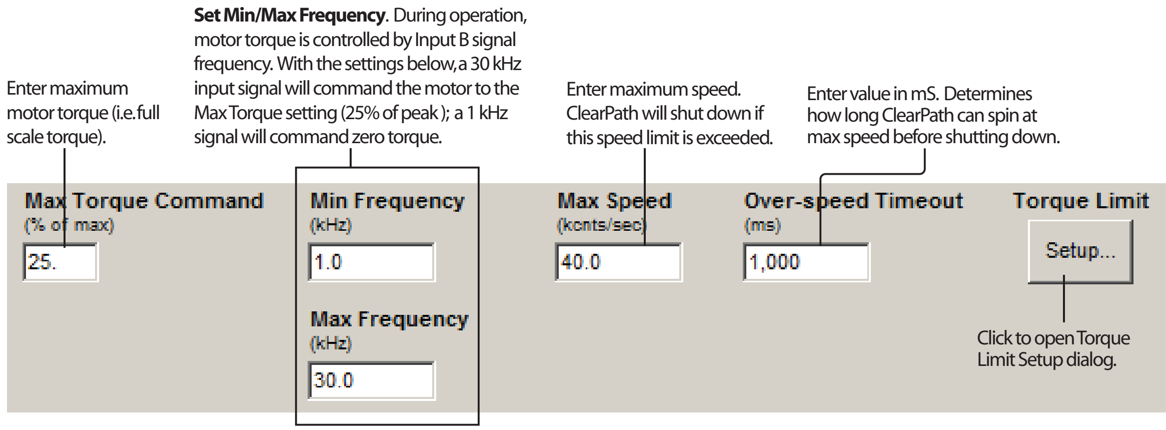


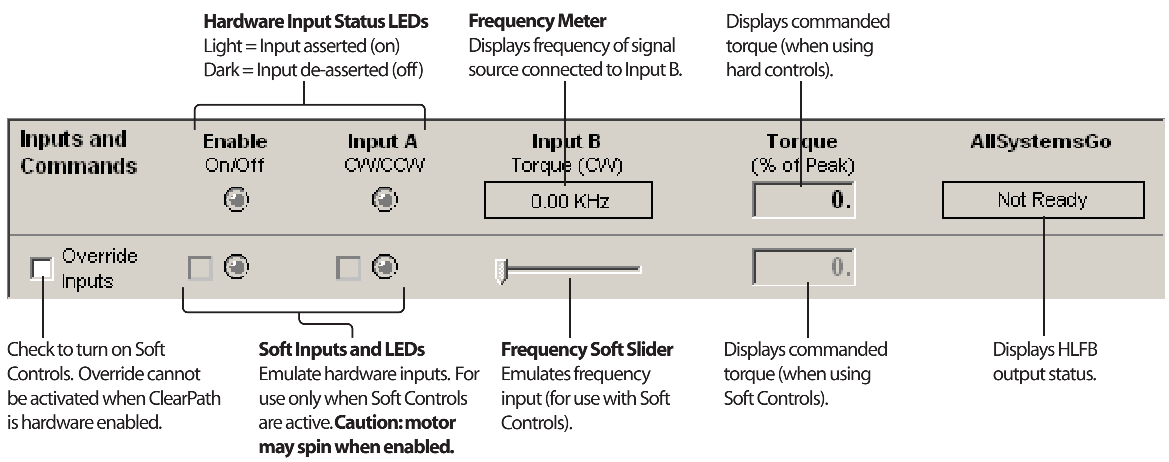
Variable Torque Mode (Frequency Control): Inputs and Timing Diagram

Notes:

- Input frequency range: 20 Hz to 500 kHz.
- If the frequency signal is off for 50mS or more the input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

MODE CONTROLS





MOVE TO ABSOLUTE POSITION (2-POSITION)

Available on
MCVC + MCPV

MODE SUMMARY

Trigger ClearPath to move to one of two preset locations. This mode was designed for replacing hydraulic or pneumatic cylinders that move between two positions.

HOW IT WORKS.

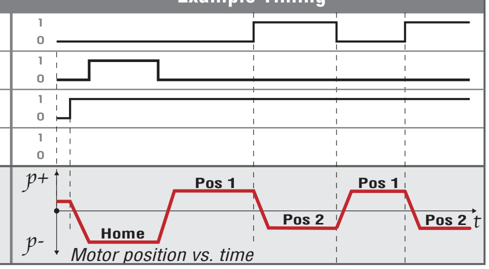
Assert the Enable Input to energize the motor. Once enabled, ClearPath automatically executes a homing move to a [user-supplied] switch or sensor wired to Input B. Once a home position is established, ClearPath automatically moves to one of the two user-defined positions (based on the state of Input A). After that, just toggle Input A to move between the two target positions.

Absolute Position

An absolute position is referenced to an established “home” position. Your target positions, in this context, are defined in terms of *distance from the home position*. For example, Position 1 could be defined as 5200 encoder counts from home, while Position 2 might be defined as 2000 encoder counts from home.

Position Control **Absolute Position (2-Position Programmable)**

Signal	Function	Input Type	Example Timing
Input A	Position Select	Logic: High=Pos. 2 Low=Pos. 1	
Input B	Home Switch	Logic: High=Home Low= Not Home	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	
Notes: ClearPath must home to a switch upon enable to establish the Home (zero) position to which the other target positions are referenced.			

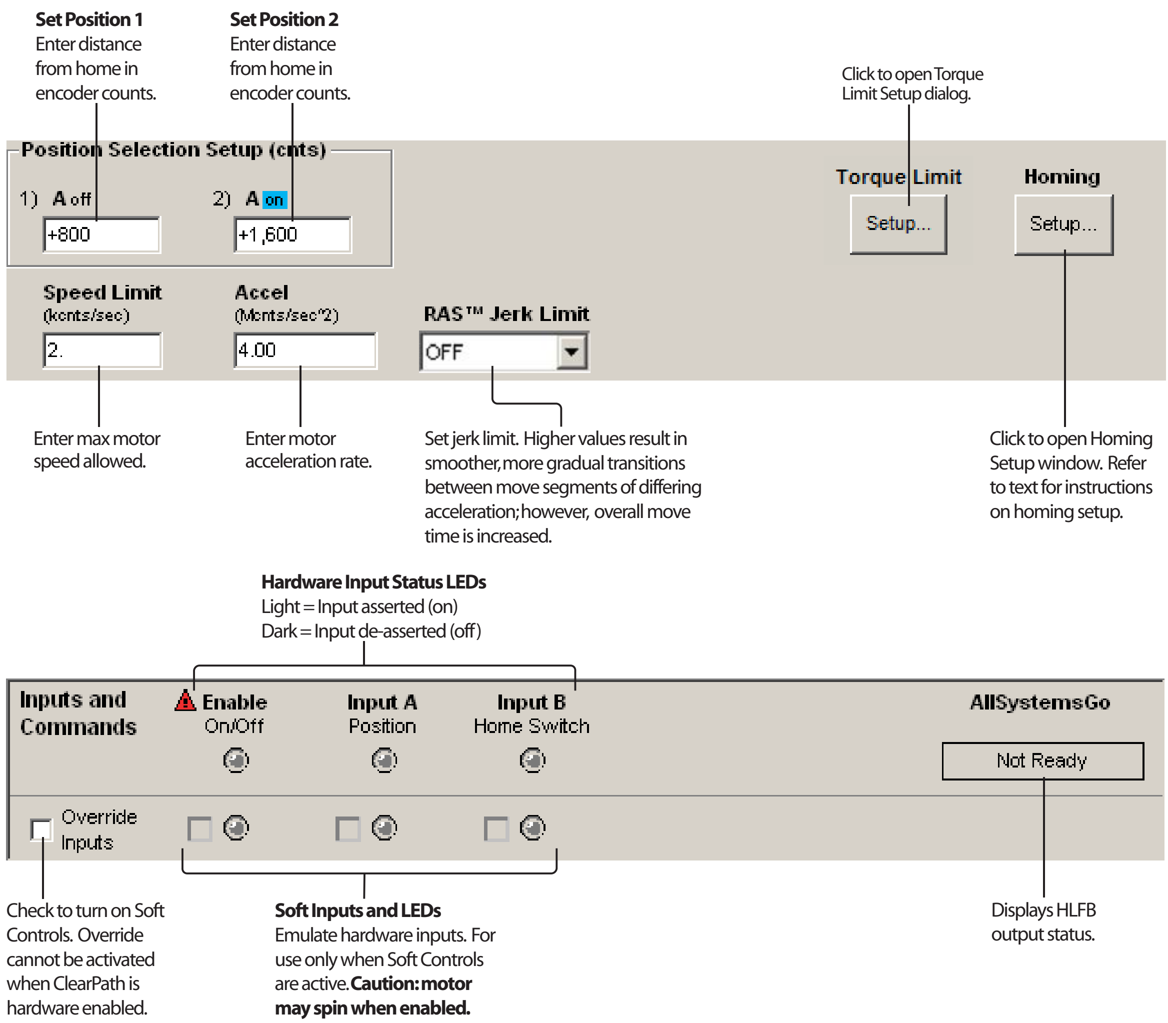


Absolute Position Mode (2): Inputs and Timing Diagram

Notes:

- If the state of Input A is changed during a move, ClearPath will immediately ramp to a stop and move to the newly indicated position.
- Input B switch polarity can be inverted via a checkbox in the Homing Setup dialog. When home switch polarity is inverted, ClearPath interprets Input B-low as “in the home switch”, and Input B-high as “not in the home switch”.
- Disable time = 10 mS

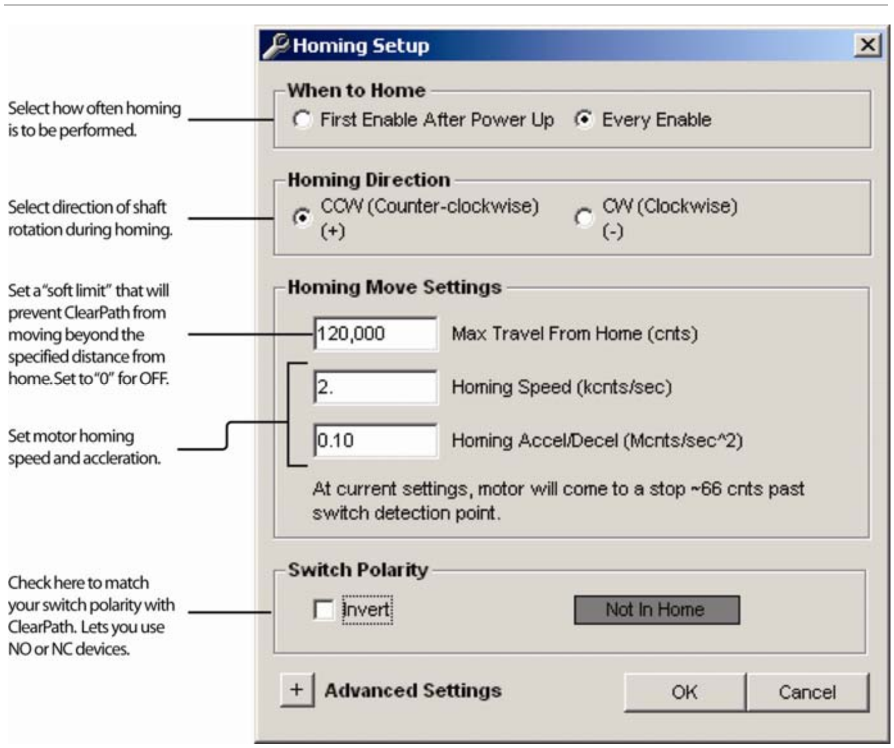
MODE CONTROLS



HOMING SETUP (HOME-TO-SWITCH)

Homing is required in this mode. Follow the instructions below to set up switch homing.

1. Securely fasten a limit switch or sensor to one end of the motion axis and wire it to Input B.
2. Click the Setup button to open the homing dialog.
3. Enter homing parameters. See figure next page for description of homing parameters.



Homing setup dialog

4. Test and modify your homing setup for proper performance.

How Switch Homing Works:

- During homing, the axis is automatically driven toward the homing switch at the user-specified direction and speed.
- Once the switch is actuated, the motor ramps to a stop and the encoder position counter is zeroed. This position is now considered the home reference position.

MOVE TO ABSOLUTE POSITION (4-POSITION)

Available on

MCPV

MODE SUMMARY

Command ClearPath to move to one of four preset locations. Perfect for replacing air cylinders in scenarios where more power and/or finesse are needed (and you want to position at more than just two locations).

Absolute Position

An absolute position is referenced to an established “home” position. Your target positions, in this context, are defined in terms of *distance from the home position*. For example, Position 1 might be defined as 2000 encoder counts from home, while Position 2 might be defined as 5200 encoder counts from home.

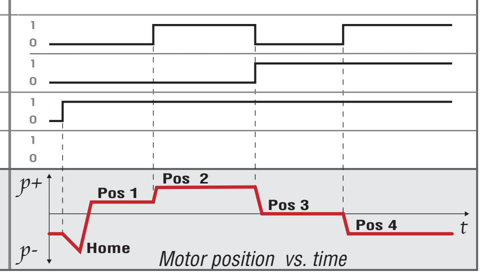
HOW IT WORKS

Assert the Enable Input to energize the motor. Once enabled ClearPath automatically homes to a hard stop to establish an absolute home reference position. Note: Homing is required in this mode.

After homing, ClearPath can be commanded to move to any of four user-defined positions by changing the state of Input A and B. Changing these inputs has the dual effect of selecting target position, and triggering the move. See table below for timing and input details. All moves execute at the user-defined speed and acceleration.

Position Control **Absolute Positioning (4-Position Programmable)**

Signal	Function	Position Settings				Example Timing
		Pos. 1	Pos. 2	Pos. 3	Pos. 4	
Input A	Position Select A	LOW	HIGH	LOW	HIGH	
Input B	Position Select B	LOW	LOW	HIGH	HIGH	
Enable	Enable	Logic: High=Enable Low=Disable				
Trigger	NA	NA				



Notes: ClearPath must home to a “hard stop” (either upon first enable or upon every enable) to establish a home reference position. All user-defined target positions are referenced to the home position.

Absolute Position Mode (4-position): Inputs and Timing Diagram

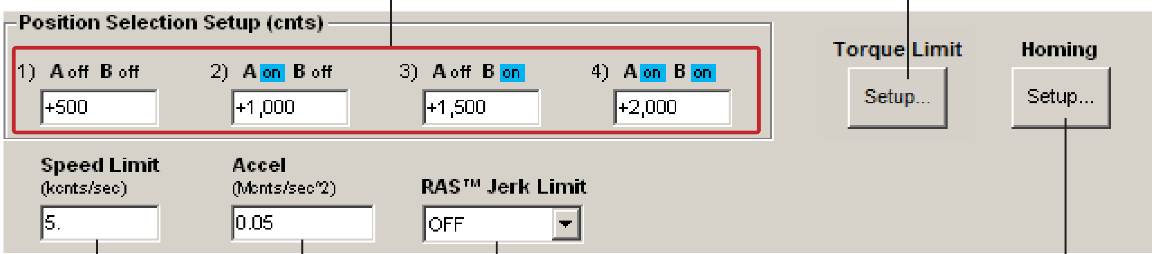
Notes:

- Changing the state of Input A and/or B while ClearPath is in motion cancels the move in progress. ClearPath immediately ramps to a stop and initiates a new move to the newly indicated target position.
- Disable time = 10 mS

MODE CONTROLS

Set Target Positions
Enter move distance (from home) for each input state.

Click to open Torque Limit Setup dialog.



Enter maximum motor speed allowed.

Enter motor acceleration rate.

Set jerk limit. Higher values result in smoother, more gradual transitions between move segments of differing acceleration; however, overall move time is increased.

Click to open Homing Setup window. Refer to text for instructions on homing setup.

Hardware Input Status LEDs
Light = Input asserted (on)
Dark = Input de-asserted (off)

Check to turn on Soft Controls. Override cannot be activated when ClearPath is hardware enabled.

