# CLEARPATH USER MANUAL

MODELS MCVC, MCPV, SDSK, SDHP

NEMA 23 AND NEMA 34 FRAME SIZES

VERSION 3.05 MAY 7, 2019

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# TABLE OF CONTENTS

# 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 most ClearPath operational modes. 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

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[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

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

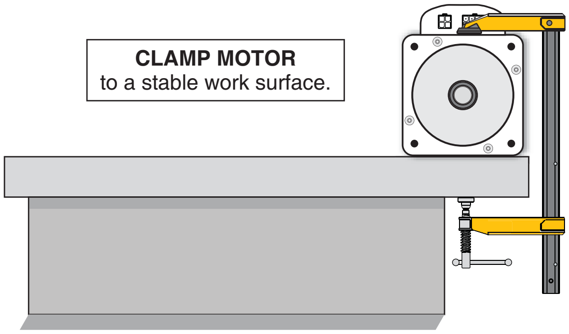
## INSTALL CLEARPATH MSP SOFTWARE

MSP is a free download from Teknic's website. Click here for a direct link. To install MSP, 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.



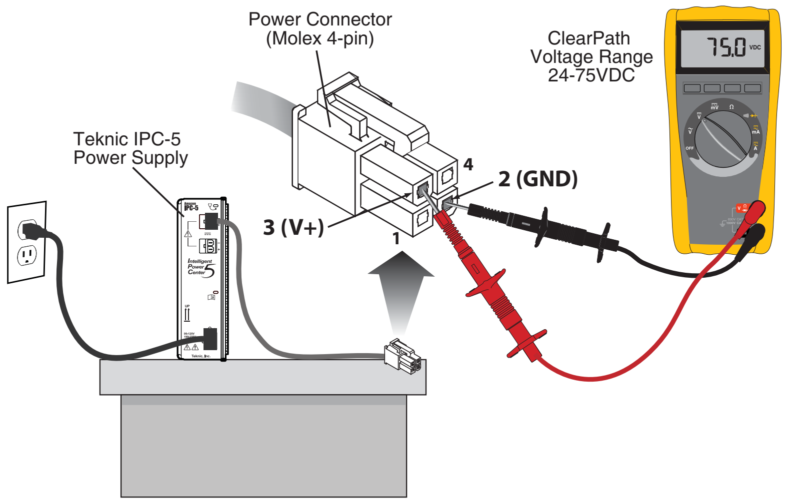
*Clamp it!*

## 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.

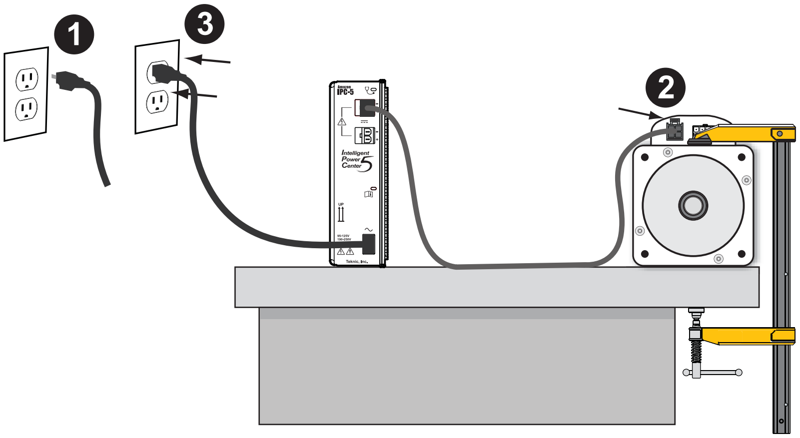
For Teknic DC power cables (PN: CPM-CABLE-PWR-MS120), test DC voltage at pins 3 and 2 as shown below (pin 3 is v+ and pin 2 is GND). This should display a positive voltage reading.



*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.

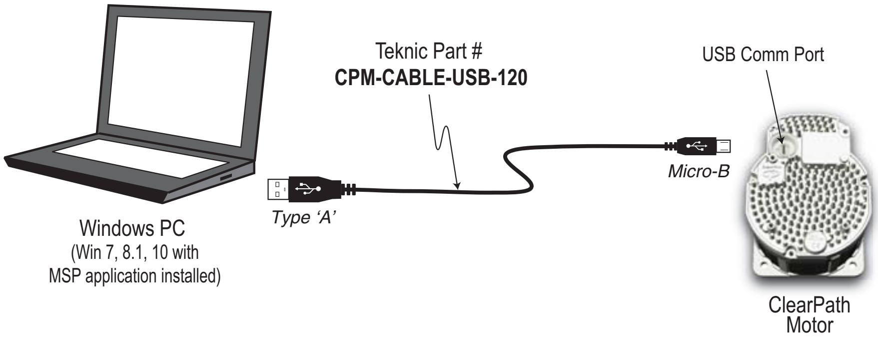


***Power up sequence***

## 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.

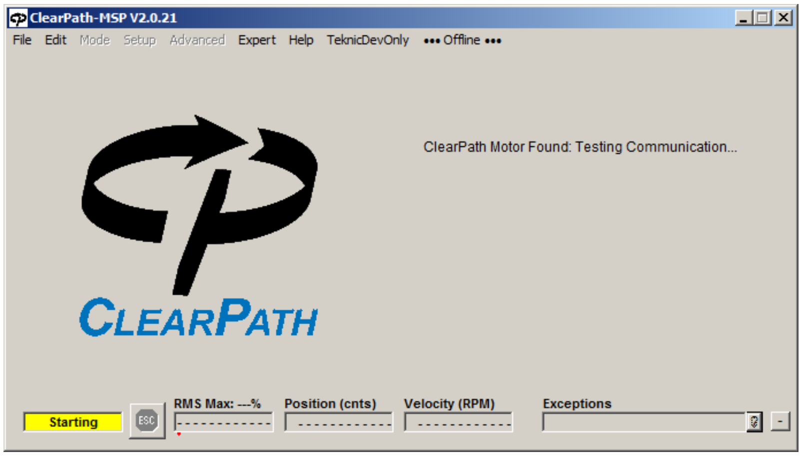
**Damage Warning:** Do not use USB cables of unknown origin (e.g. found in a junk drawer) with your ClearPath. Non-standard cables may be incompatible with ClearPath, and may even damage your motor.



*Connect ClearPath to your PC*

## OPEN CLEARPATH MSP (MOTOR SETUP PROGRAM)

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



ClearPath Motor Found: Testing Communication...

*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. 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.

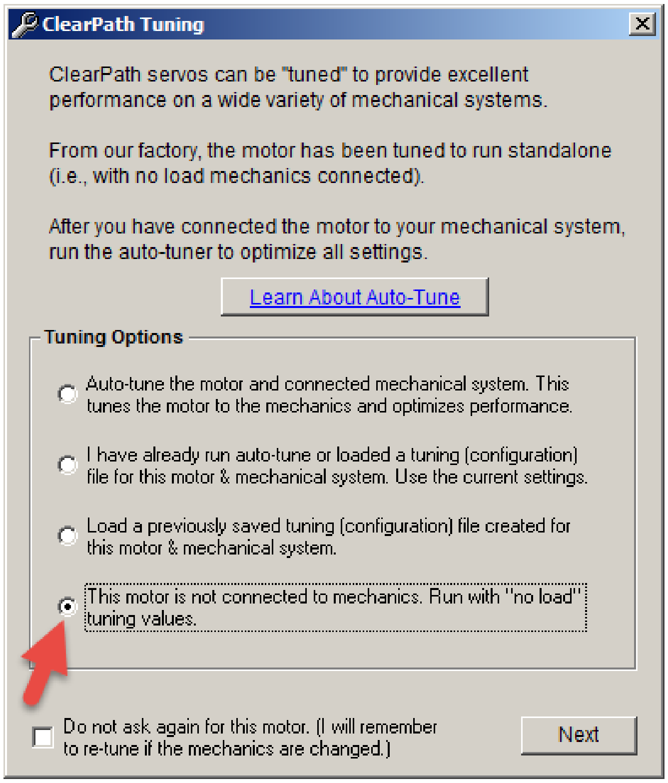
**Note:** ClearPath Soft Controls are great for test, development and training, but are not meant to be used as the control system for your machine.