Soft Inputs and LEDs emulate hardware inputs. For use only when Soft Controls are active. **Caution: motor may spin when enabled.**

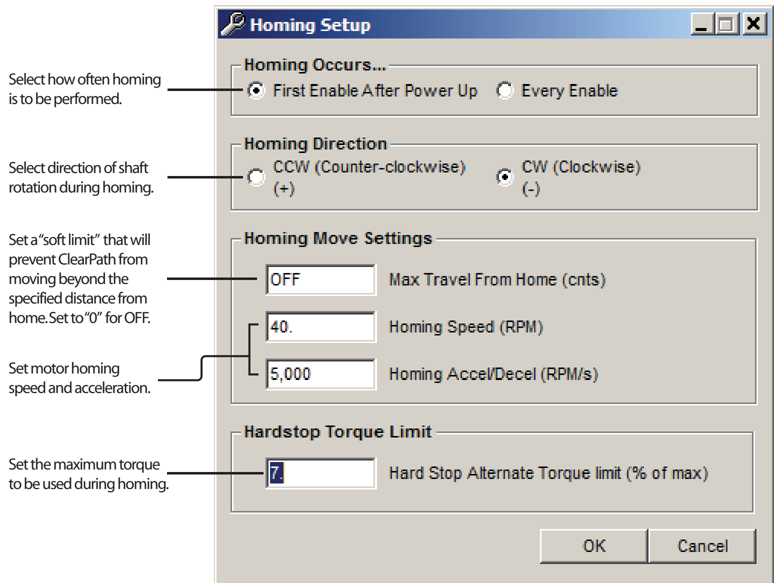
Click during homing operation to manually set home position.

Displays HLFB output status.

HOMING (AUTOMATIC HARD STOP HOMING)

Homing to a hard stop is required in this mode. When homing is initiated, the motor automatically rotates at the user-specified speed, acceleration, and direction until a hard stop is detected. Then ClearPath sets the home position.

HOMING SETUP



Homing setup dialog

1. Make sure the axis has a hard stop that you can run into (at low speed). The moving element of the axis must be able to make solid, repeatable contact with the hard stop when driven into it.

2. In MSP, click Homing Setup to open the homing setup dialog.

3. Set **When Homing Occurs...** This lets you choose when to perform a homing operation, either 1) the first time ClearPath is enabled after power up, or 2) every time ClearPath is enabled.

4. Set **Homing Direction.** Lets you choose clockwise or counter-clockwise shaft rotation during homing.

5. Set **Max Travel From Home**. This is the maximum distance from the home position (in counts) that ClearPath can be commanded to move. Enter "0" to turn this setting off. *Note: ClearPath will not execute a move that would violate this limit.*

6. Set **Homing Speed** and **Homing Accel/Decel.**

7. Set **Hardstop Torque Limit.** Enter "0" to turn this setting off.

Move to Sensor Position

Available on
MCVC + MCPV

Mode Summary

Use ClearPath digital inputs to spin the shaft CW or CCW. Wire position sensors and switches in series with ClearPath inputs to make an inexpensive two position actuator.

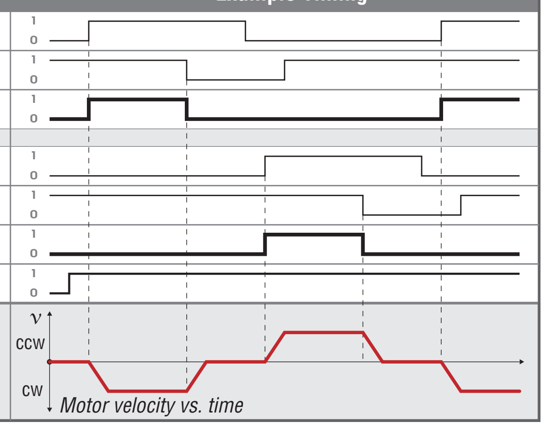
How it Works

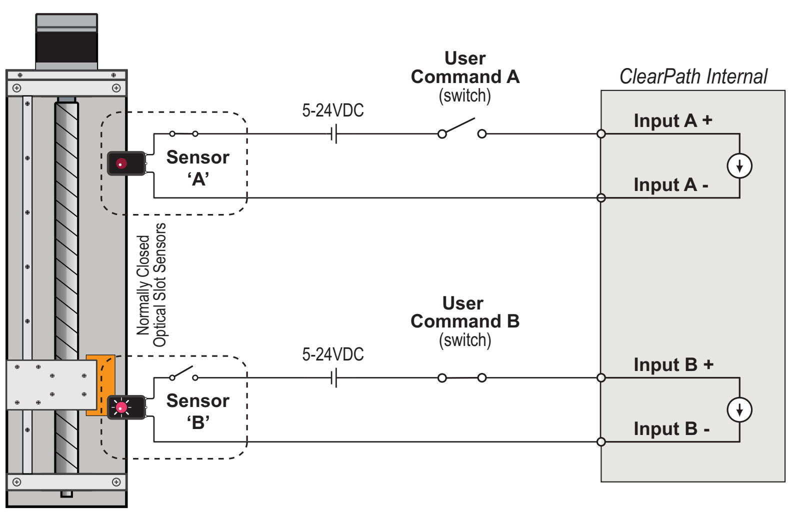
Place sensors at opposite ends of your motion path and wire them into the appropriate ClearPath inputs. See illustration below.

Assert the Enable Input to energize the motor. Apply User Commands to start motion. ClearPath moves CW or CCW until it interrupts a sensor. It then holds position until you issue a new User Command in the opposing direction. See table below for Input states and timing details.

Position Control Move to Sensor Position

Signal	Function	Example Timing
User Command A	Wired in series with Input A	
Sensor A	Wired in series with Input A	
Input A	**CW Move Request**	
User Command B	Wired in series with Input B	
Sensor B	Wired in series with Input B	
Input B	**CCW Move Request**	
Enable	**Enable:** High=Enable Low=Disable	



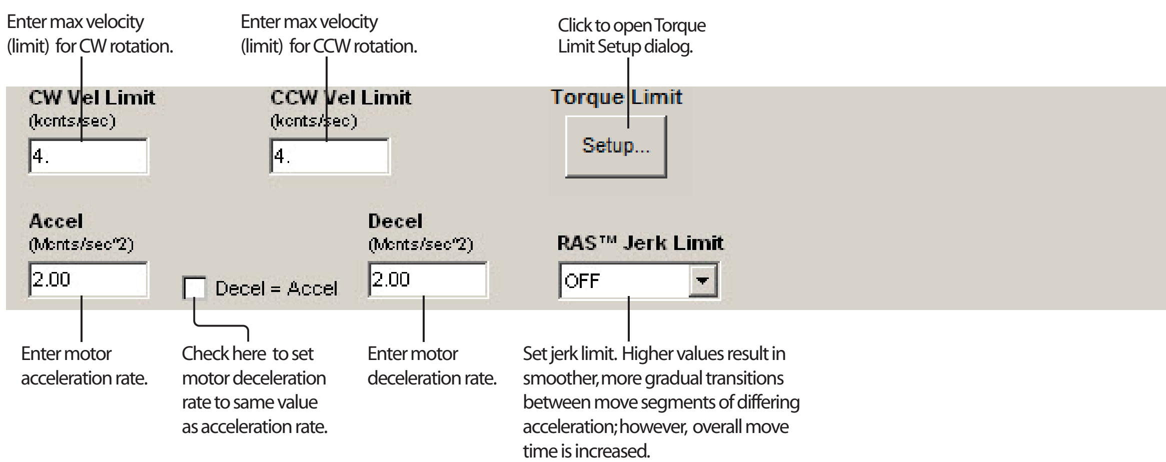


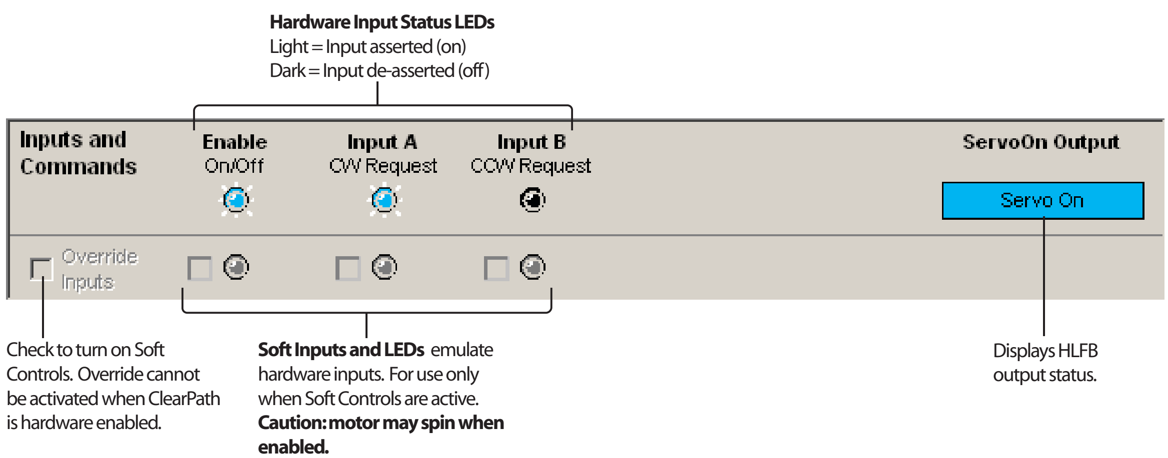
Move to Sensor: Inputs and Timing Diagram with example application sketch

Notes:

- **Stay in between the sensors.** When using an optical slot type sensor, the "flag" must be long enough to continuously interrupt the sensor from the start of deceleration through full stop. In addition, the deceleration rate must be set to ensure that the flag does not travel past the sensor.
- Changing the state of either Input A or Input B while ClearPath is in motion effectively cancels the move in progress. ClearPath immediately ramps to a stop and holds position until a new move request[4] is received.
- Disable time = 10 mS

MODE CONTROLS





[4] In this scenario, the next move request must be in the opposite direction from the previous move request. Thus, if the motor was spinning in the CW direction when the move was canceled, ClearPath will only respond to a CCW move request.

MOVE INCREMENTAL DISTANCE (2-DISTANCE)

Available on
MCPV

MODE SUMMARY

Send a trigger pulse to tell ClearPath to move a user-defined distance from its current position. Send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any distance in one smooth, uninterrupted move.

Incremental Positioning

An incremental move is referenced to its own starting position, not to an absolute "home" reference position. So, if the incremental move distance is set to +1000 counts, the shaft will move +1000 counts from its current position each time a trigger pulse is received.

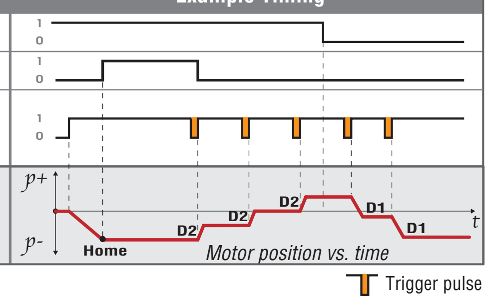
HOW IT WORKS

Assert the Enable Input to energize the motor. ClearPath can be set to perform an optional homing routine (home-to-switch only in this mode). Incremental move distance is selected with Input A. Pulsing the Enable/Trigger Input launches each move.

Position Control Incremental Positioning (2 Incremental Distances)

Signal	Function	Input Type	Example Timing
Input A	Increment Select	Logic: Low=Dist.1 High=Dist. 2	
Input B	Home Switch (optional)	Logic: High=Home Low= Not Home	
Enable/ Trigger	Enable Trigger	Logic: High=Enable Low=Disable Pulse Enable line low to trigger moves	

Notes: ClearPath can be programmed to home upon enable (see text for full details). Moves are triggered on rising edge of trigger pulse.



Incremental Position Mode: Inputs and Timing Diagram

Notes:

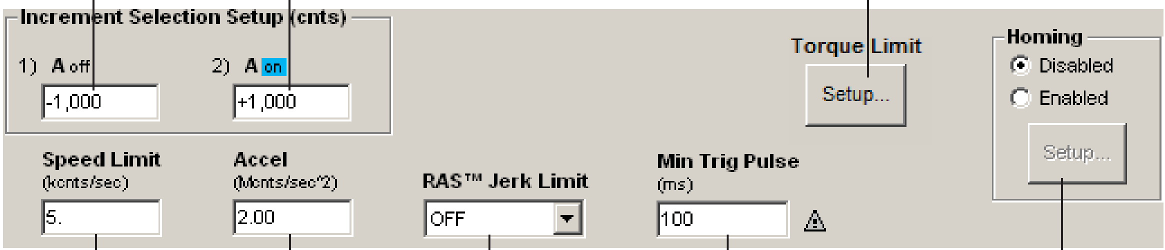
- A trigger pulse is required to launch each incremental move. Move distance is selected with Input A.
- To create a longer continuous move, you can send multiple trigger pulses and ClearPath will automatically "chain" the move increments together to form a single seamless move. Note: To successfully "chain" move increments), the burst of trigger pulses must be sent rapidly. They must be received by the ClearPath during the acceleration through constant velocity portion of move, *but not during the deceleration phase*. If a trigger pulse is received during the deceleration phase of a move, that move will run to completion (motor will stop). Then the next incremental move will execute.

Mode Controls

Set Increment 1
Enter move distance in encoder counts.

Set Increment 2
Enter move distance in encoder counts.

Click to open Torque Limit Setup dialog.



Enter max motor speed allowed.

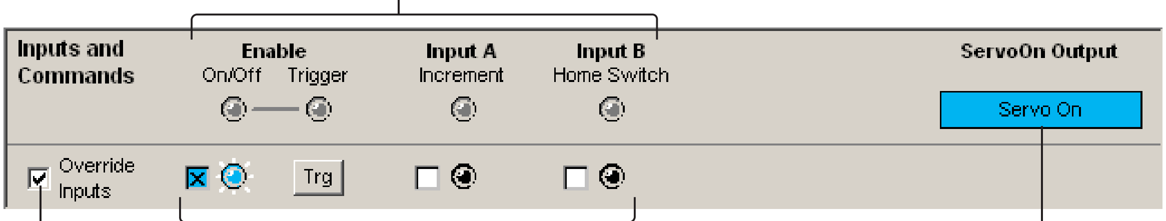
Enter motor acceleration rate.

Set jerk limit. Higher values result in smoother, more gradual transitions between move segments of differing acceleration; however, overall move time is increased.

Enter value (1-400mS) to set how long the Enable line must be pulled low to qualify as a valid trigger pulse.

Click to open Homing Setup window (when homing is enabled). Refer to text for instructions on homing setup.

Hardware Input Status LEDs
Light = Input asserted (on)
Dark = Input de-asserted (off)



Check to turn on Soft Controls. Override cannot be activated when ClearPath is hardware enabled.