### SPINNING A MODEL MCPV OR MCVC

*Spinning Step & Direction 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. The "Tuning" dialog will appear. For now select the bottom option (run with no load).



ClearPath Tuning

ClearPath servos can be "tuned" to provide excellent performance on a wide variety of mechanical systems.

From our factory, the motor has been tuned to run standalone (i.e., with no load mechanics connected).

After you have connected the motor to your mechanical system, run the auto-tuner to optimize all settings.

Tuning Options

○ Auto-tune the motor and connected mechanical system. This tunes the motor to the mechanics and optimizes performance.

○ I have already run auto-tune or loaded a tuning (configuration) file for this motor & mechanical system. Use the current settings.

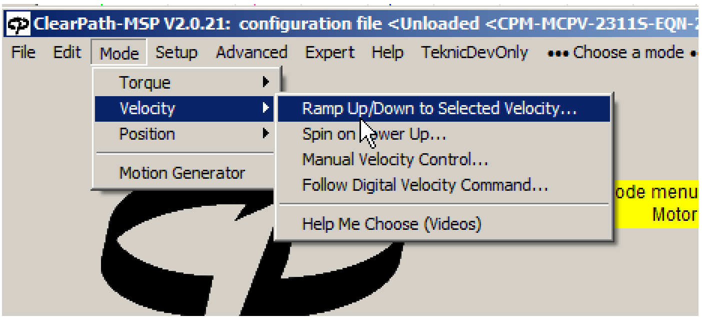
○ Load a previously saved tuning (configuration) file created for this motor & mechanical system.

● This motor is not connected to mechanics. Run with "no load" tuning values.

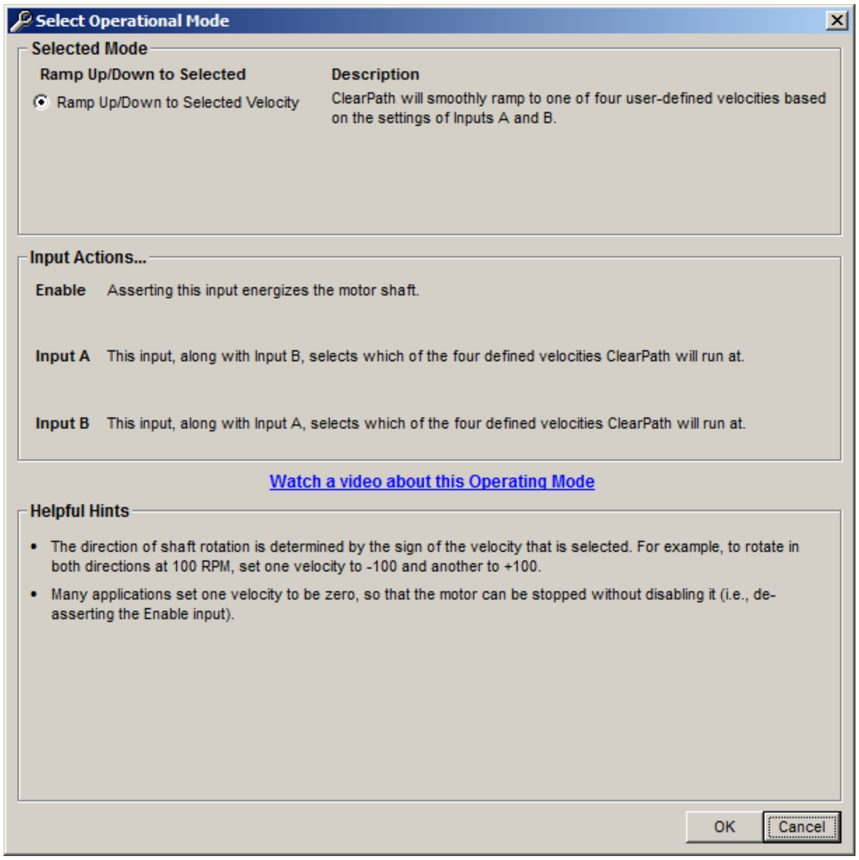
☐ Do not ask again for this motor. (I will remember to re-tune if the mechanics are changed.)

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>Velocity>Ramp Up/Down to Selected Velocity***.



4. A dialog window will open (see below). Please read all of the text presented, especially if you're unfamiliar with how the op mode works. Click OK to proceed.


**Select Operational Mode**

**Selected Mode**

**Ramp Up/Down to Selected**

● Ramp Up/Down to Selected Velocity

**Description**

ClearPath will smoothly ramp to one of four user-defined velocities based on the settings of Inputs A and B.

**Input Actions...**

**Enable** Asserting this input energizes the motor shaft.

**Input A** This input, along with Input B, selects which of the four defined velocities ClearPath will run at.

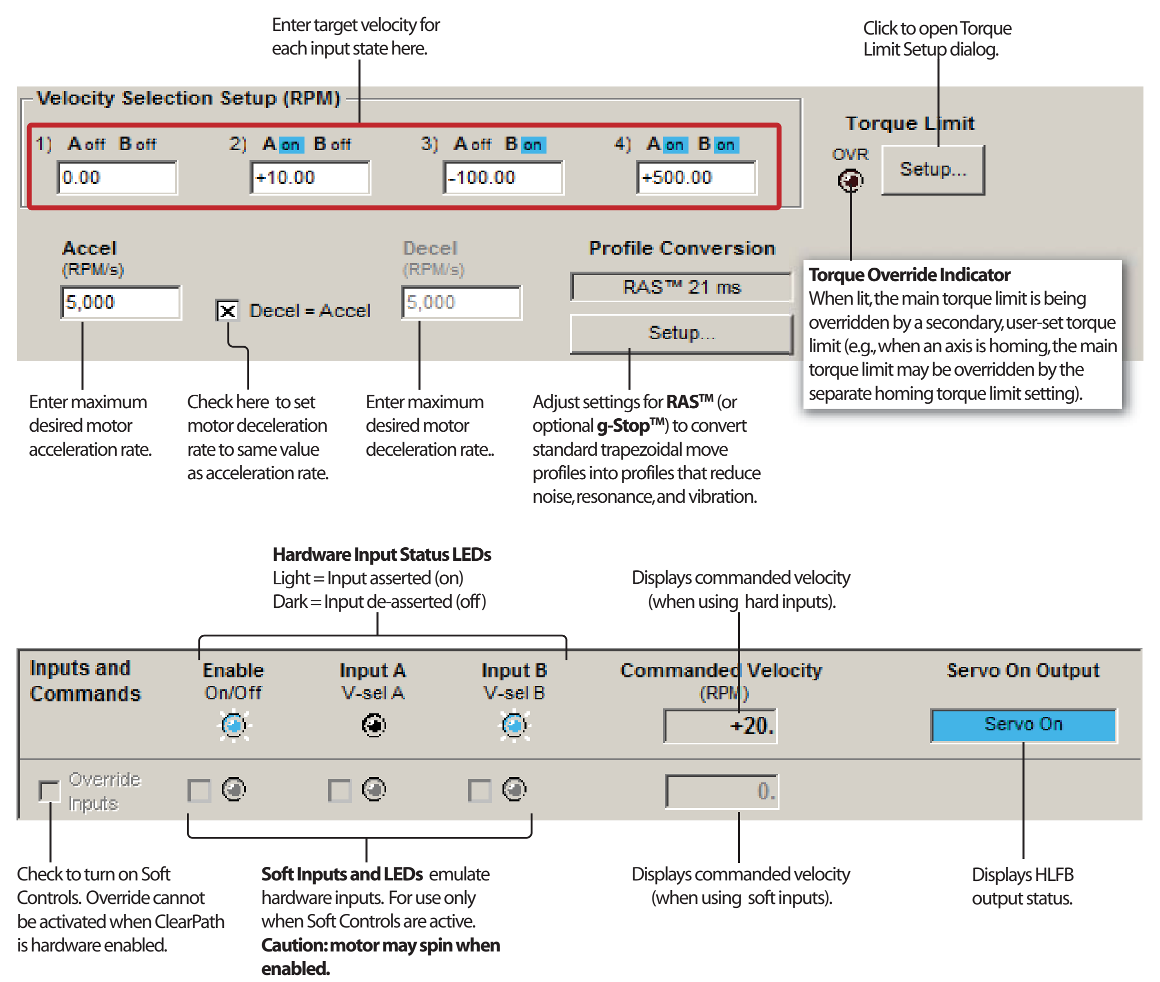
**Input B** This input, along with Input A, selects which of the four defined velocities ClearPath will run at.

Watch a video about this Operating Mode

**Helpful Hints**

- The direction of shaft rotation is determined by the sign of the velocity that is selected. For example, to rotate in both directions at 100 RPM, set one velocity to -100 and another to +100.
- Many applications set one velocity to be zero, so that the motor can be stopped without disabling it (i.e., de-asserting the Enable input).

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



Velocity Selection Setup (RPM)

1) A off B off: 0.00

2) A on B off: +10.00

3) A off B on: -100.00

4) A on B on: +500.00

Accel (RPM/s): 5,000

☒ Decel = Accel

Decel (RPM/s): 5,000

Profile Conversion: RAS™ 21 ms

Commanded Velocity (RPM): +20.

Enter target velocity for each input state here.

Click to open Torque Limit Setup dialog.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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..

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

**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.

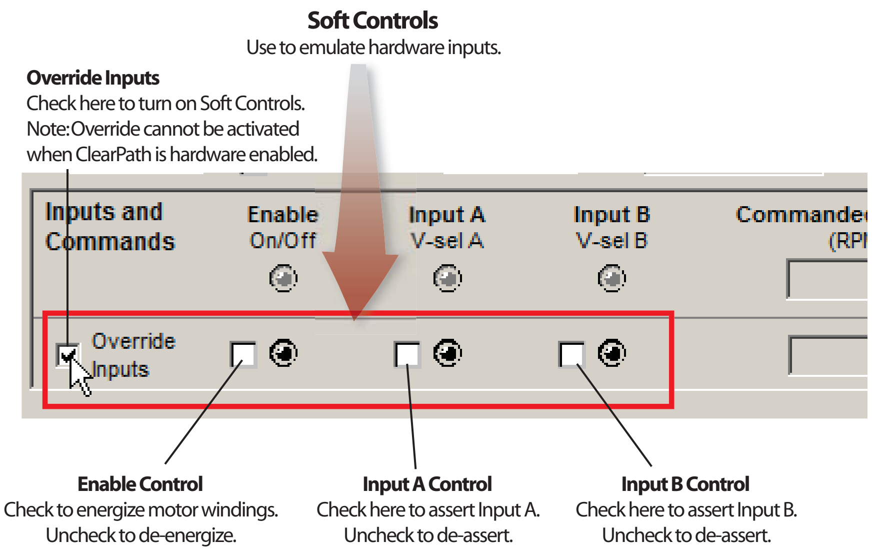
**Soft Inputs and LEDs** emulate hardware inputs. For use only when Soft Controls are active. **Caution: motor may spin when enabled.**

Displays commanded velocity (when using soft inputs).

Displays HLFB output status.

***Mode Controls for mode "Ramp Up/Down 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.



**Soft Controls**
Use to emulate hardware inputs.

**Override Inputs**
Check here to turn on Soft Controls.
Note:Override cannot be activated when ClearPath is hardware enabled.

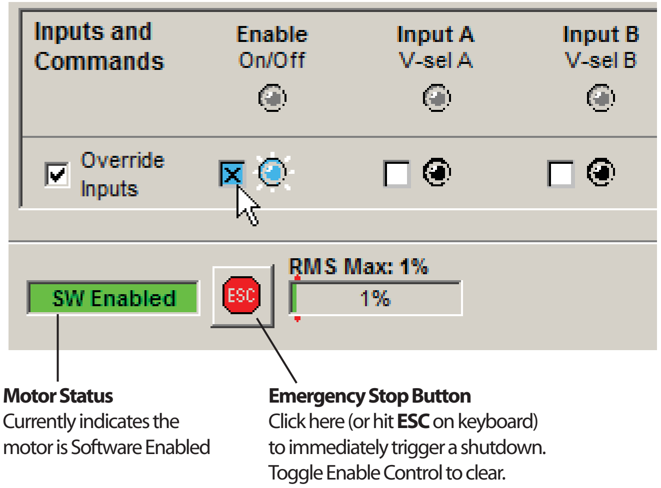
**Enable Control**
Check to energize motor windings.
Uncheck to de-energize.

**Input A Control**
Check here to assert Input A.
Uncheck to de-assert.

**Input B Control**
Check here to assert Input B.
Uncheck to de-assert.

***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.**

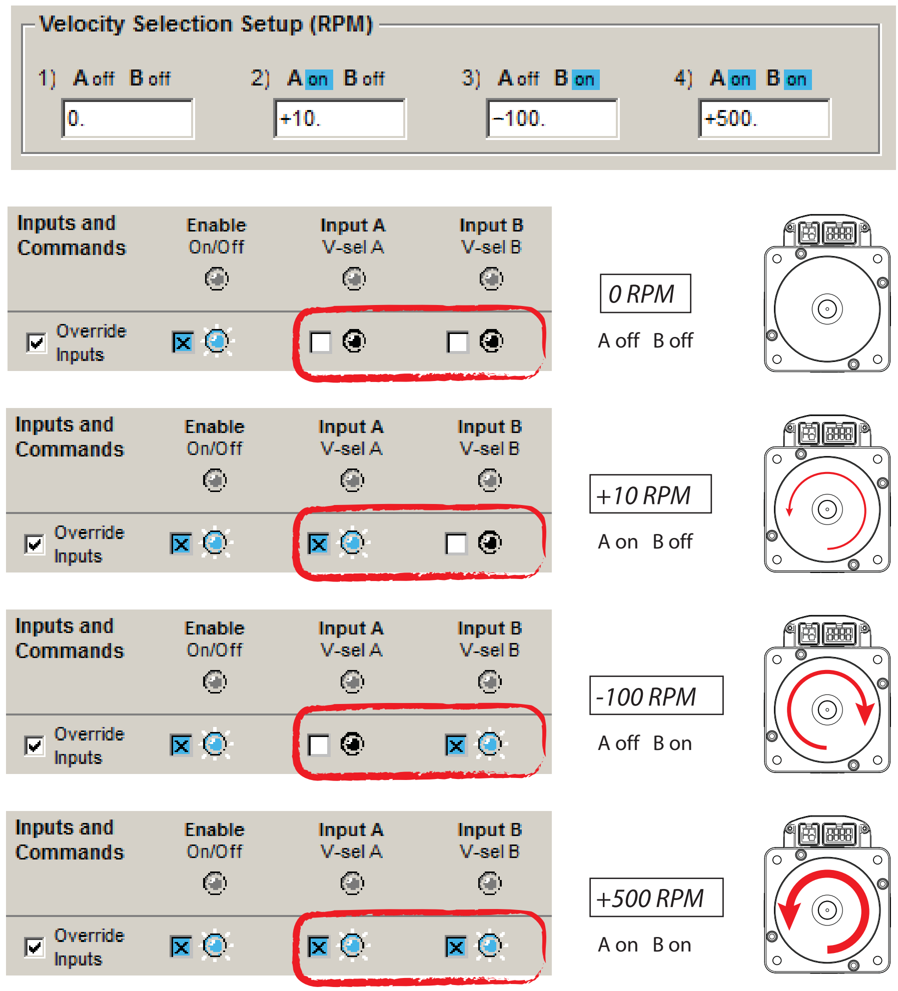


**Motor Status**
Currently indicates the motor is Software Enabled

**Emergency Stop Button**
Click here (or hit **ESC** on keyboard) to immediately trigger a shutdown.
Toggle Enable Control to clear.