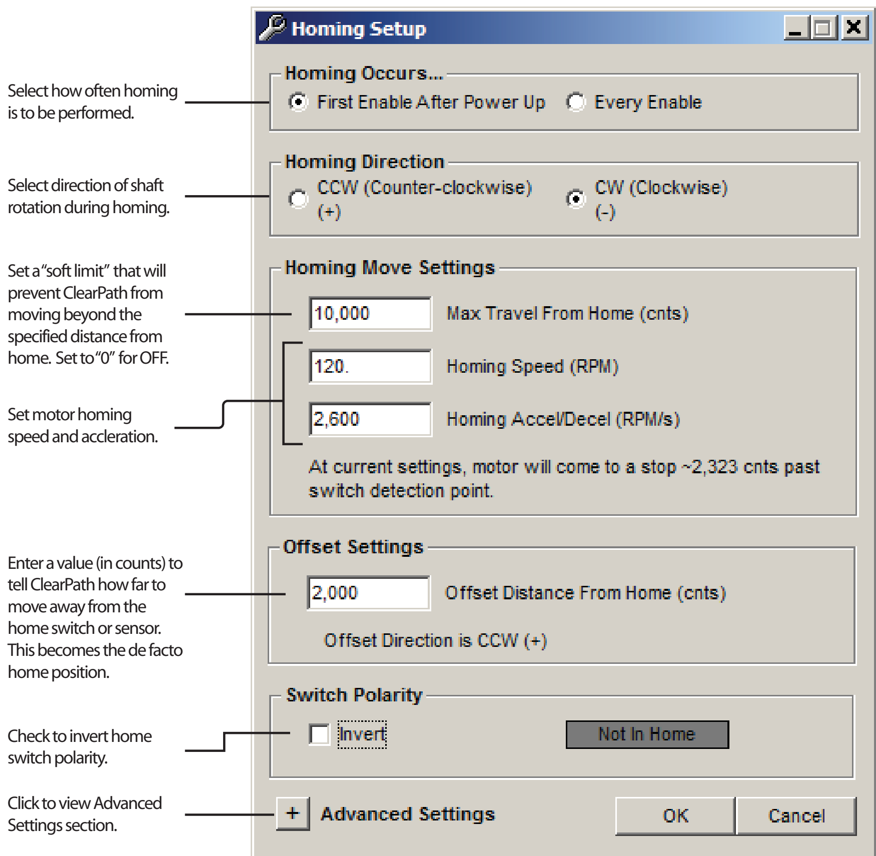
Soft Inputs and LEDs
Emulate hardware inputs. For use only when Soft Controls are active. **Caution: motor may spin when enabled.**

Displays HLFB output status.

HOMING SETUP (HOME-TO-SWITCH)

This mode supports optional home-to-switch functionality. When homing is initiated, the motor automatically rotates at the user-specified speed, acceleration, and direction until a user-supplied switch or sensor is actuated. Then ClearPath sets the home position (a settable homing offset is optional). See homing setup instructions below.

STANDARD SETTINGS



Homing: Standard Settings

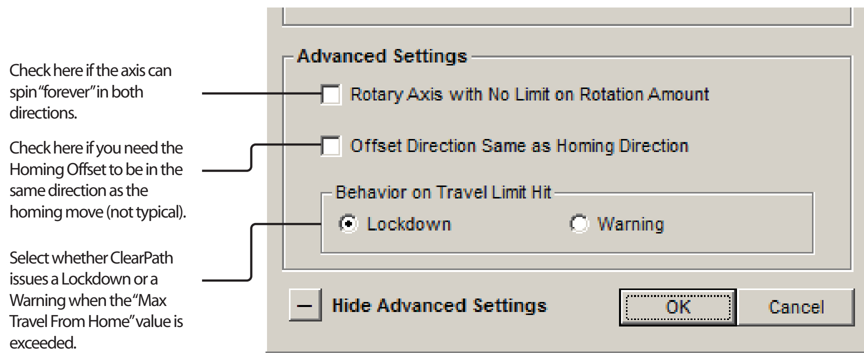
1. Install a compatible switch or sensor at one end of travel and wire it to Input B. Note: To work properly, the switch or sensor must be placed at the end of travel. Refer to I/O section (earlier in this document) for switch/sensor wiring information.
2. In MSP, enable homing and click Setup to open the homing setup dialog (shown above).
3. Set **When to Home.** Choose to perform a homing sequence either 1) the first time ClearPath is enabled or 2) every time ClearPath is enabled.
4. Set **Homing Direction.** Choose clockwise or counter-clockwise shaft rotation during homing.
5. Set **Homing Move Settings.**

a. Set **Homing Speed** and **Homing Accel/Decel**.

b. Enter **Max Travel From Home.** This is maximum distance from the home position (in counts) that ClearPath can be commanded to move. Note: ClearPath will not execute a move that would violate this limit. See Advanced Settings, *Behavior on Limit Hit*, below for additional settings related to this feature.

6. **Switch Polarity.** Use this checkbox to change whether Input B (the home sensor input) must be high or low to be considered asserted.

ADVANCED SETTINGS



Homing: Advanced Settings

Rotary Setting with No Limit on Rotation Amount

Check this box if you have an axis such as a conveyor or turntable with unlimited travel in either direction.

Offset Direction Same as Homing Direction

Check this box if you want the post-homing offset move to be in the same direction as the homing move. This setting is mainly used with rotary axes with unlimited bi-directional motion such as a turntable or conveyor.

Behavior on Travel Limit Hit

This setting tells ClearPath whether to issue either a Warning or a Lockdown (read note below) if you attempt to move past the "Max Travel from Home" setting described earlier.

Warning vs. Lockdown

- **A Lockdown** disallows motion. You must toggle Enable to clear a Lockdown. The indicator LED on ClearPath flashes alternating yellow and green when a Lockdown occurs.
- **A Warning** allows motion only in the direction away from the soft limit and the Warning automatically clears when the reason for the Warning is no longer present. The indicator LED on ClearPath flashes a green 2-blink code when a Warning occurs.

MOVE INCREMENTAL DISTANCE (4-DISTANCE)

Available on

MCPV

MODE SUMMARY

Send a trigger pulse to tell ClearPath to move a user-defined distance [increment] from its current position. Send multiple, quick trigger pulses to tell ClearPath to travel a multiple of any distance in one smooth, uninterrupted move.

Incremental Positioning

An incremental move is referenced to its own starting position, not to an absolute "home" reference position. So, if the incremental move distance is set to +1000 counts, the shaft will move +1000 counts from its current position each time a trigger pulse is received.

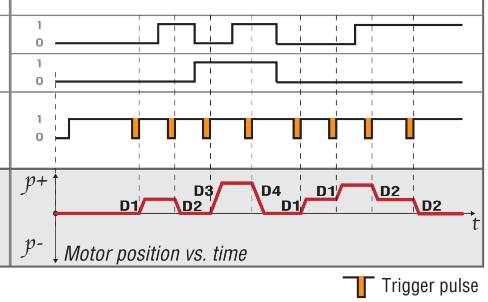
HOW IT WORKS

Assert the Enable Input to energize the motor. ClearPath can be set to perform an optional homing routine (home-to-hard stop only in this mode). Move distance is selected with Inputs A and B. Pulsing the Enable/Trigger Input launches each move.

Position Control Incremental Positioning (4-Distance Programmable)

Signal	Function	Incremental Distance Settings				Example Timing
		Dist.1	Dist.2	Dist.3	Dist.4	
Input A	Increment Select A	LOW	HIGH	LOW	HIGH	
Input B	Increment Select B	LOW	LOW	HIGH	HIGH	
Enable/ Trigger	Enable Trigger	Logic: High=Enable Low=Disable Pulse Enable line to trigger moves				

Notes: ClearPath can be programmed to home upon enable (see text for full details). Moves are triggered on rising edge of trigger pulse.



Incremental Position Mode: Inputs and Timing Diagram

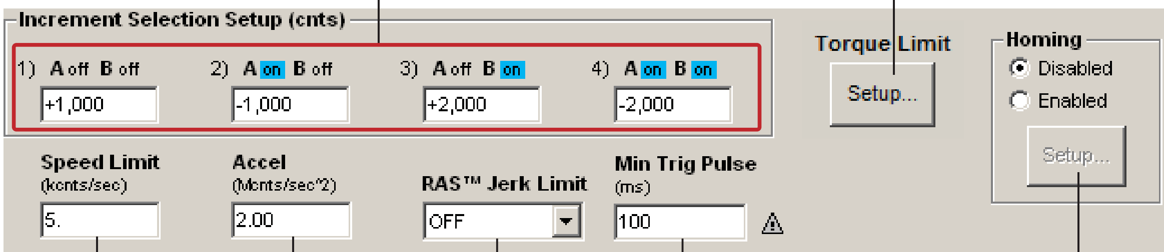
Notes:

- A trigger pulse is required to launch each move. Move distance is selected with Input A and B.
- To create a longer continuous move, you can send multiple trigger pulses and ClearPath will automatically "chain" the move increments together to form a single non-stop move. Note: To successfully "chain" move increments, the burst of trigger pulses must be sent rapidly. The pulse train must be received by the ClearPath during the acceleration through constant velocity portion of move, *but not during the deceleration phase.*
- If a trigger pulse is received during the deceleration phase of a running move, it will not be chained to the original move. In fact, the "late pulse" will trigger a separate move.

Mode Controls

Set Move Increments
Enter move distance for each input state.

Click to open Torque Limit Setup dialog.



Enter maximum motor speed allowed.

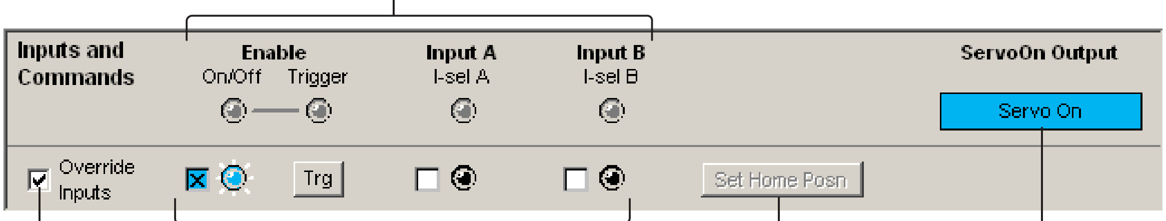
Enter motor acceleration rate.

Set jerk limit. Higher values result in smoother, more gradual transitions between move segments of differing acceleration; however, overall move time is increased.

Enter value (1-400mS) to set how long the Enable line must be pulled low to qualify as a valid trigger pulse.

Click to open Homing Setup window. Refer to text for instructions on homing setup.

Hardware Input Status LEDs
Light = Input asserted (on)
Dark = Input de-asserted (off)



Check to turn on Soft Controls. Override cannot be activated when ClearPath is hardware enabled.

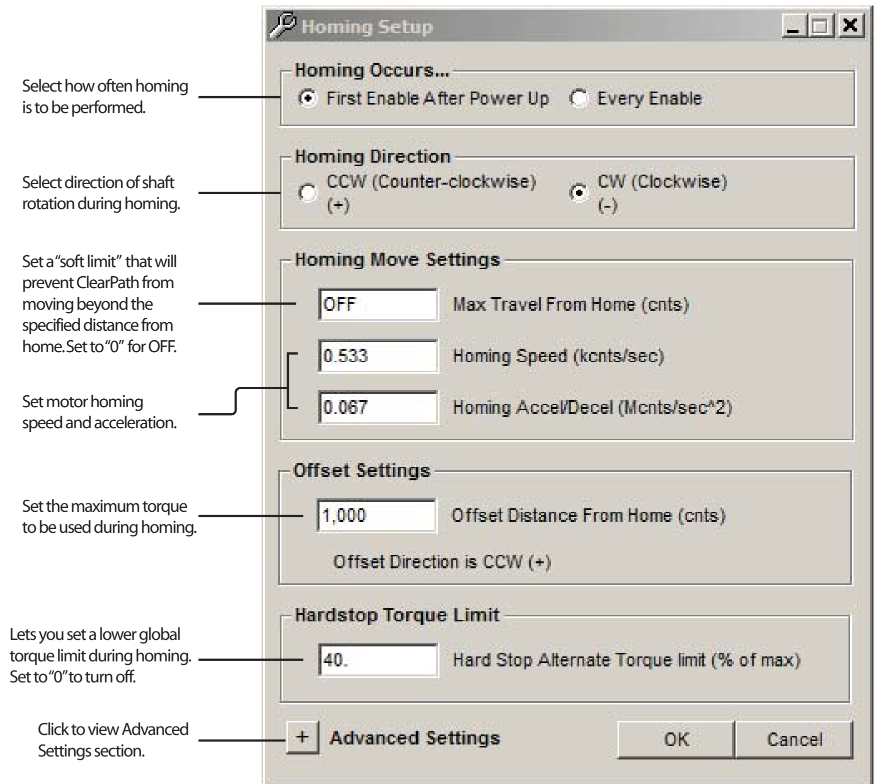
Soft Inputs and LEDs
Emulate hardware inputs. For use only when Soft Controls are active. **Caution: motor may spin when enabled.**

Click during homing operation to manually set home position.

Displays HLFB output status.

HOMING (AUTOMATIC HARD STOP HOMING)

Homing to a hard stop is optional in this mode. When homing is initiated, the motor automatically rotates at the user-specified speed, acceleration, and direction until a hard stop is detected. Then ClearPath sets the home position.



HOMING SETUP (STANDARD SETUP)

1. Make sure the axis has a hard stop that you can run into (at low speed). The moving element of the axis must be able to make solid, repeatable contact with the hard stop when driven into it.

2. In MSP, enable homing and click Homing Setup to open the homing setup dialog.

3. Set **When Homing Occurs.** This lets you choose when to perform a homing operation, either 1) the first time ClearPath is enabled after power up, or 2) every time ClearPath is enabled.

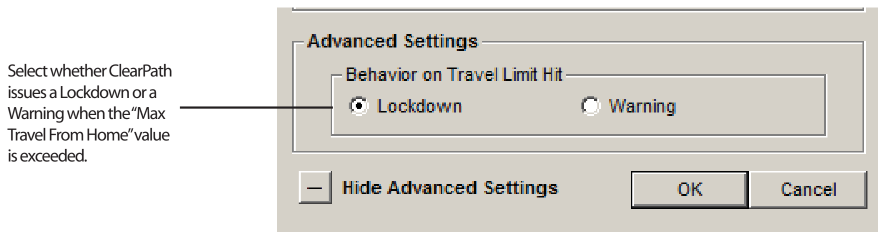
4. Set **Homing Direction.** Lets you choose clockwise or counter-clockwise shaft rotation during homing.

5. Set **Max Travel From Home**. This is the maximum distance from the home position (in counts) that ClearPath can be commanded to move. Enter "0" to turn this setting off. *Note:*

ClearPath will not execute a move that would violate this limit.

6. Set **Homing Speed** and **Homing Accel/Decel.**
7. Set **Offset Distance.** This lets you tell ClearPath exactly how far to move away from the hard stop (in counts) to set the final home position.
8. Set **Hardstop Alternate Torque Limit.** Enter "0" to turn this setting off.

ADVANCED SETTINGS



Warning vs. Lockdown

- **A Lockdown** disallows motion. You must toggle Enable to clear a Lockdown. The indicator LED on ClearPath flashes alternating yellow and green when a Lockdown occurs.
- **A Warning** allows motion only in the direction away from the soft limit and the Warning automatically clears when the reason for the Warning is no longer present. The indicator LED on ClearPath flashes a green 2-blink code when a warning occurs.

PULSE BURST POSITIONING

Available on
MCPV

MODE SUMMARY

ClearPath will move a distance proportional to the number of pulses sent to Input B. This mode offers much of the flexibility of a “step-and-direction” system, without the need for an expensive indexer to create smooth move trajectories (that function is handled by ClearPath’s internal trajectory generator). This mode is limited to two speeds and one acceleration/deceleration rate set by the user.

Note: A fairly simple PLC counter or a software loop can be used to generate pulses for use with this mode.

HOW IT WORKS

Assert the Enable Input to energize the motor. (Note: ClearPath can be configured to perform a homing routine upon enable.) To execute positioning moves, send a high speed stream of pulses to Input B, where each pulse represents an incremental unit of distance. Total move distance is determined by the number of pulses sent to Input B.

All moves are executed at the user-defined acceleration and speed setting. Direction of motor shaft rotation is controlled by Input A. See inputs and timing diagram below.

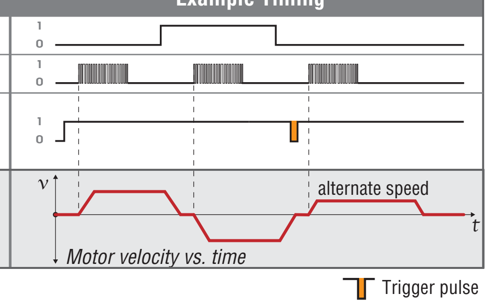
Trigger function: **Alternate Speed**

To execute a move at the alternate speed, briefly pulse the Enable input low-high. Then, the next pulse burst sent to ClearPath will result in a move executed at the alternate speed setting. Once that move is complete, ClearPath automatically returns to its default speed setting.