***Enable ClearPath 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.



Velocity Selection Setup (RPM)

1) A off B off: 0.

2) A on B off: +10.

3) A off B on: -100.

4) A on B on: +500.

*Change velocity and direction by checking Inputs A and B*

## ADDITIONAL NOTES

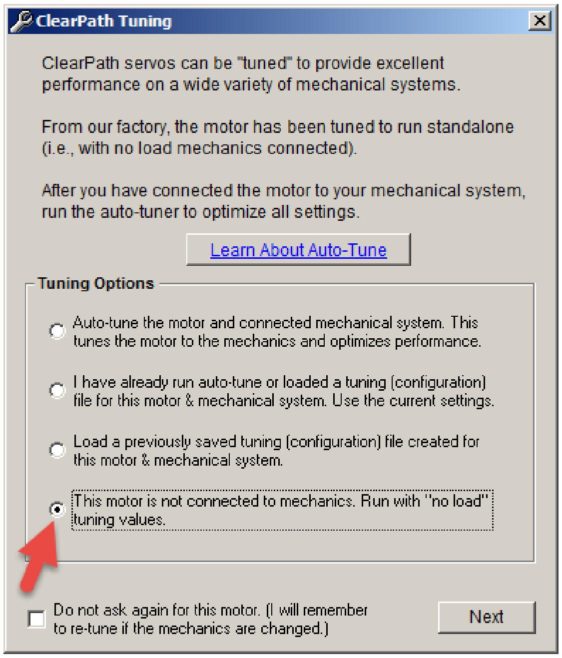
- The direction of shaft rotation is set by entering a "+" or "-" sign in front of the velocity settings (see top of figure above). "+" will cause CCW rotation, "-" will cause CW rotation.

## 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 software controls.

1. Open MSP software.
2. Establish USB communication to your motor.
3. The "Tuning" dialog will appear. For now select the bottom option (run with no load) and hit "Next".



ClearPath servos can be "tuned" to provide excellent performance on a wide variety of mechanical systems.

From our factory, the motor has been tuned to run standalone (i.e., with no load mechanics connected).

After you have connected the motor to your mechanical system, run the auto-tuner to optimize all settings.

Tuning Options

○ Auto-tune the motor and connected mechanical system. This tunes the motor to the mechanics and optimizes performance.

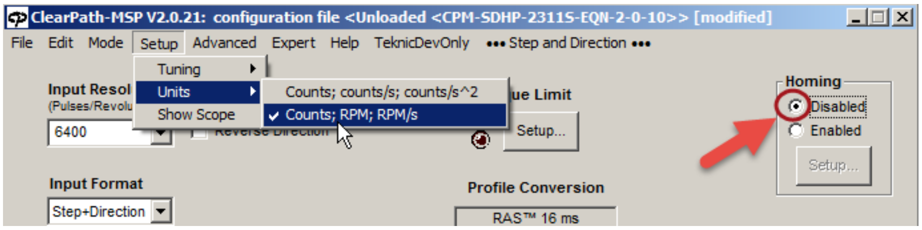
○ I have already run auto-tune or loaded a tuning (configuration) file for this motor & mechanical system. Use the current settings.

○ Load a previously saved tuning (configuration) file created for this motor & mechanical system.

● This motor is not connected to mechanics. Run with "no load" tuning values.

☐ Do not ask again for this motor. (I will remember to re-tune if the mechanics are changed.)

4. In MSP, Select *Mode>Step and Direction*. The mode controls window will open.
5. Set Units to RPM as shown in the figure below. This just tells MSP in what units to display distance, velocity, and acceleration.
6. Disable homing (see figure below).



ClearPath-MSP V2.0.21: configuration file <Unloaded <CPM-SDHP-2311S-EQN-2-0-10>> [modified]

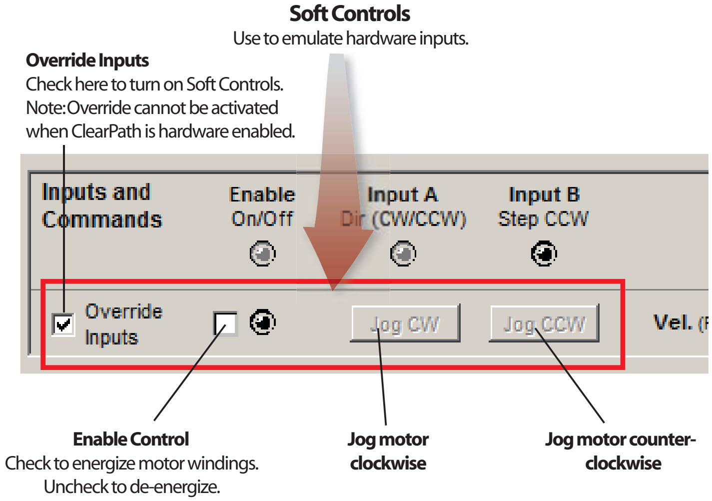
Input Resol (Pulses/Revolu 6400

Input Format Step+Direction

Homing ● Disabled ○ Enabled

Profile Conversion RAS™ 16 ms

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



**Soft Controls**
Use to emulate hardware inputs.

**Override Inputs**
Check here to turn on Soft Controls.
Note:Override cannot be activated when ClearPath is hardware enabled.

**Enable Control**
Check to energize motor windings.
Uncheck to de-energize.

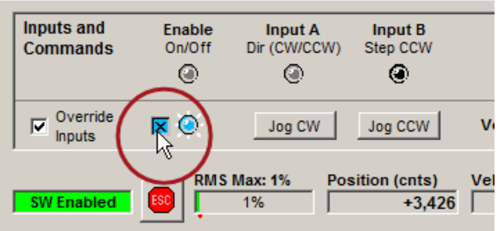
**Jog motor clockwise**

**Jog motor counter-clockwise**

*Check "Override Inputs" to turn on Soft Controls*

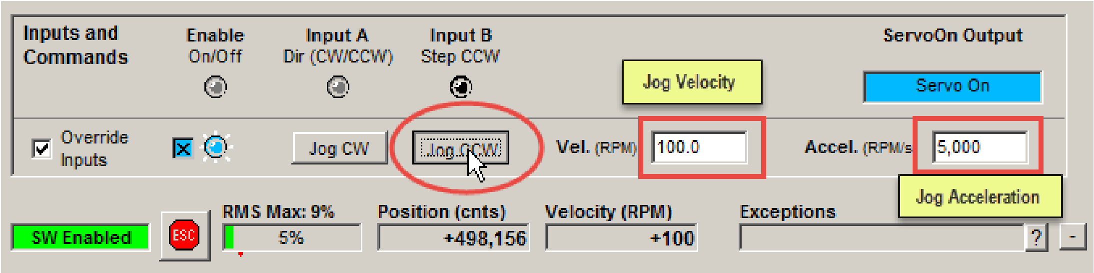
8. **Safety check!** Before proceeding, make sure that the motor is securely clamped down and the shaft is safely positioned away from fingers, clothing, hair, cables, etc.

9. Check the Enable checkbox. **Caution: the motor is now energized and capable of motion.**



*Enable using Soft Controls*

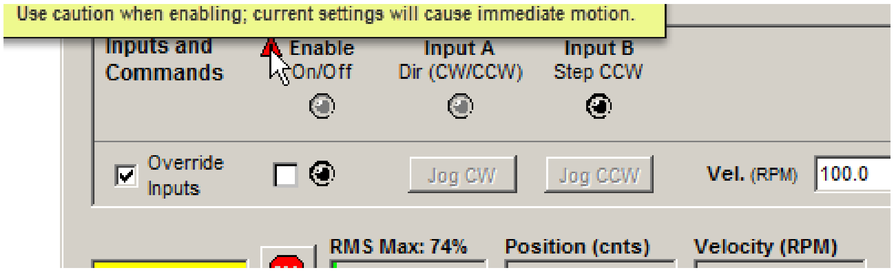
10. **Make some moves.** With the motor enabled, click the jog button. Change direction by checking Input A. Test different velocity and acceleration settings.



*Click and hold to jog buttons to spin your ClearPath-SD motor*

## IF YOU EXPERIENCE A MOTOR SHUTDOWN OR WARNING

- If you see a small **triangular warning icon** (figure below) anywhere in the Mode Controls section, hover your cursor over the triangle to read the message (like a tool tip).



Use caution when enabling; current settings will cause immediate motion.

*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 of your moves until the warning goes away.
- The majority of shutdowns are caused by weak power supplies, mechanical problems, and/or 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

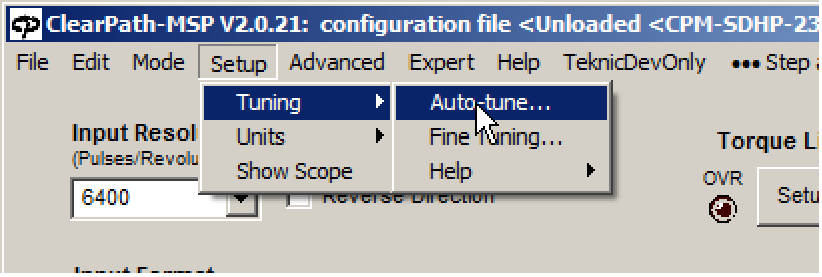
***Tuning is required** whenever you bolt your ClearPath motor to a new or different mechanical system.* The Auto-Tune feature simplifies this formerly complicated and time consuming process.

### BEFORE YOU BEGIN THE AUTO-TUNE PROCESS:

- Disable your motor.
- 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 a flimsy 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 carefully 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 HELP

**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 previous versions of MSP before installing new versions.
- 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 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.

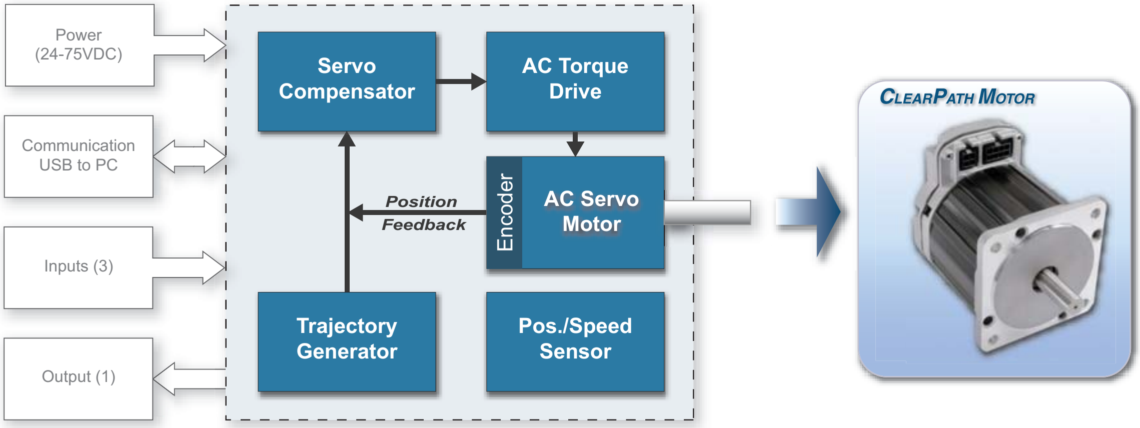
Teknic has made all reasonable efforts to accurately present the information in the published documentation and shall not be responsible for any incorrect information which may result from oversights. Due to continuous product improvements, the product specifications as stated in the documentation are 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:

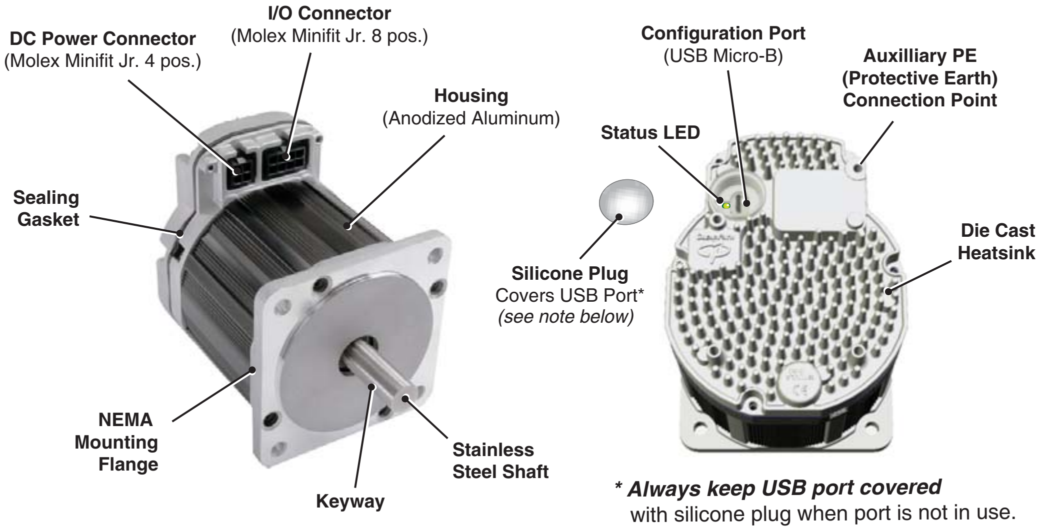
- Point-to-Point Positioning (move and settle with precision).
- Velocity Modes (spin at constant rotational speeds).
- Torque Modes (precisely control torque at the shaft).
- Stepper Emulation (use standard step-and-direction signals).

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



**** Always keep USB port covered***
with silicone plug when port is not in use.

***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.

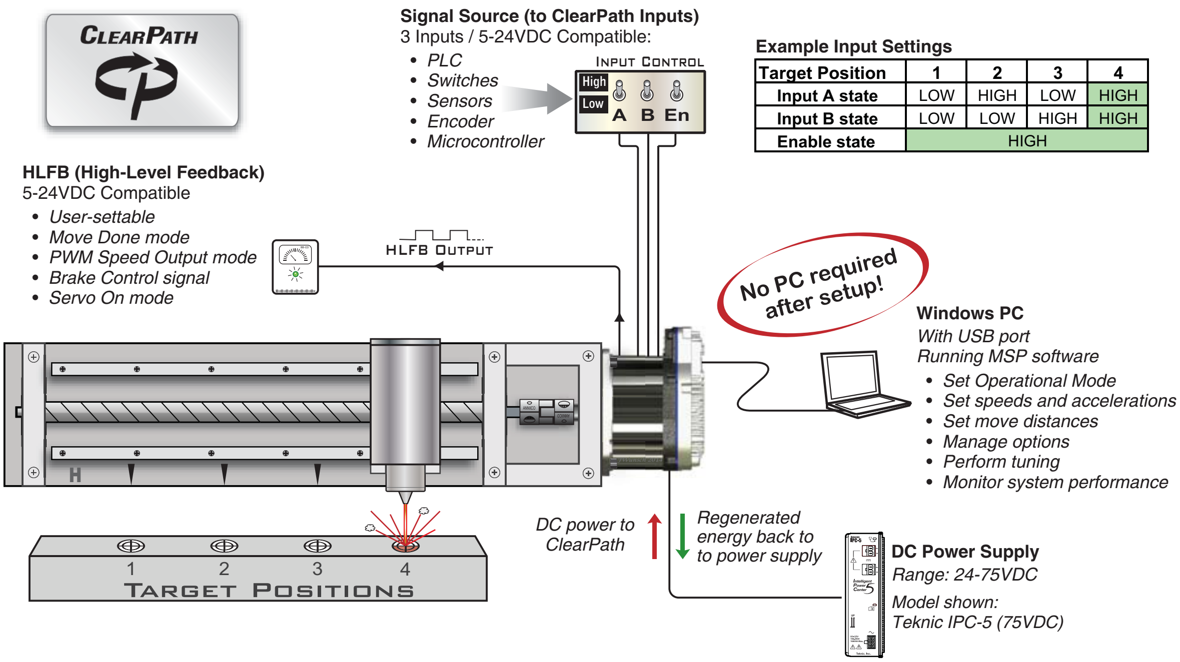
## EXAMPLE APPLICATION: ABSOLUTE POSITIONING MODE

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.