Pulse Positioning **Pulse Burst Positioning**

Signal	Function	Input Type	Example Timing
Input A	Direction Select	Logic: High=CW Low=CCW	
Input B	Pulse Input	Pulse: High-Speed Pulse Burst	
Enable Trigger	Enable Speed Select	Logic: High=Enable Low=Disable Pulse low to select alternate speed	

Notes: ClearPath requires a **minimum pulse width = 1uS**. Pulses less than < 1uS will be filtered out as noise by ClearPath.



cc_mcsd

Pulse Burst Positioning Mode: Inputs and Timing Diagram

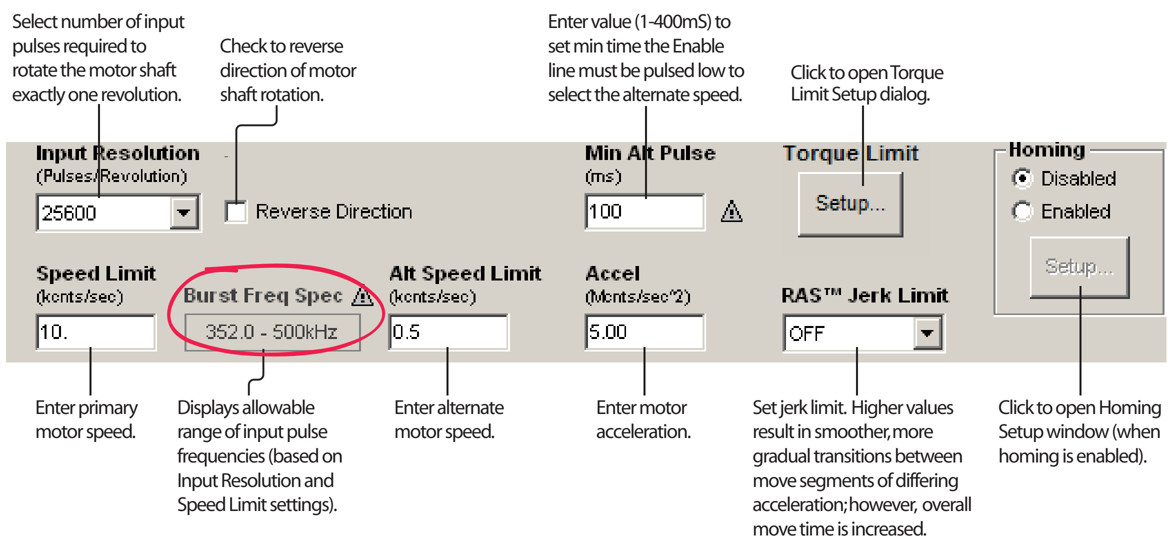
Notes:

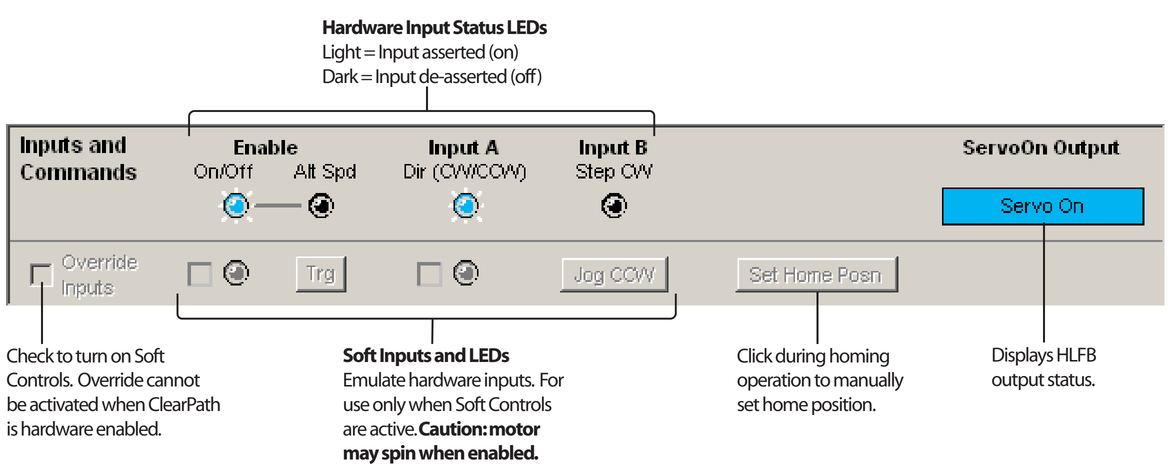
- The frequency of the pulse train applied to Input B must always be higher than the specified speed limit(s). This ensures that the motor's pulse buffer is never empty. See the “Burst Frequency

Spec" (circled in red on the figure below) for the range of allowable pulse input frequencies.

- Sending pulses at a fixed frequency is OK! In fact, that's one of the reasons we developed this mode. Just send a burst of pulses and ClearPath creates a smooth motion profile based on your acceleration and velocity settings.

MODE CONTROLS





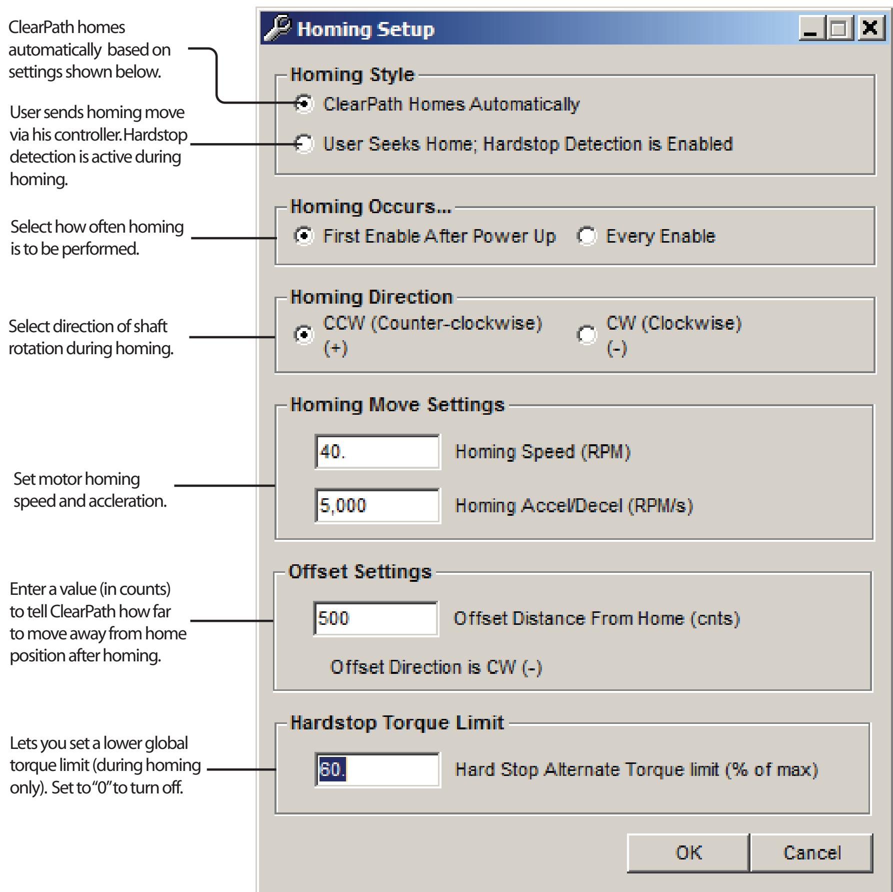
INPUT RESOLUTION

Input resolution is defined as the number of pulses that must be sent to the motor's input (Input B in this mode) to make the shaft rotate exactly one revolution. Changing this setting does not change the encoders native or commandable resolution.

HOMING SETUP (HARD STOP HOMING)

In this mode, ClearPath can be configured to home to a hard stop to establish a home reference position before functional positioning begins.

1. Install a hard stop that guarantees the moving element of the axis makes solid, repeatable contact with the stationary element when driven into it.
2. Enable homing in MSP.
3. Click the Setup button to open the homing dialog.
4. Enter homing parameters in the setup window.
5. Test and modify your homing setup for consistent, repeatable performance.



Homing Setup dialog

Operational Modes: SDSK and SDHP

The ClearPath SD (Step and Direction) family was designed to replace stepper motor and drive systems with a single, cost-effective unit.

Note: ClearPath SDSK and SDHP models accept **quadrature AB** signal sources as well as **step and direction** signals.

Step and Direction Input

Available on
SDSK + SDHP

Mode Summary

You provide standard step and direction signals and ClearPath faithfully follows them. Use the included RAS (Regressive Auto Spline) feature to smooth the motion profile. This mode is great for replacing stepper motor and drive systems with a single, compact device that costs less and does more.

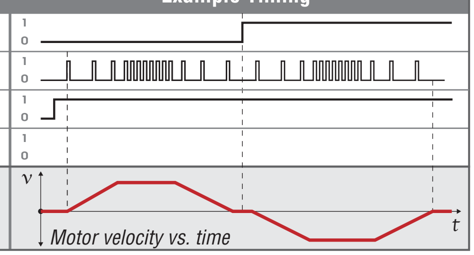
How it Works

Assert the Enable Input to energize the motor. Then, supply standard step and direction pulses to Inputs A and B to command motion. This model requires step and direction signals from an external indexer, controller, or similar.

Stepper Replacement Step and Direction Input Control

Signal	Function	Input Type	Example Timing
Input A	Direction	Logic: High=CW Low=CCW	
Input B	Step	Pulse: Digital Step Input	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	

Notes: ClearPath requires a **minimum pulse width = 1uS**. Pulses less than < 1uS will be filtered out as noise by ClearPath.



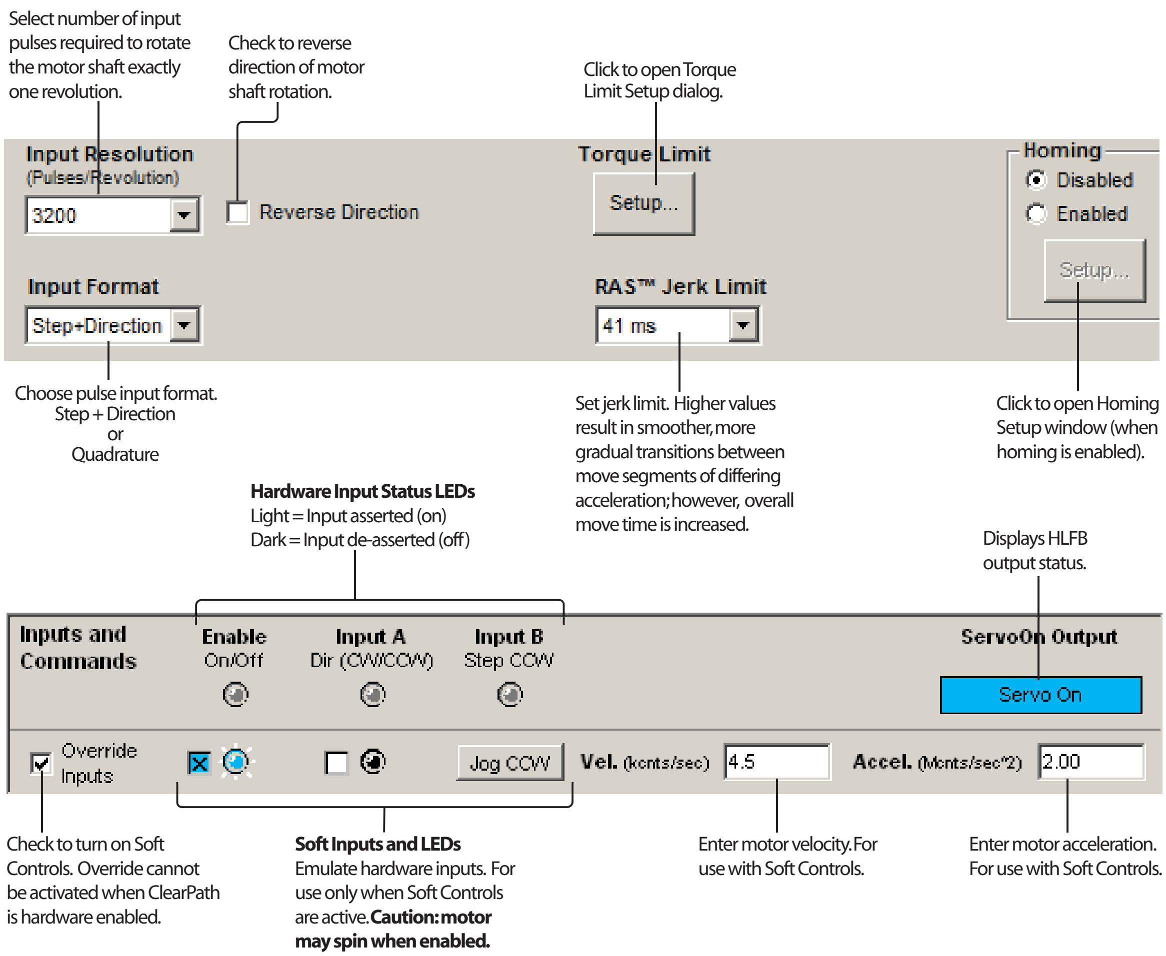
all_cpm

Step and Direction Inputs and Timing

Notes:

- Minimum pulse on/off time = 1uS. See diagram next page for step and direction timing information.
- Motion occurs on the rising edge of each step input pulse.
- Time before Disable = 10 mS

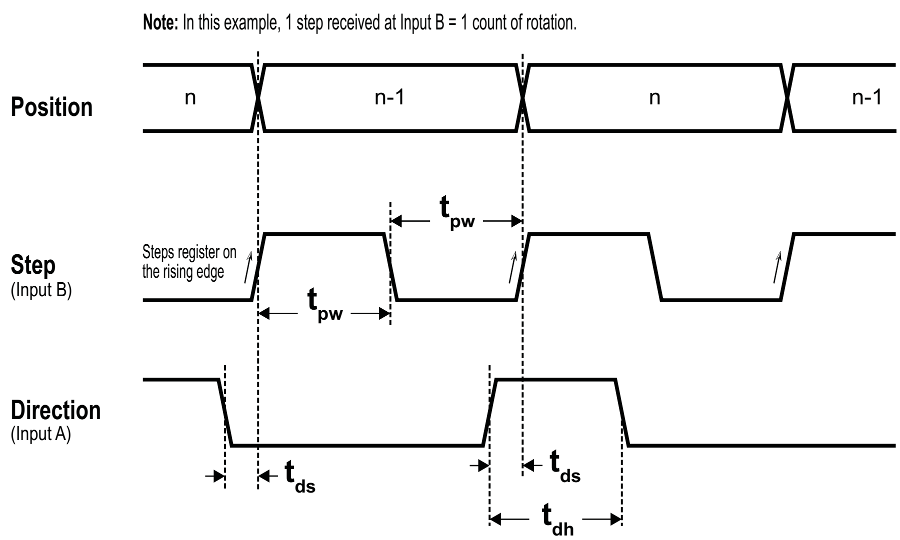
Mode Controls



STEP AND DIRECTION TIMING

The ClearPath Step Input is "positive edge-triggered", so ClearPath registers a step only when Input B sees the rising edge of a step input pulse (i.e. an electrical transition from low to high). Refer to the diagram below for details and important step and direction signal timing requirements.