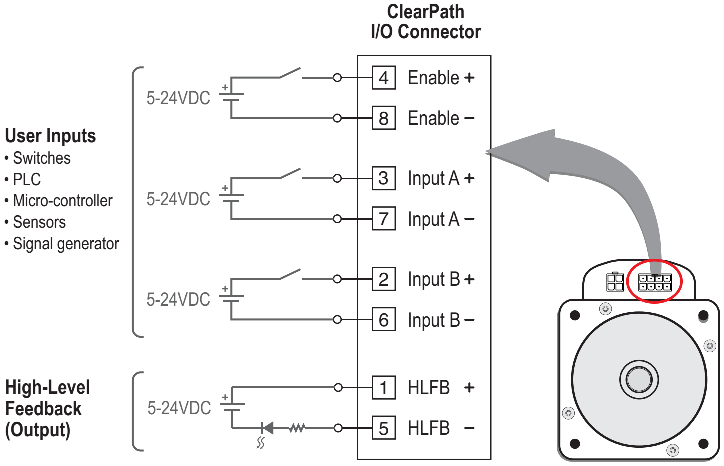
**Save your settings!** You can save your ClearPath settings to a motor configuration file—the file extension is .mtr—at any time. This allows you to easily test and compare various sets of tuning parameters. And, if you build many machines of the same design, you'll appreciate how quickly you can load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

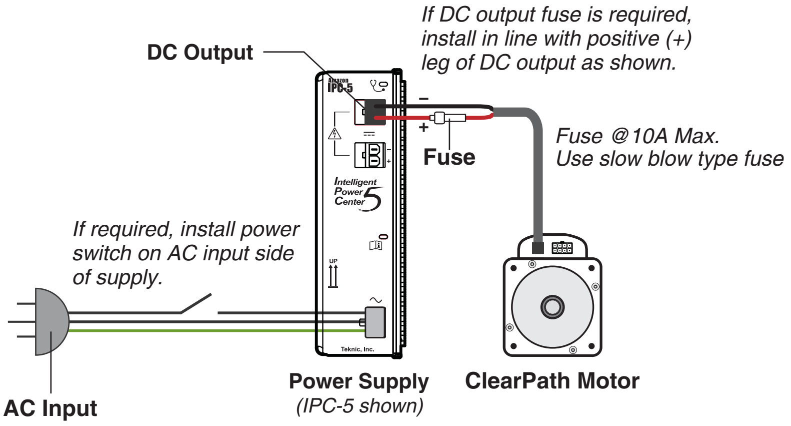
## POWER SUPPLY SWITCHING AND FUSING

### 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

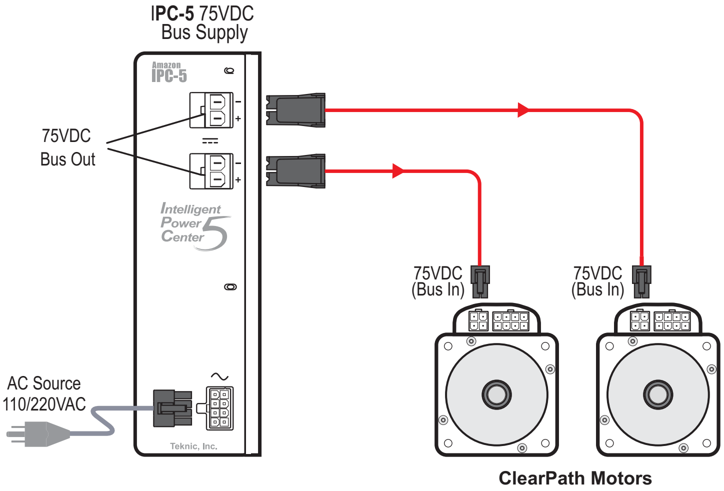
If you require an external fuse on your power supply's DC output (to meet compliance standards for example) it should be installed in line with the positive leg of the DC output wiring as shown below. Use a maximum 10A time delay fuse. Note: Teknic IPC power supplies are not internally fused on the DC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



***Power supply switching and fusing detail***

## BASIC POWER CONNECTION (2 MOTORS)

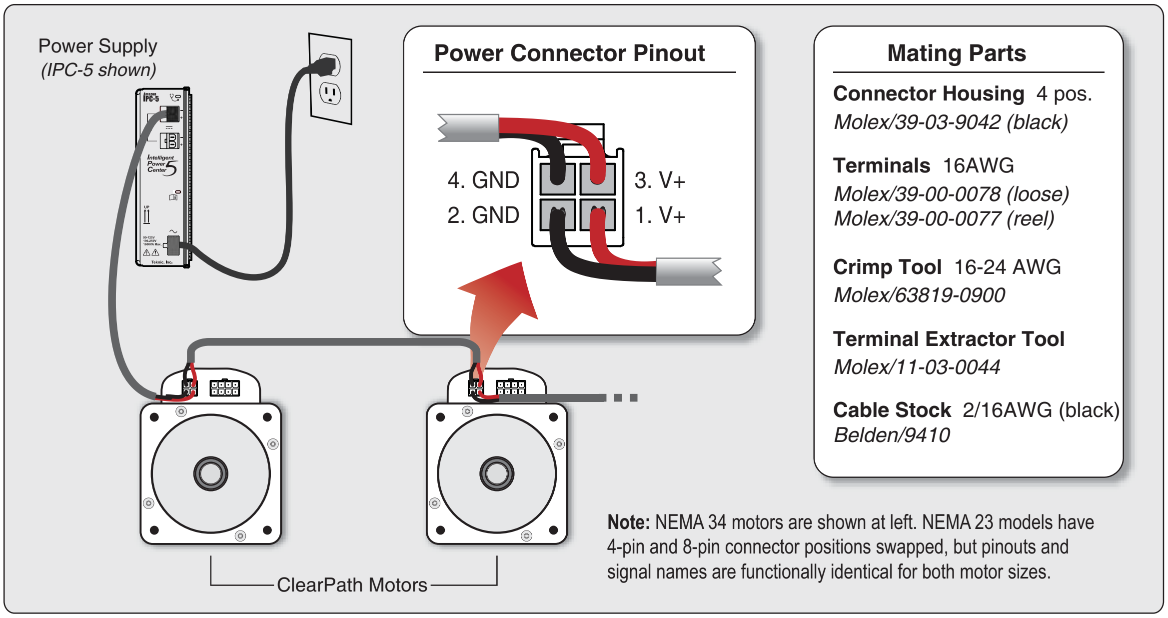
One or two motors can be connected directly to the IPC-3 or IPC-5 power supply as shown below. To connect more than two motors, consider chaining power or using the optional Power Hub board.



***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.



**Mating Parts**

**Connector Housing** 4 pos.
*Molex/39-03-9042 (black)*

**Terminals** 16AWG
*Molex/39-00-0078 (loose)*
*Molex/39-00-0077 (reel)*

**Crimp Tool** 16-24 AWG
*Molex/63819-0900*

**Terminal Extractor Tool**
*Molex/11-03-0044*

**Cable Stock** 2/16AWG (black)
*Belden/9410*

**Note:** NEMA 34 motors are shown at left. NEMA 23 models have 4-pin and 8-pin connector positions swapped, but pinouts and signal names are functionally identical for both motor sizes.

***ClearPath Power Supply Connection***

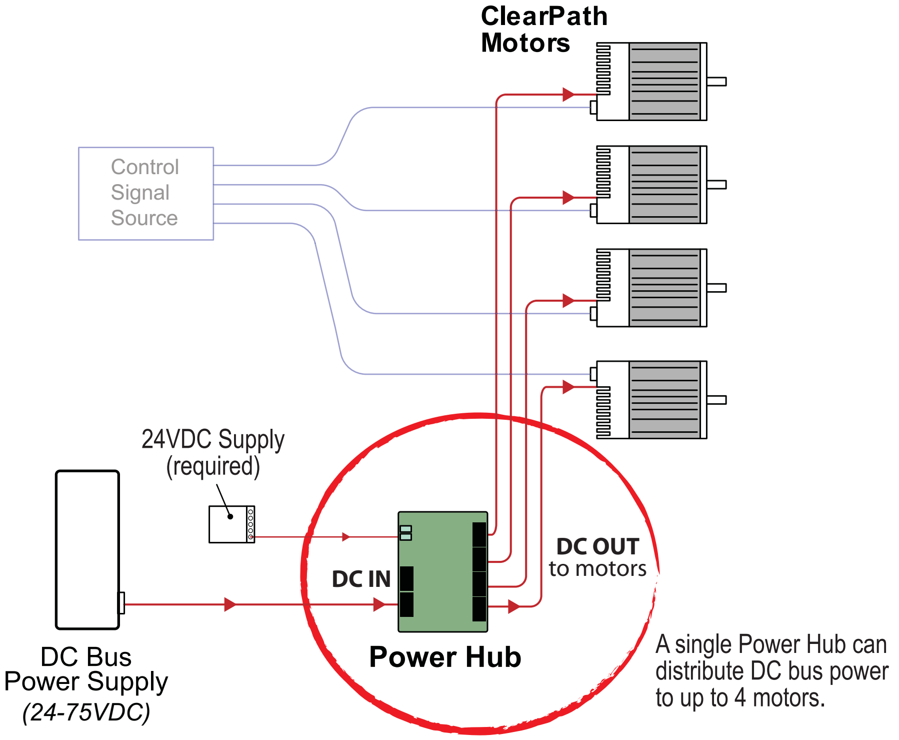
# USING A POWER HUB

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 Power Hub, thus eliminating the need for special "power chaining" cables.
2. Delivers low voltage **logic power backup** to your ClearPath motors. Logic power backup keeps the motors' electronics "alive" even if DC bus power is dropped. This translates to uninterrupted communication, continuous status monitoring, and retention of encoder position.

**Note:** You will be unable to spin your motors when using only logic power backup. Logic power backup will keep the motor electronics alive, but is not designed to run motors.

## POWER HUB OVERVIEW DIAGRAM



***Power Hub in a ClearPath system***

## POWER HUB: THINGS TO KNOW

- **Logic backup power is not designed to spin motors.** It is designed to maintain uninterrupted, low voltage power to the motor electronics (encoder, DSP, communication, I/O, and associated circuits).
- **Damage Warning: Reversing DC bus power polarity to the Power Hub will permanently damage it.** Use a meter to verify correct DC bus power polarity before connecting the power supply to the Power Hub.
- **Do not "hot swap" DC power connectors.** Turn off DC bus power supply 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.*
- **Logic backup power should not be used as a means of switching DC bus power on and off.** To control DC bus power, use a contactor on the AC side of the DC bus power supply.
- **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.

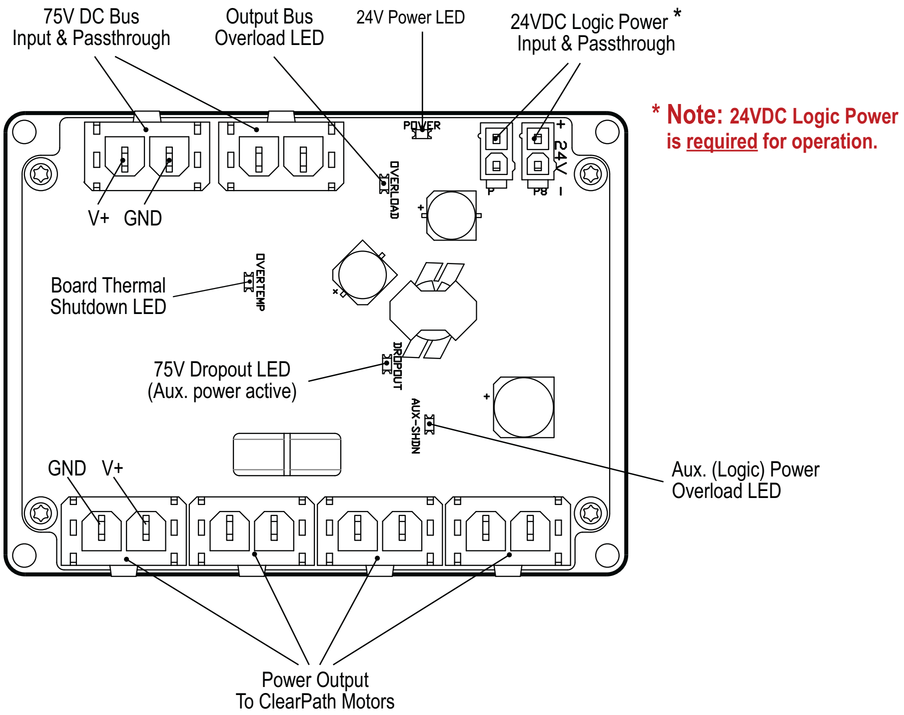
  I*t is the user's responsibility to ensure that the DC bus power supply has sufficient continuous and peak power to meet their application requirements.*

- **Do not attempt to power more than four ClearPath motors from a single Power Hub.**

## POWER HUB: COMPLIANCE NOTES

- Any 3rd party (non-Teknic) power supply used with the Power Hub, should be current limited or fused to 25A or less using 25A, 300VDC (UL Listed) fuses.
- If UL compliance is a consideration, select a DC, UL Listed fuse.
- For those seeking a Class G fuse, the SC-25 from Eaton Cooper Bussmann, or OSLCO25 from Littelfuse is recommended. Fuse holders (also rated this way) include the HPS-FF and TCFH30N (from ECB/Littelfuse respectively).

## PARTS OF A POWER HUB



*Parts of a Power Hub*

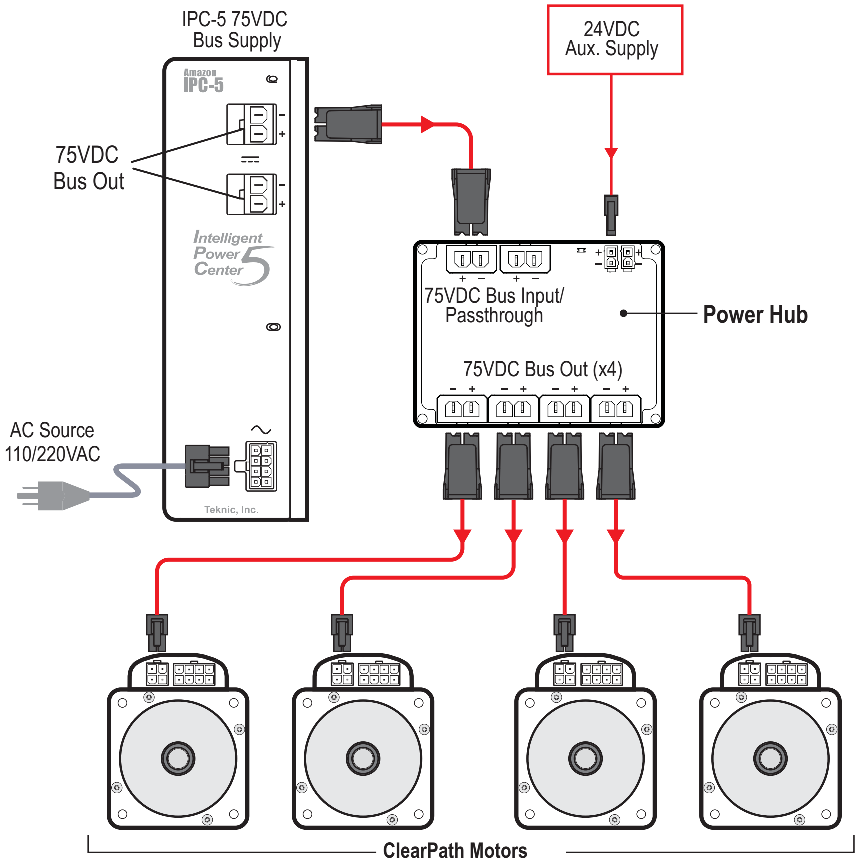
**DC Bus Power Input/Passthrough (Qty. 2)** - Supply 24-75VDC power from your DC Bus Supply to either of these connectors (they are wired in parallel). The other connector can be used to daisy chain bus power to a second Power Hub if desired, or left unconnected.