Note: ClearPath can be configured to move one count for each step received, or one count per [x steps] received, based on the Input Resolution setting.



t_{pw} *Minimum* step pulse width = 1uS

t_{ds} Minimum time between direction change and step input change = 25nS

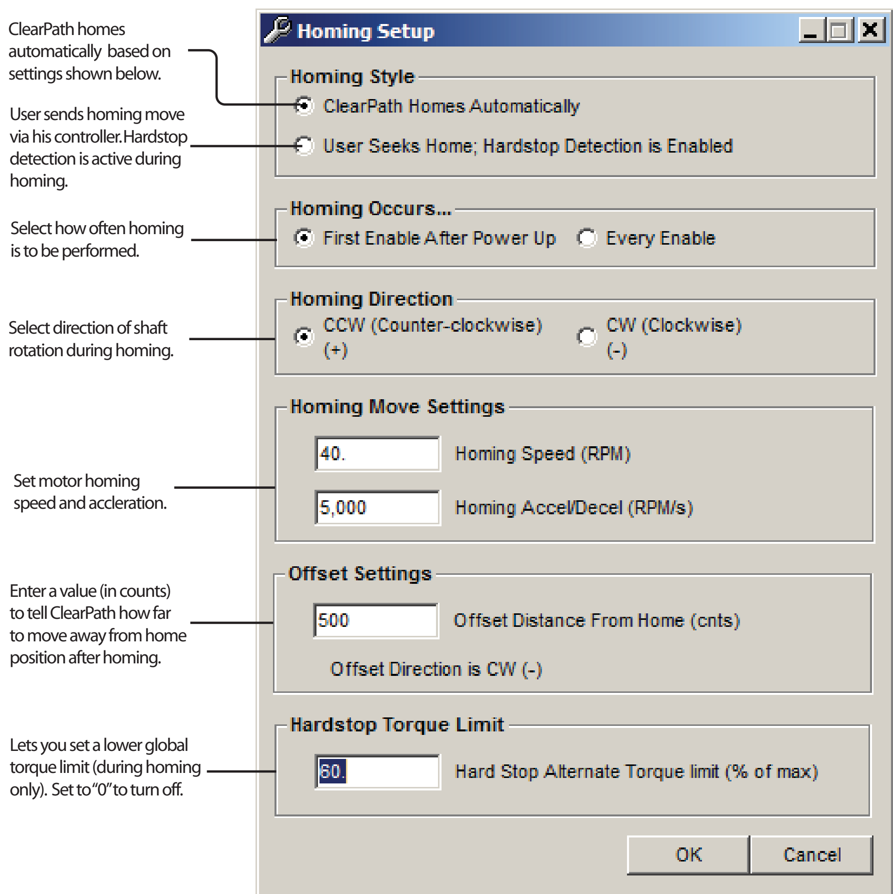
t_{dh} Minimum direction hold time = 1uS

ClearPath step and direction timing

HOMING SETUP (HARD STOP HOMING)

In this mode, ClearPath can be configured to home to a hard stop to establish a home reference position before functional positioning begins.

1. Install a hard stop that guarantees the moving element of the axis makes solid, repeatable contact with the stationary element when driven into it.
2. Enable homing in MSP.
3. Click the Setup button to open the homing dialog.
4. Enter homing parameters in the setup window.
5. Test and modify your homing setup for consistent, repeatable performance.



Hard Stop Homing Setup

QUADRATURE INPUT

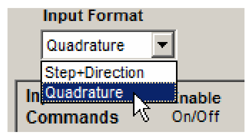
Available on
SDSK + SDHP

MODE SUMMARY

You send 2-channel quadrature signals and ClearPath moves in response. This mode is great for replacing quadrature driven stepper systems with a single compact device that costs less and does more.

HOW IT WORKS

To get started, select "Quadrature" from the Input Format drop down menu in the Mode Controls section.

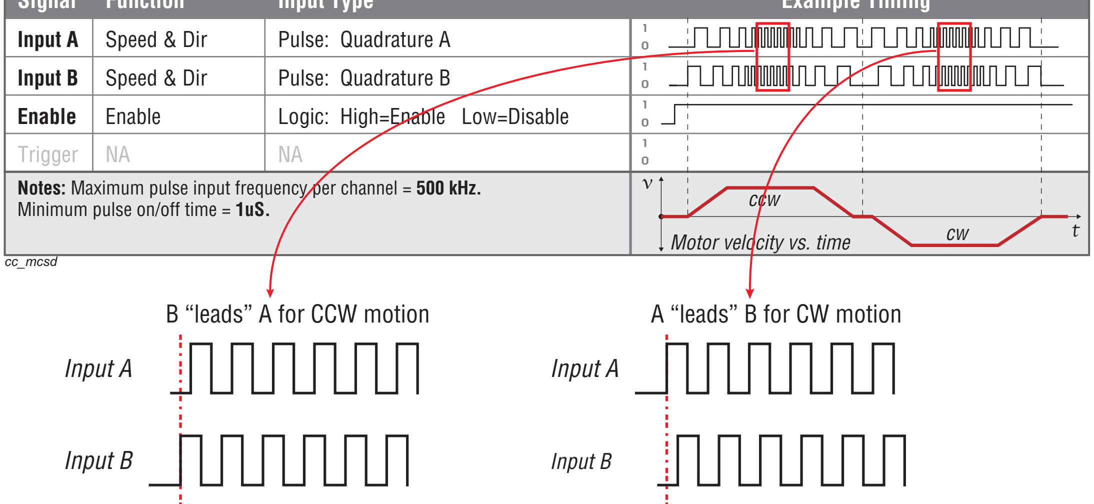


Assert the Enable Input to energize the motor. Then, send quadrature pulses from an external indexer or controller to ClearPath Inputs A and B to command motion.

Stepper Replacement **Quadrature Signal Control**

Signal	Function	Input Type	Example Timing
Input A	Speed & Dir	Pulse: Quadrature A	
Input B	Speed & Dir	Pulse: Quadrature B	
Enable	Enable	Logic: High=Enable Low=Disable	
Trigger	NA	NA	

Notes: Maximum pulse input frequency per channel = **500 kHz.**
Minimum pulse on/off time = **1uS.**

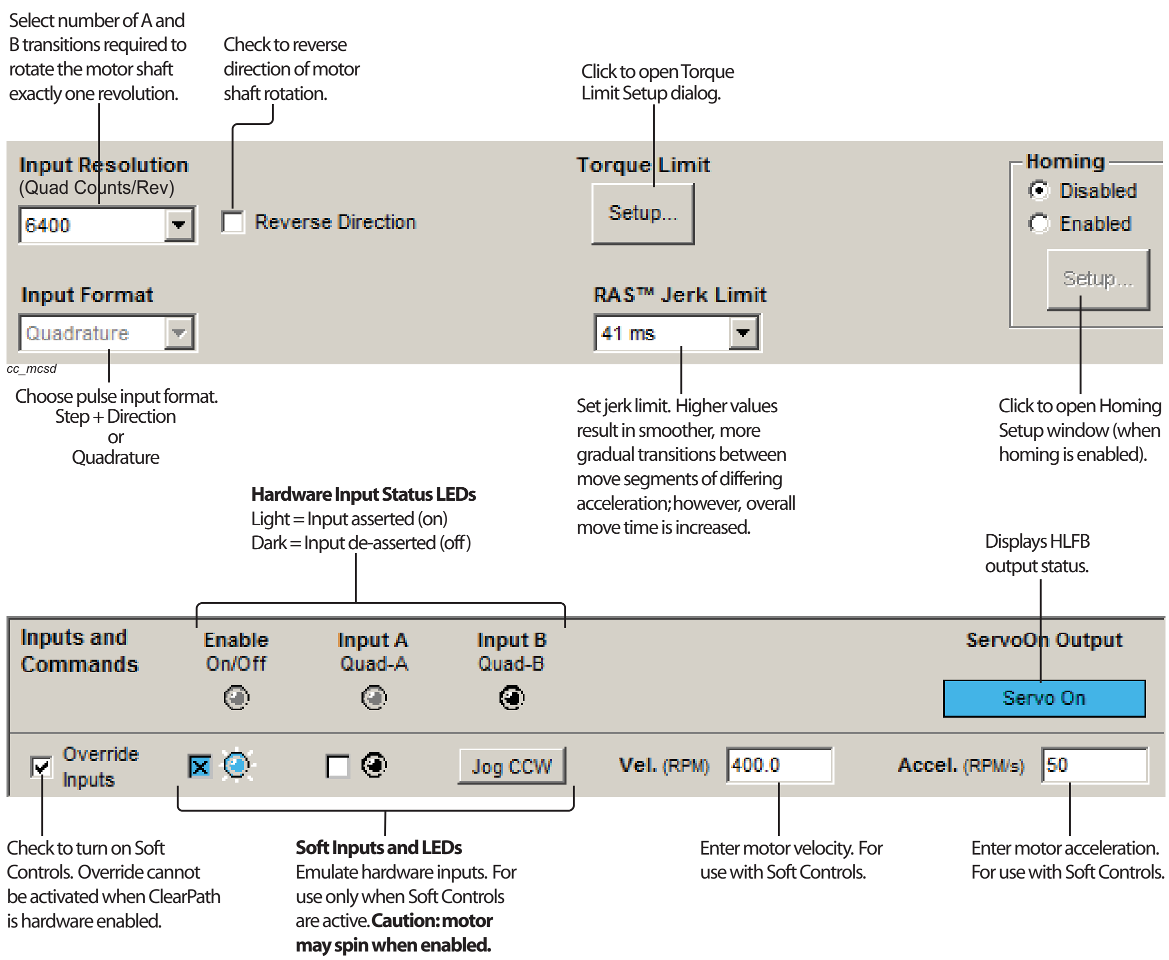


Step and Direction Inputs and Timing

Notes:

- Input B must lead Input A for CCW motion; Input A must lead Input B for CW motion.
- Minimum pulse on/off time = 1uS.
- Minimum time between adjacent channel transitions = 25nS.
- Time before Disable = 10 mS.

MODE CONTROLS



INPUT RESOLUTION SETTING

The Input Resolution setting provides a simple way to change the ratio of quadrature counts input to encoder counts moved.

Example 1) For a motor with a 6400 count/revolution encoder, setting the Input Resolution to **6400 quadrature counts/rev. results in a simple 1:1 relationship.** This just means that for each quadrature count seen at the ClearPath input, the motor shaft will rotate exactly 1 encoder count.

Example 2) For the same 6400 count motor, a setting of **800 quadrature counts per rev. results in a 1:8 relationship**. Thus, 1 quadrature count seen at the input will result in 8 encoder counts of motion at the shaft.

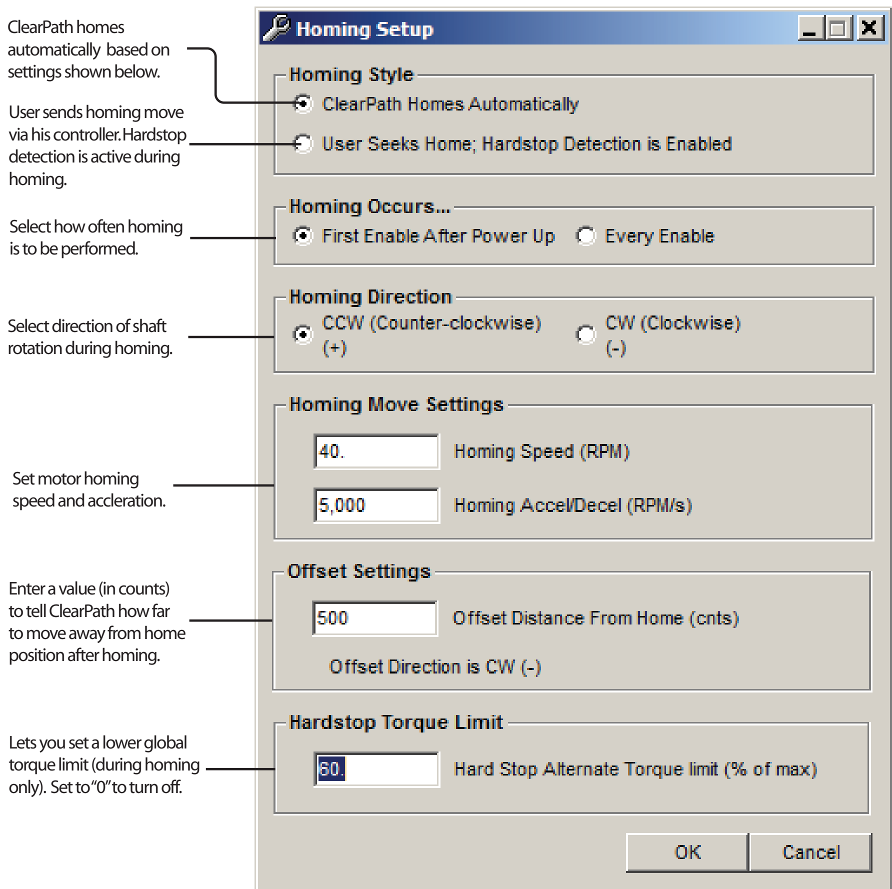
Available Input Resolution Settings

Input Resolution choices are 200, 400, 800, 1600, 3200, 6400, 12800, 25600, and 51200 quadrature counts per revolution.

HOMING SETUP (HARD STOP HOMING)

In this mode, ClearPath can be configured to home to a hard stop to establish a home reference position before functional positioning begins.

1. Install a hard stop that guarantees the moving element of the axis makes solid, repeatable contact with the stationary element when driven into it.
2. Enable homing in MSP.
3. Click the Setup button to open the homing dialog.
4. Enter homing parameters in the setup window.
5. Test and modify your homing setup for consistent, repeatable performance.



Hard Stop Homing Setup

APPENDIX A: LED BLINK CODES

Note: In cases where multiple exceptions use the same blink code, connect ClearPath to a PC running MSP to read exception type.

LED Activity	Exception Type	Affect on Motion	Servo Status	How to Clear Exception	Status or Exception Message Reported in UI
No LED Activity	N/A	N/A	Servo off	N/A	**No (or low) Power** Verify power is correctly wired and within specified voltage range.
Yellow – on solid	N/A	N/A	Servo off	N/A	**Status: Disabled** Motor power is turned off.
Yellow - flicker	N/A	N/A	Servo on	N/A	**Status: Performing Commutation Start-up**
Green - flicker	N/A	N/A	Servo on	N/A	**Status: Enabled** Motor power is on. ClearPath will respond to motion commands.
Yellow - 2 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**User Stop** ESC key or button was pressed by the user.
Yellow - 2 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Motor Enable Conflict** The hardware inputs did not match the active software override inputs when the motor was enabled via the hardware enable line.
Yellow - 3 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Max Bus Voltage Exceeded** Probable cause: high AC line voltage, large regenerated voltage upon deceleration.
Yellow - 3 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Power Event Detected** Probable cause: Dropped AC phase; Bus volts under operating voltage.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Command Speed Too High** Probable cause: commanded speed/velocity is beyond motor spec.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Tracking Error Limit Exceeded** Possible causes: excessive friction, mechanical misalignment, vel/accel too high, low DC bus voltage.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**RMS Torque Limit Exceeded** Possible causes: excessive friction, mechanical misalignment, duty cycle too high, undersized motor.
Yellow - 4 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Excessive Bus Current** Probable cause: bad tuning, low bus voltage.
Yellow - 5 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Excessive Motor Temp** Possible causes: ambient temperature too high for motor load; poor cooling; fan not running (if used).

LED Activity	Exception Type	Affect on Motion	Servo Status	How to Clear Exception	Status or Exception Message Reported in UI
Yellow – 6 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Momentary Low Bus Voltage** Power supply drooped below 18V, insufficient current capabilities, and/impedance too high.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Old Config File Version** Probable cause: Firmware updated after config file was saved. Create or load new config file.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Motor Phase Overload** Phase current is beyond allowed ADC limit. Probable cause: incorrect tuning or wrong config file.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Hard Stop Gave Way** A mechanical hard stop was detected during homing but it gave way before homing was completed.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Excessive Bus Current** Probable cause: bad tuning, low bus voltage.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Commutation Startup Error** DC bus too low for proper commutation start-up. Possible causes: brown out, incorrect power supply voltage, supply configured for higher AC line voltage.
Yellow - 7 blinks	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Old Config File Version** Load config file compatible with motor's firmware version, or reset motor to factory defaults.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Velocity Set Too High** Velocity/speed limit exceeds motor's factory-set maximum speed.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**RAS Change Rejected** Unexpected error. Contact Teknic for work-around or new firmware.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**Speed Too High For RAS** Unexpected error. Contact Teknic for work-around or new firmware.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**MagAlign Distance Error** Distance traveled does not match expected value. Possible cause: motor against an end stop, incorrect motor settings.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**MagAlign Direction Error** Direction traveled is incorrect. Probable cause: external forces during MagAlign procedure.
Yellow - strobe	Shutdown	Disallows motion	Servo off	Toggle Enable input	**DSP Watchdog Restart** Firmware problem. Re-flash firmware with same or newer firmware version. Return unit to Teknic if problem not solved.

LED Activity	Exception Type	Affect on Motion	Servo Status	How to Clear Exception	Status or Exception Message Reported in UI
Green/Yellow alternating	Lockdown	Disallows motion	Servo on	Toggle Enable input	**Travel Limits Violated (lockdown)** Commanded position is on the wrong side of the home position.
Green/Yellow alternating	Lockdown	Disallows motion	Servo on	Toggle Enable input	**Travel Limits Violated (lockdown)** Commanded position is beyond the Max Travel from Home position as specified in Homing Setup.
Green/Yellow alternating	Lockdown	Disallows motion	Servo on	Toggle Enable input	**Motor Enable Conflict** The hardware inputs did not match the active software override inputs when the motor was enabled via the hardware enable line.
Green – 2 blinks	Warning	Allows motion (if cause is no longer present)	Servo on	Auto-clears at start of next move if cause is no longer present	**Travel Limits Violated (warning)** Commanded position is on the wrong side of the home position.
Green – 2 blinks	Warning	Allows motion (if cause is no longer present)	Servo on	Auto-clears at start of next move if cause is no longer present	**Travel Limits Violated (warning)** Commanded position is beyond the Max Travel from Home position as specified in Homing Setup.
Green – 2 blinks	Warning	Allows motion (if cause is no longer present)	Servo on	Auto-clears at start of next move if cause is no longer present	**Move Buffer Underrun** Possible causes: move increments too small or sent too slowly.
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Torque Saturation** Power supply may be insufficient for application; Torque Limit may be set too low for command. Try lowering velocity and/or acceleration.
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Voltage Saturation**
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Over Speed**
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Over Temp** Internal electronics above shutdown threshold. Add fan.
Green - 3 blinks	Alert	Allows motion	Servo on	Auto-clears when cause is no longer present	**Power Event Detected (warning)** Probable cause: Dropped AC phase; Bus volts under operating voltage.
Red Toggle	Motor Failure	Disallows Motion	Servo off	Not clearable (typically)	**Motor Has Failed** Return to Teknic for repair or replacement.

If ClearPath shows no LED activity

During operation, if ClearPath DC bus voltage droops below approximately 18VDC, the following will occur:

- ClearPath will go into a shutdown state.
- The LED will turn off. Note: ClearPath will continue to communicate if voltage remains high enough.

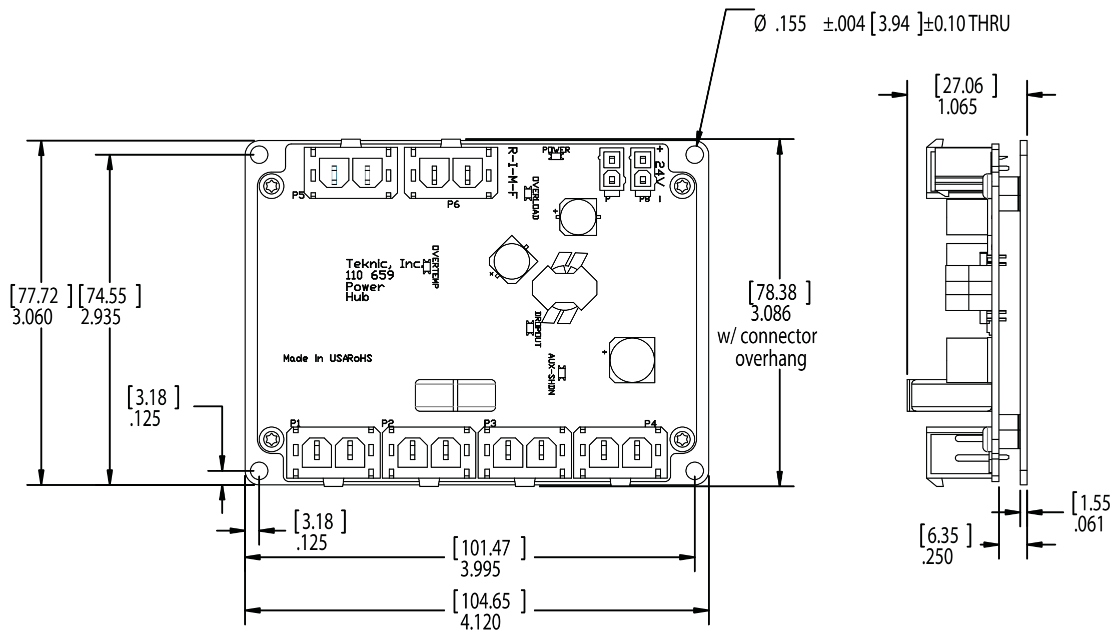
- The LED will remain off. Toggling the Enable *will not* clear this shutdown.

Once voltage returns to approximately 20VDC or higher:

- ClearPath will remain in a shutdown state but the LED will “wake up” and flash a yellow blink code 6 (see table above for complete description of this exception code).
- At this point, toggle the enable to clear the shutdown.

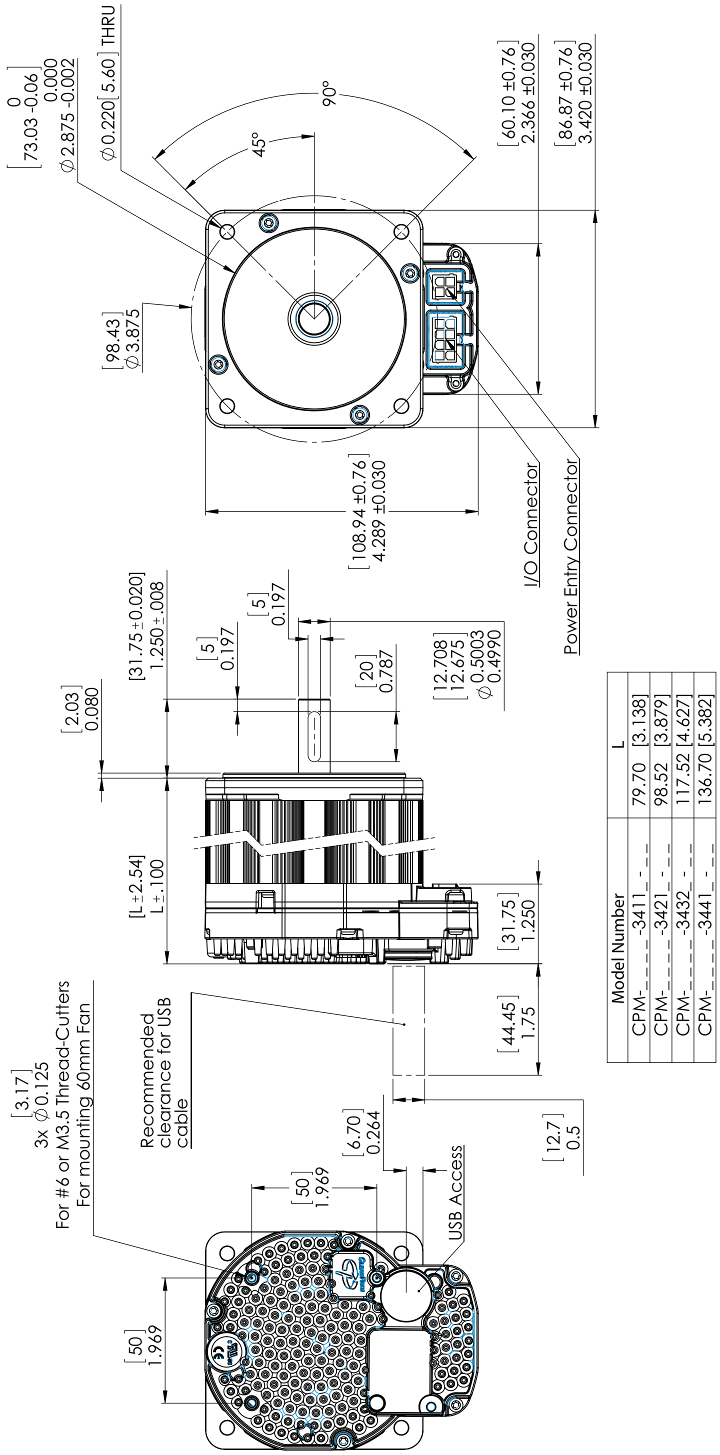
APPENDIX B: MECHANICAL INSTALLATION

MOUNTING DIMENSIONS: POWER HUB



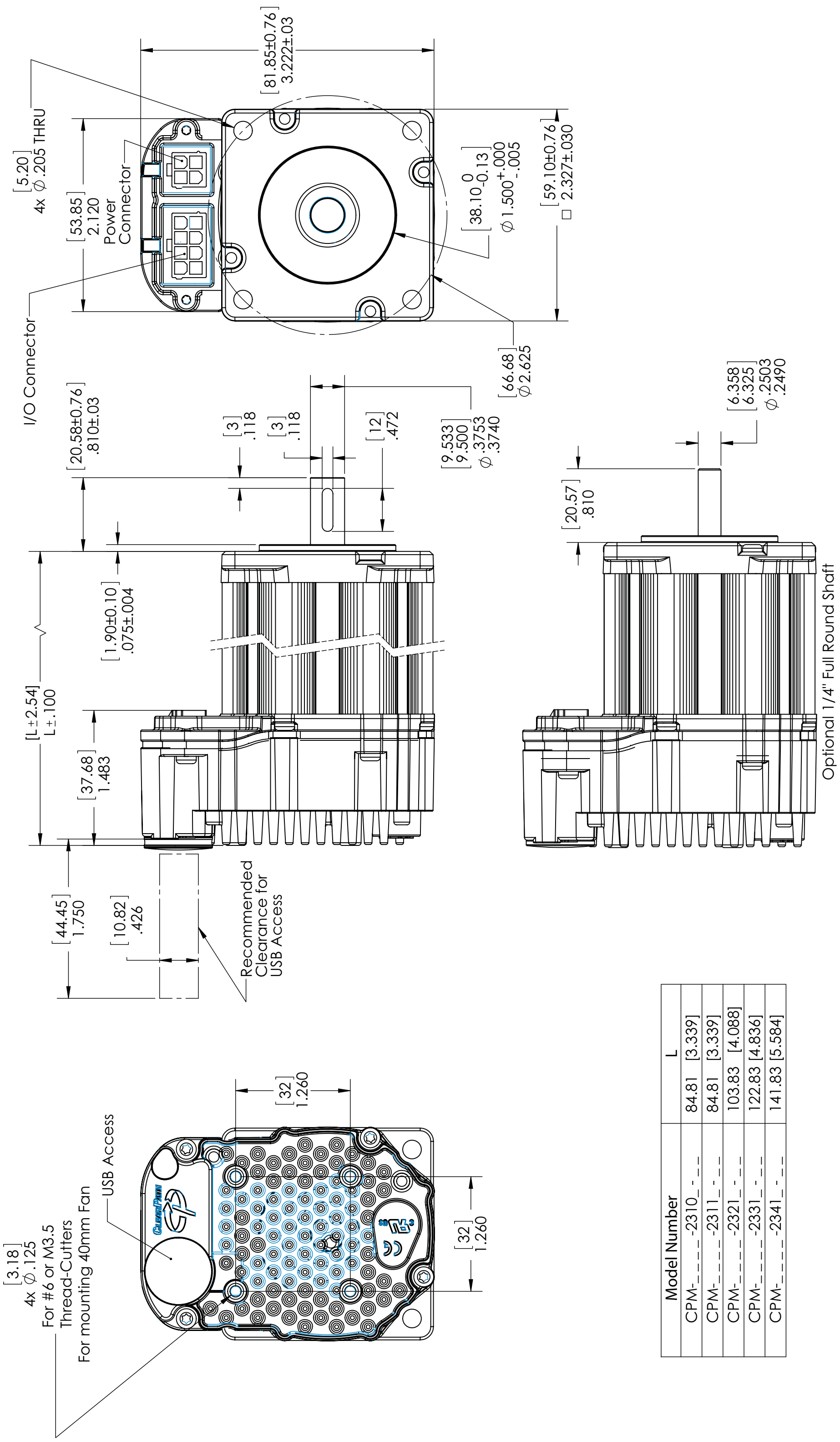
Power Hub Mounting Dimensions

MOUNTING DIMENSIONS: CLEARPATH NEMA 34



Model Number	L
CPM-____-3411_-__	79.70 [3.138]
CPM-____-3421_-__	98.52 [3.879]
CPM-____-3432_-__	117.52 [4.627]
CPM-____-3441_-__	136.70 [5.382]

MOUNTING DIMENSIONS: CLEARPATH NEMA 23



Model Number	L
CPM-_ _ _ _-2310_ - _ _	84.81 [3.339]
CPM-_ _ _ _-2311_ - _ _	84.81 [3.339]
CPM-_ _ _ _-2321_ - _ _	103.83 [4.088]
CPM-_ _ _ _-2331_ - _ _	122.83 [4.836]
CPM-_ _ _ _-2341_ - _ _	141.83 [5.584]

Motor Mounting Considerations

Tip: Teknic recommends mounting the motor such that the USB port and status LED are visible and accessible when the motor is mounted to the machine.

- **Do not** mount ClearPath over a heat source such as a power supply, spindle drive, etc. ClearPath will automatically shut down if its internal temperature exceeds specifications.
- **Do not** mount ClearPath in an unventilated enclosure.
- **Do** allow for at least 1" of space around each ClearPath.
- ClearPath can be fitted with an external accessory fan if desired. See ***Fan Mounting and Cooling*** later in this section for details.

Connecting ClearPath to a Mechanical System

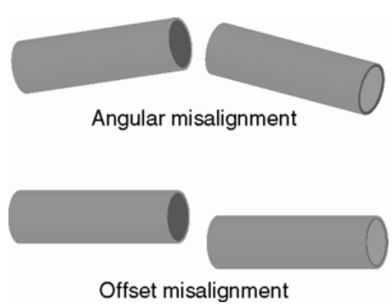
While it's obvious that ClearPath must be connected to a mechanical system to do useful work, it's not always clear just how to connect the motor to the mechanics.

Problems arise when a connecting element (such as a coupling) slips, exhibits excessive backlash, or can not accommodate typical shaft-to-shaft misalignments. Ultimately, the choice of shaft interface or coupling depends on the application, whether a precision positioning stage or a low speed conveyor.

The shaft interface (coupling, pulley, pinion, etc.) must be securely clamped to the shaft with minimum backlash (ideally none). This primary mechanical interface is critical in achieving and maintaining the best possible performance from a servo motion system.

Motor Connection: General Tips and Guidelines

- **Align with care.** When connecting two shafts—such as a motor shaft to a screw shaft—the rotating centers must be carefully aligned in both the angular and offset sense (including offsets/adjustments for thermal growth) to achieve the best possible motion quality and longest motor/bearing life.



Some couplings are more forgiving of misalignment than others, but in general, misalignment will cause undesired vibration/noise, shortened bearing life, and even broken motor shafts.

- **Use lightweight components.** Aluminum couplings, pinions, and pulleys add significantly less inertia to the motion system than steel parts of the same size. In most applications, lower inertia is preferable because it allows the motor (and attached mechanics) to accelerate harder and move and settle faster.
- **Avoid using set screws.** Coupling devices with set screws are prone to failure and often become the weak link when joining a motor to a load. Set screws deform the metal around the screw's point of contact, often resulting in a raised bur on the shaft that can make it hard to remove and replace the coupling element. Set screws also tend to slip and score the shaft.
- **Tip:** Couplings, pulleys and pinions with circumferential clamping mechanisms tend not to damage motor shaft, hold better, and are easier to replace than those that use set screws.
- **Clamp close to the motor.** For maximum performance, secure pulleys and pinions as close to the motor face as is practical. This effectively reduces the lever arm (and associated bearing load) for applications with a side load.
- **Don't over tighten belts.** Always read the belt manufacturer's guidelines for proper belt tension, but never exceed the ClearPath specification for maximum side load. Overly tight belts put undue stress on the motor shaft and bearing systems that can result in premature bearing and shaft failure.
- **Avoid using shaft keys when possible.** Although ClearPath includes a keyway feature on the shaft, Teknic does not generally recommend the use of keys. Keys tend to cause run-out and backlash errors, particularly in reciprocating, precision positioning motion applications.

  However, keys *should be* considered for use in applications where coupling slip could result in a dangerous or hazardous condition. Also, key use may be appropriate for unidirectional applications (where the motor always spins in the same direction) as these applications are less prone to key-related lash problems.
- **Avoid direct loads.** In general, ClearPath motors are not designed for connection to direct loads (e.g. direct connection to a grinding wheel). However, direct connection may make sense if the load is of low-mass and balanced, as with small mirrors for laser applications.

NOTES ON COUPLING SELECTION

A complete coverage of the topic *Coupling Selection for Servo Applications* is beyond the scope of this document, but many articles and resources can be found on the web for those interested in learning more. Because there are so many different coupling styles and applications, selecting the "right" coupling for a particular application can be challenging.

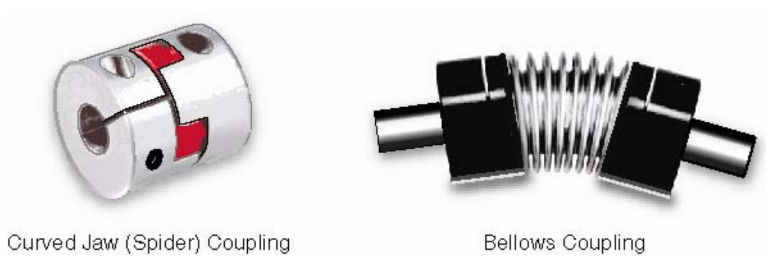
General Guidelines for Coupling Selection

Teknic has a few guiding principles when it comes to coupling selection for servo applications. Keep in mind that these are rules of thumb and may not apply to every application. In general:

- **Don't** undersize the coupling. Understand how much torque your application requires and stay within the coupling manufacturers specifications. Always leave reasonable engineering margin.
- **Don't** use set screw type couplings. They damage the motor shaft and tend to be less reliable over time than clamp style couplings.
- **Do** use clamp style couplings. These clamp around the circumference of the shaft at one or two points without deforming the shaft surface.
- **Don't** use rigid couplings—they are notoriously intolerant of misalignments.
- **Don't** use beam style (helical) couplings if vibration damping or torsional stiffness is critical to your application. Beam couplings tend to resonate/whine at higher speeds.
- **Don't** use any coupling that requires you to drill into, deform, or "pin" the motor shaft.

Coupling Recommendation

Teknic often recommends **zero-backlash curved jaw couplings** (commonly referred to as "spider couplings") as a good choice for many servo applications. These couplings are moderately priced and widely available from well established manufacturers such as Ruland.



Couplings for servo applications

Note: Curved jaw couplings (also known as spider couplings) are a good choice for many applications, but cannot tolerate a great deal of misalignment or axial motion. Also, never exceed the manufacturer's rating for "maximum torque with zero backlash" when using jaw couplings.

Bellows couplings are also excellent for high precision positioning applications. Bellows couplings allow for more misalignment than jaw couplings but are generally more expensive.

Both curved jaw and bellows coupling offer excellent positioning accuracy, high speed performance, and vibration damping when installed and operated within the manufacturer's specifications and guidelines.

Coupling Information on the Web

Ruland's website has a good collection of technical information on coupling types and coupling selection for servo systems. Click here for access to technical articles, videos, and CAD drawings. Or go to http://www.ruland.com/a_articles.asp.

INSTALLING PULLEYS AND PINIONS

PULLEY AND PINION MOUNTING

- Always follow the manufacturers mounting guidelines.
- Mount pulleys and pinions as close to the motor face as possible while still following the manufacturer's installation guidelines.
- Never drill through, "pin", or deform the motor shaft when mounting a pulley or pinion.

Application Tip: To prevent loosening/slip, some users bond their pulleys and pinions to the motor shaft with a high strength adhesive such as Loctite #638. While this is very effective in preventing pulley slip, it can be difficult to undo once the adhesive has cured.

ABOUT END-OF-TRAVEL STOPS

End-of-travel stops are typically installed to prevent the moving element of a linear axis from flying off the machine in the event of a use or control error. There are a few common types of end stop to consider, but the final choice depends on the application objectives and requirements.

HARD BLOCKS

This is usually a solid block of steel, aluminum, or hard plastic secured at one or both ends of travel and positioned in such a way as to make even, repeatable contact with a hard surface on the moving element. Hard blocks are very effective at arresting motion, but can result in mechanical damage when struck at high speeds.

In several modes, ClearPath must home to a hard stop to establish a home reference position before functional positioning can begin.

ELASTOMERIC (RUBBER) STOPS

High durometer rubber stops (hard rubber) can also be used with applications that use HardStop Homing. This type of end stop offers a higher level of shock absorption and axis protection than hard blocks. Spongy, low durometer rubber stops are not recommended in most cases. They offer little benefit over a hard end stop during an axis crash.

PNEUMATIC (DASHPOTS)

Pneumatic hard stops (dashpots) offer excellent shock absorption performance but are considerably more expensive than hard blocks. Examples of specialized dashpots include the hydraulic cylinder in an automobile shock absorber as well as many automatic door closers.

END STOPS AND HARD STOP HOMING

End stops from medium durometer rubber to steel can be used successfully with Hard Stop Homing. When selecting end stops for a Hard Stop Homing application consider the following:

- Axes with low friction that are easily back driven can tolerate “softer” rubber end stops and still achieve good homing performance.
- Higher friction applications and those that cannot be back driven will generally require harder end stop material to achieve best Hard Stop Homing performance.
- Be prepared to test and experiment with different end block materials to ensure proper homing operation with your mechanical system.

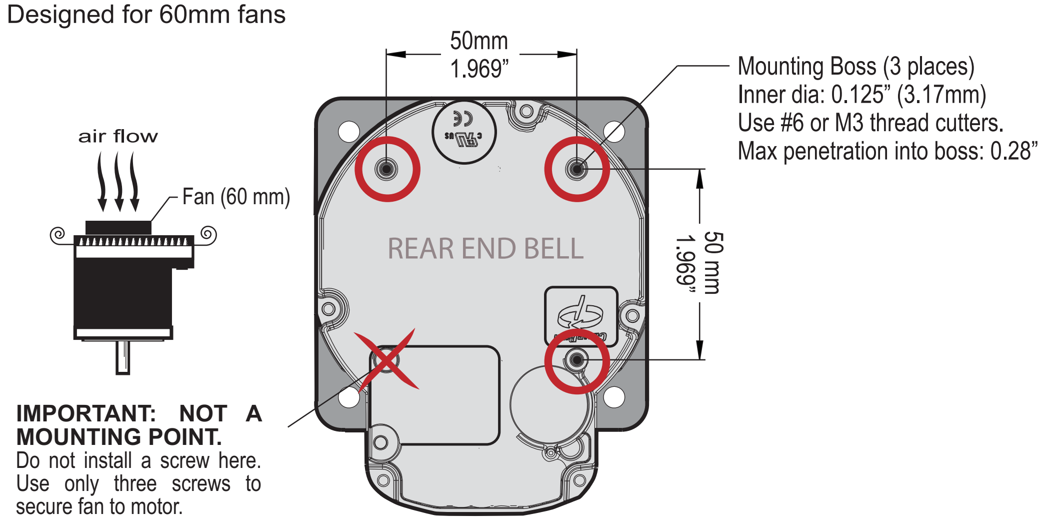
FAN MOUNTING AND COOLING

All ClearPath motors have unthreaded mounting bosses on the rear casting to accommodate a standard DC fan (60mm for NEMA 34 motors, or 40mm for NEMA23 size motors). See the diagram below for mounting dimensions, hardware and supported fan sizes. Teknic does not sell accessory fans, but they are readily available through electronics suppliers including Digikey and Mouser.

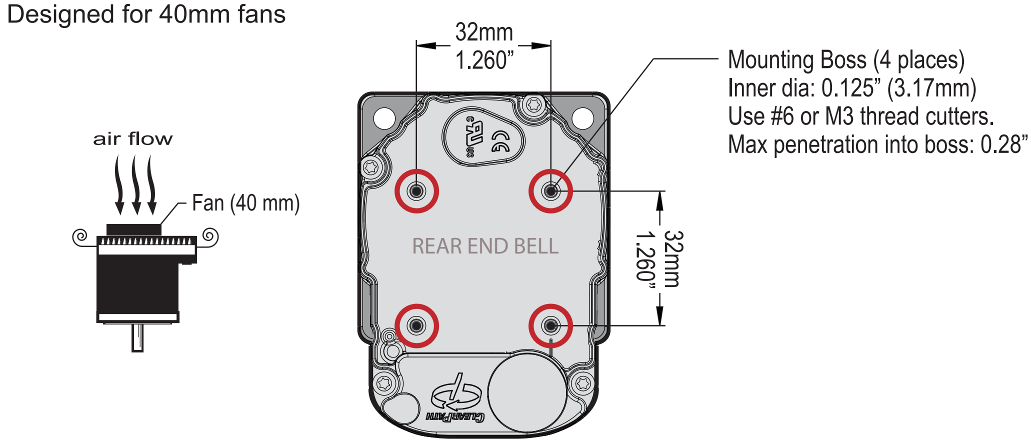
Note: As with all electronic products, *cooler is better* for longest life span. So, even though ClearPath can reliably operate at elevated temperatures (exceeding the ratings of most other motor drives) your system should always be designed with the best cooling you can reasonably provide.

Note: ClearPath will shut down to self-protect when the rear cover temperature reaches 80 degrees C.

ClearPath NEMA 34
Designed for 60mm fans

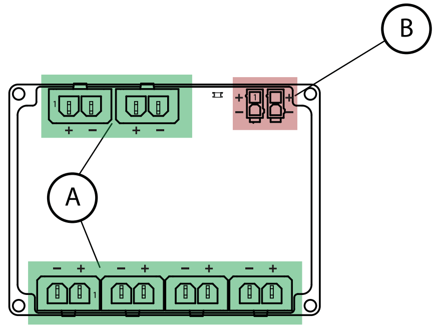


ClearPath NEMA 23
Designed for 40mm fans

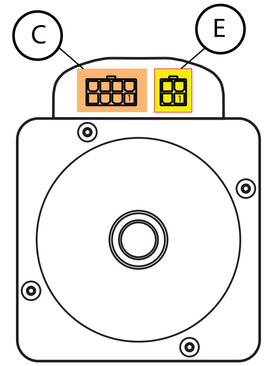


APPENDIX C: MATING CONNECTORS & CABLE PINOUTS

MATING CONNECTOR INFORMATION



POWER4- HUB



ClearPath Motor

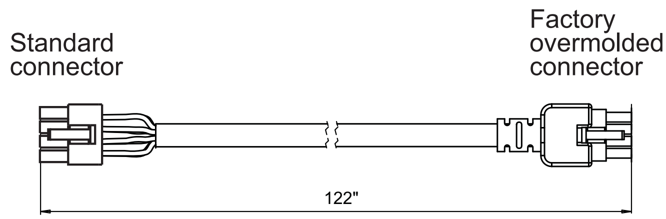
Parts listed in table manufactured by Molex Inc. Visit www.molex.com for complete specifications and application information.

Ref.	Description	Mating Connector PN	Terminal PN	Terminal Desc.	Crimp Tool	Extraction Tool	Recommended Wire Gauge[1]
A	Molex Sabre, Receptacle, 2 circuits	44441-1002 (natural, UL 94V-2) 44441-2002 (black, UL 94V-0)	43375-0001	Female crimp terminal, tin plate, 14-16 AWG	63811-7200 (14-16 AWG)	63813-2700	16 AWG
B	Molex MiniFit-Jr, Receptacle, 2 circuits	39-01-2020 (natural, UL 94V-2) 39-01-3025 (black, UL 94V-2) 39-01-3028 (natural, UL 94V-0) 39-03-9022 (black, UL 94V-0)	39-00-0059 (reel) 39-00-0060 (loose)	Female crimp terminal, tin plate, 18-24 AWG	63819-0900 (16-24AWG)	11-03-0044	20 AWG
C	Molex MiniFit-Jr, Receptacle, 8 circuits	39-01-2080 (natural, UL 94V-2) 39-01-3085 (black, UL 94V-2) 39-01-2085 (natural, UL 94V-0) 39-03-9082 (black, UL 94V-0)	39-00-0046 (reel) 39-00-0047 (loose)	Female crimp terminal, tin plate, 22-28 AWG	63819-1000 (22-28 AWG)	11-03-0044	22 AWG
D							
E	Molex MiniFit-Jr, Receptacle, 4 circuits	39-01-2040 (natural, UL 94V-2) 39-01-3045 (black, UL 94V-2) 39-01-2045 (natural, UL 94V-0) 39-03-9042 (black, UL 94V-0)	39-00-0077 (reel) 39-00-0078 (loose)	Female crimp terminal, tin plate, 16 AWG	63819-0900 (16-24 AWG)	11-03-0044	16 AWG

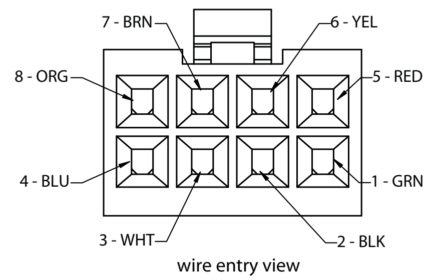
[1]AWG values listed are the actual wire gauges used in Teknic-manufactured cables.

CABLE PINOUT: CPM-CABLE-CTRL-MU120

Cable description: ClearPath I/O connector cable. Overmolded Molex MiniFit Jr. 8-position connector to standard MiniFit Jr. 8-position connector (no over-mold on one end for easy access to wires).

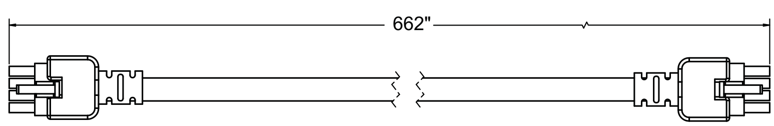


Pin Assignments		
Pin	Color	Name
1	GRN	HLFB +
2	BLK	Input B +
3	WHT	Input A +
4	BLU	Enable +
5	RED	HLFB -
6	YEL	Input B -
7	BRN	Input A -
8	ORN	Enable -

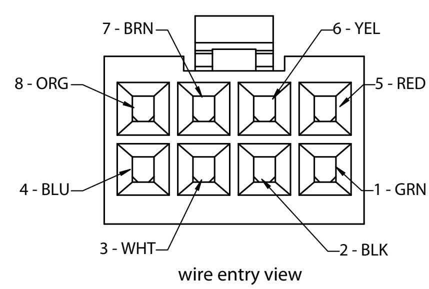


CABLE PINOUT: CPM-CABLE-CTRL-MM660

Cable description: ClearPath I/O connector cable (double-ended). Molex MiniFit Jr. 8-position connector to same. Use "as is" or cut in half to make two cables with flying leads.

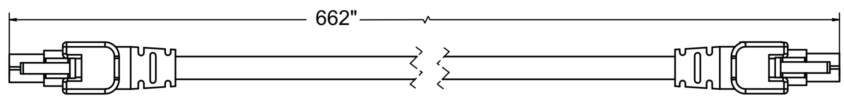


Pin Assignments		
Pin	Color	Name
1	GRN	HLFB +
2	BLK	Input B +
3	WHT	Input A +
4	BLU	Enable +
5	RED	HLFB -
6	YEL	Input B -
7	BRN	Input A -
8	ORN	Enable -

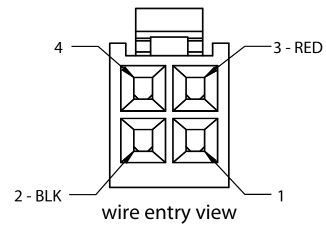


CABLE PINOUT: CPM-CABLE-PWR-MM660

Cable description: ClearPath power cable (double-ended). MiniFit Jr. 4-position connector to same. Use “as is” or cut in half to make two cables with flying leads.

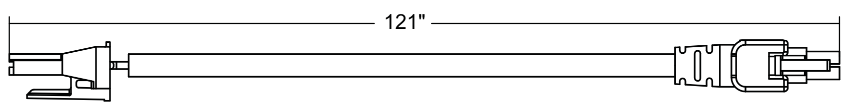


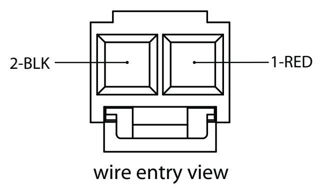
Pin Assignments		
Pin	Color	Name
2	BLK	GND
3	RED	V+

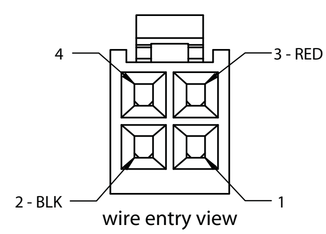


CABLE PINOUT: CPM-CABLE-PWR-MS120

Cable description: ClearPath power cable. This cable connects the DC output of a Teknic IPC-3 or IPC-5 power supply to the ClearPath power input connector. It features a Sabre 2-position connector to Molex MiniFit Jr. 4-position connector.







Pin Assignments		
Pin	Color	Name
1	RED	V+
2	BLK	GND

Pin Assignments		
Pin	Color	Name
2	BLK	GND
3	RED	V+

APPENDIX D: COMMON SPECIFICATIONS

Electrical Power Requirements:	
Supply Voltage, Typical:	24VDC to 75VDC
Supply Voltage, Absolute Min:	21.5VDC (as measured at input terminals)
Supply Voltage, Absolute Max:	90VDC (as measured at input terminals)
Continuous Bus Current, Typical:	1A to 4A (application dependent)
Continuous Bus Current, Maximum:	10A
Idle Power usage from Bus	4W (enabled, no torque used by axis or load) 3W (disabled)
Electrical I/O:	
Logic Input Voltage Range:	4.0VDC to 28VDC
Input Current @ 5V:	7.5mA (min.)
Input Current @ 28V:	12.0mA (min.)
HLFB Absolute Maximum Voltage	30VDC (across output terminals)
HLFB Output Current, Maximum:	9mA (non-inductive load)
HLFB Output voltage drop @ 2mA:	0.30VDC (+/- 100mV)
HLFB Output voltage drop @ 5mA:	0.55VDC (+/- 100mV)
Motor Bearing, NEMA34:	
Maximum Radial Load, NEMA34:	220N (50-lbs), applied 25mm (1.0in) from front bearing
Maximum Thrust Load, NEMA34:	44N (10-lbs)
Bearing Life, NEMA34:	2.4 x10^9 to 5.3 x10^9 revs (typ., load dependent.)
Motor Bearing, NEMA23:	
Maximum Radial Load, NEMA23:	110N (25 lbs), applied 25mm (1.0in) from front bearing
Maximum Thrust Load, NEMA23:	22N (5 lbs)
Bearing Life, NEMA23:	3.2 x10^9 to 5.0 x10^9 revs (typ., load dependent.)
Environmental:	
Shock (peak, maximum):	10G (applied no more than twice)
Vibration (RMS, 2 Hz-200 Hz):	1.0G or 0.5mm, whichever is less
Maximum External Shaft Deceleration:	250,000 rad/s^2
Maximum Ambient Operating Temp.:	For seasonal/intermittent duty: 70°C/158°F (RMS torque output de-rated) For continuous long-term use: 55°C/122°F (RMS torque output de-rated) For full-rated output speed/torque: 40°C/104°F
Maximum Body Temp.:	100°C
Maximum Rear Cover Temp.:	70°C
Storage Temperature:	-20°C to 85°C
Humidity:	0% to 95%, Non-Condensing
Recommended Optional Fan, NEMA23:	40mm square, 45.25 mm bolt center, >7CFM
Recommended Optional Fan, NEMA34:	60mm square, 70.71 mm bolt center, >14CFM
Environmental Sealing:	
Front Face, with shaft seal option:	IP65
Front Face, without shaft seal option:	IP53
Body/rear, with dielectric sealing grease in connectors	IP55
Body/rear, no sealing provisions	IP53
Compliance:	
Regulatory Certifications:	UL recognized, CE, RoHS
Electrical Safety:	UL508C, EN 61010-1
EMI:	EN 61326-1
Country of Origin:	USA
Warranty:	3 years

APPENDIX E: GROUNDING AND SHIELDING

PROTECTIVE EARTH (PE) CONNECTION

Compliance Note: ClearPath must be properly connected to the machine's Protective Earth terminal to meet EMC emissions specification EN-61000-6-4, and EMC immunity specification EN-61000-6-2, as well as EMC electrical safety specification EN-61010 (for CE/UL compliance).

Connect ClearPath to your machine's Protective Earth terminal (PE) using one of the following methods.

- **If the motor mounting plate is bonded to machine PE (typical),** most of the work is already done. Simply secure ClearPath to the mounting plate with conductive fasteners (don't use anodized or coated hardware). Ensure direct, bare metal-to-metal contact between the ClearPath motor face and mounting surface.
- **If the motor mounting plate *is not* bonded to machine PE** it's still easy to make a good PE connection. Just install a grounding wire from ClearPath's Auxiliary PE Connection Point (located on the motor's rear casting) to a point on the machine that is bonded to machine PE. **Use grounding wire with same AWG number (or heavier) as the ClearPath DC power input wiring.**

Note: In scenarios where ClearPath *is not* connected to a PE (Protective Earth) return path–such as during bench testing or maintenance–temporary grounding measures may be necessary to comply with safety requirements.

GROUNDING AND SHIELDING

- Always maintain separation between isolated control ground and power ground.
- Shielded cable is not required for ClearPath control cables.
- If you choose to use shielded control cable, connect the cable's isolated ground at one point (at the controller only). Do not hook isolated control ground to the machine frame or chassis at any other location.
- Do not ground ClearPath I/O circuits to the machine frame or chassis.

Note: All ClearPath I/O signals are electrically isolated from ClearPath's DC power input and motor output circuits, as well as from the motor case. This design feature helps to ensure that control signals aren't compromised by induced currents from the motor, power supply, or internal PWM.

POWER RETURNS

- Never use the machine frame or chassis as a power return. Use discrete cable or wires for all power wiring.
- Use only recommended wire gauge (16-18AWG typical) for all ClearPath power wiring. When in doubt, use heavier wire.

APPENDIX F: CLEARPATH PART NUMBER KEY

CPM - SDSK - 34 1 1 P - E L N

Teknic Product Identifier

CPM = ClearPath Motor.
Note: All ClearPath part numbers begin with CPM.

ClearPath Family/Model

MCPV = Motion Controller/Position, Velocity, Torque Modes
MCVC = Motion Controller/Velocity, Torque, 2 Position Modes
SDSK = Step and Direction/"Stepper Killer" (Typically 3x power of similar sized steppers)
SDHP = Step and Direction/High Power model

Motor Frame Size

23 = NEMA 23 frame size
34 = NEMA 34 frame size

Approximate Body Length (excludes shaft length)

1 = 82 mm
2 = 100 mm
3 = 120 mm
4 = 140 mm

Winding/Magnetic Structure

Indicates specific winding design
Note: Different designs offer different torque, speed, and power characteristics.

Motor Winding Type

S = Series-Wye *(higher torque, lower speed)*
P = Parallel-Wye *(in between S and D characteristics)*
D = Parallel-Delta *(higher speed, lower torque)*

Enhanced Options

R = Positioning Resolution of **800 counts per revolution**; Standard selection of RAS settings.
E = Positioning Resolution of **6400 counts per revolution**; Extended selection of RAS settings.
Note: MCVC available in R only. SDHP available in E only.
Note: All ClearPath models feature an internal encoder resolution of 12,800 counts per revolution.

Motor Shaft Diameter

L = Standard shaft diameter
Note: Standard diameter is 1/2" for NEMA 34 models and 3/8" for NEMA 23 models.
Q = 1/4" shaft diameter
Note: Q option available only on NEMA 23, 1 and 2 stack motors.

Shaft Seal

N = Standard dust sealing
S = Extra Vyton seal, for environments with strong abrasives, such as fiberglass, or where liquid exposure may occur
Note: Seal option S not available for 1/4" shaft diameter models.

APPENDIX G: ENCODER RESOLUTION

INTRODUCTION

This section discusses the following topics:

- ClearPath's Internal (native) Encoder Resolution versus Positioning Resolution.
- Understanding and using the Input Resolution setting for *Step and Direction* and *Pulse Burst Positionin*g applications.

TERMS USED IN THIS SECTION

Count (or "encoder count")

A count is the smallest increment of encoder/shaft motion that can be commanded at a given encoder resolution. This family of ClearPath motors come in either 800 or 6400 counts per revolution. See *Positioning Resolution*, next page.

Step (also called "step pulse", or just "pulse")

A step is an electrical pulse sent from a controller, PLC, indexer, etc. to the ClearPath motor's step input as a means of commanding motion. One step pulse sent to the ClearPath Step Input tells ClearPath to rotate the shaft one increment of motion. If the step-to-count ratio is 1:1, then 1 step will command 1 count of motion.

Steps per count

This is just the number of step pulses required to move the motor shaft one count. This is often set at 1:1, but can be adjusted using the Input Resolution setting in MSP (covered later in this section).

Counts per step

This is the number of counts the motor shaft will move for each step sent to the ClearPath Step Input. This is often set at a 1:1 ratio, but can be adjusted using the Input Resolution setting in MSP (covered later in this section).

NATIVE RESOLUTION

ClearPath motors described in this manual are all equipped with an incremental rotary encoder with a native resolution of 12800 counts per revolution. This "internal" resolution is used by the motor's motion algorithms, and is one of the factors behind ClearPath's high precision, highly repeatable motion performance.

POSITIONING RESOLUTION

Positioning Resolution—also called *"Commandable Resolution"*—is the ClearPath motor's working encoder resolution. This is the encoder resolution you specified when ordering your ClearPath. The two available

Positioning Resolution options for NEMA 23 and NEMA 34 ClearPaths are:

- **800 counts per revolution** (0.45° of rotation per count).
- **6400 counts per revolution** (0.05625° of rotation per count).

What is my motor's Positioning Resolution?

ClearPath part numbers ending in -**E**xx have a Positioning Resolution of 6400 counts per revolution (denoted by the bold "E").

Part numbers ending in -**R**xx has a Positioning Resolution of 800 counts per revolution (denoted by the bold "R").

See Appendix F, *Part Number Key*, for help decoding a ClearPath motor part number.

Input Resolution Setting in MSP

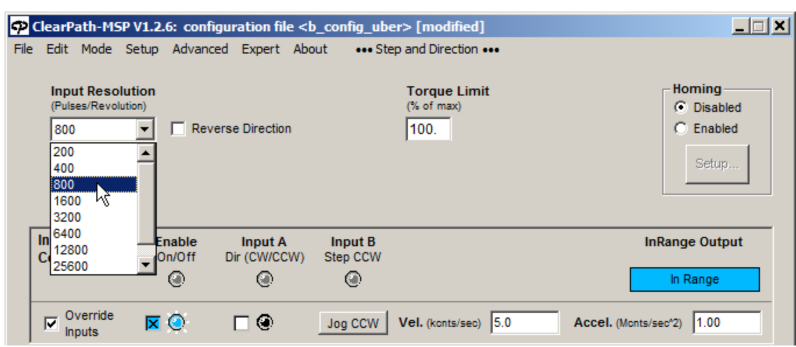
Note: This topic applies to Pulse Burst Positioning and *Step and Direction modes only.*

The **Input Resolution** setting lets you vary the ratio of step pulses to counts. It is set via a drop down menu in the mode settings of *Pulse Burst Positioning* and *Step and Direction* modes.

Input Resolution Use Cases

Note: *The examples and screenshots below are based on an* ***800 count per revolution*** *ClearPath motor.*

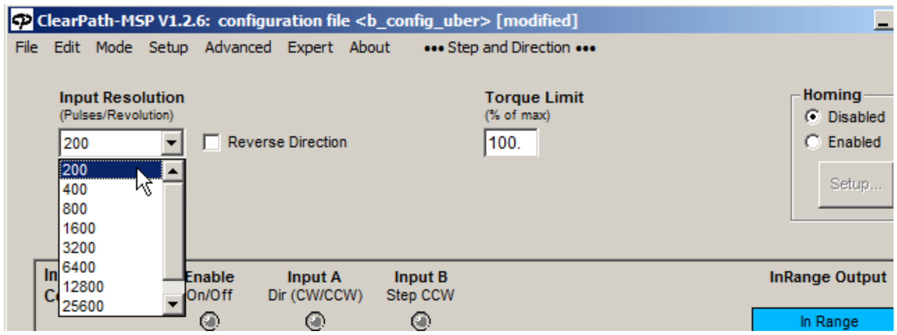
- **Case #1. You want one step pulse to command one count of motion (default).** One count per step is the most common Input Resolution setting.



Using the above setting, 800 step pulses will make this [800 count] motor rotate one full revolution.

Tip: To set a 1:1 (1 step = 1 count) relationship, set the Input Resolution to the same value as your motor's Positioning Resolution. Example: For an 800 count per revolution motor (as in the figure above) set Input Resolution to 800 pulses per rev. For a 6400 count per rev motor, set it to 6400 pulses per revolution.

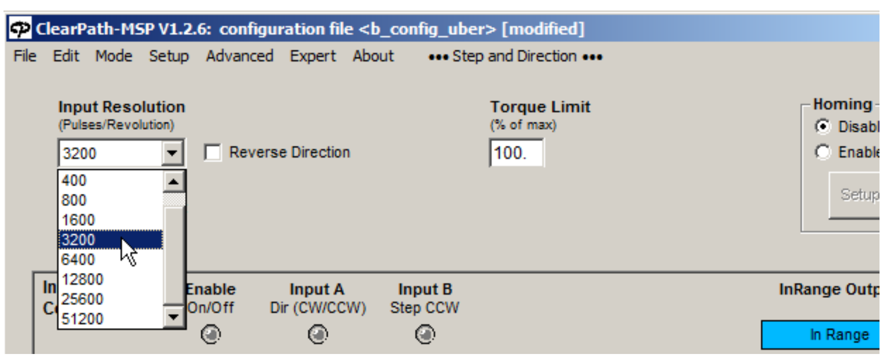
- **Case #2. You want one step pulse to command multiple counts of motion.** ClearPath can be configured such that a single step pulse commands 2, 4, 8, or more counts of motion. This strategy is most often used to compensate for a "slow" controller, i.e., a controller that can't put out step pulses fast enough to meet the user's velocity requirements.



With the above Input Resolution setting, it takes only 200 step pulses to make this [800 count] motor rotate one full revolution.

- **Case #3. You need multiple step pulses to command *one* count of motion.** This use case is less typical, but can be convenient if you happen to be replacing a stepper motor with a ClearPath, but the two motors have different positioning resolutions.

  In the below example, by selecting 3200 step pulses per revolution, the controller must send 4 step pulses to command a single count of motion, 8 steps to command two counts of motion, and so forth.



With the above Input Resolution setting, it takes 3200 step pulses to make this [800 count] motor rotate one full revolution.

INDEX

Teknic, Incorporated
115 Victor Heights Pkwy
Victor, NY 14564