**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.

**24VDC Logic Power Input, with Passthrough (Qty. 2)** - Supply low power 24VDC logic power to either of these connectors (they are wired in parallel). The other connector can be used to daisy chain power to a second Power Hub.

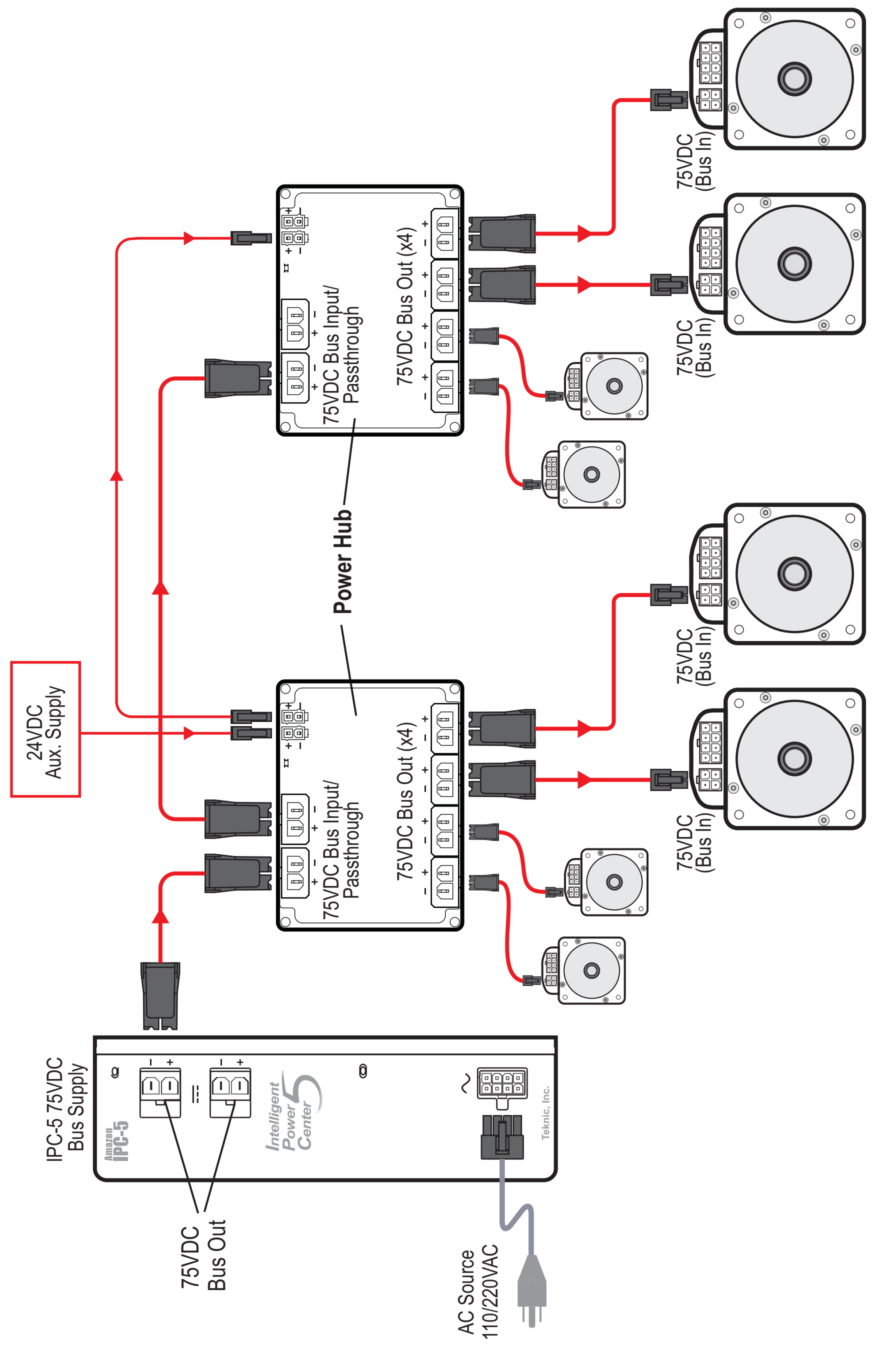
**Power Hub LEDs** - There are 5 LED indicators on a Power Hub. Please refer to the section "Power Hub LEDs" (later this section) for a complete explanation of what the Power Hub LEDs indicate.

## CONNECTIONS FOR A SINGLE POWER HUB SYSTEM



*Single Power Hub System*

## CONNECTIONS FOR A DUAL POWER HUB SYSTEM

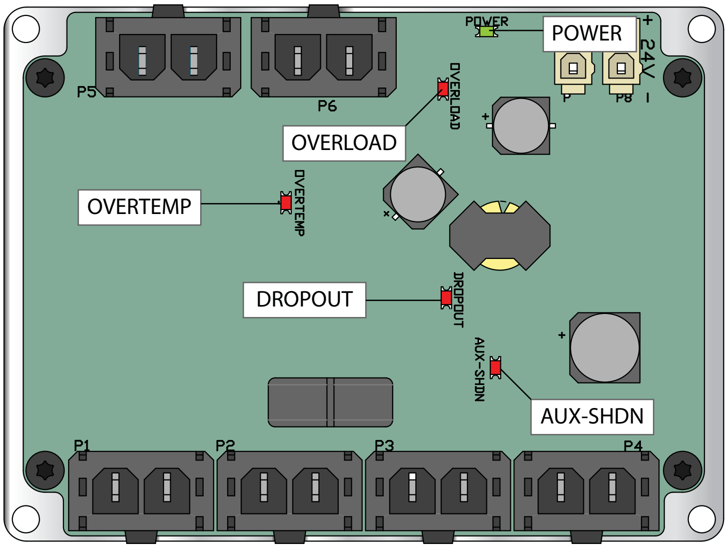


*Two Power Hubs powering 8 ClearPath motors*

## AUXILIARY (24V) LOGIC POWER SUPPLY

The Power Hub requires 24VDC to function. This is labeled as "24VDC Aux. Supply" above. See appendix " Logic Power Supply Sizing" for power budgeting information. Note: Never use the main DC bus power supply (even if it is 24VDC) for this purpose.

## POWER HUB LED CODES



***Power Hub LEDs***

| LED Name | Color | <u>LED On</u> Indicates | <u>LED Off</u> Indicates |
|---|---|---|---|
| **POWER**<br>*24V Power* | Green | Normal operation.<br>Aux. 24V supply voltage detected. | Aux. 24V supply voltage not detected. Hub not functional. |
| **OVERLOAD**<br>*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**<br>*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.<br>(Board temp is < 105°C.) |
| **DROPOUT**<br>*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**<br>*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

- **Damage Warning: Reversing DC bus power polarity to the Power Hub will permanently damage it.** 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.** Turn off DC bus power supply before connecting a motor to the Power Hub. Connecting and disconnecting the motor from a live power supply will cause electrical arcing that will pit and carbonize connectors over time.

- **Do not attempt to power more than four ClearPath motors from a single Power Hub.**

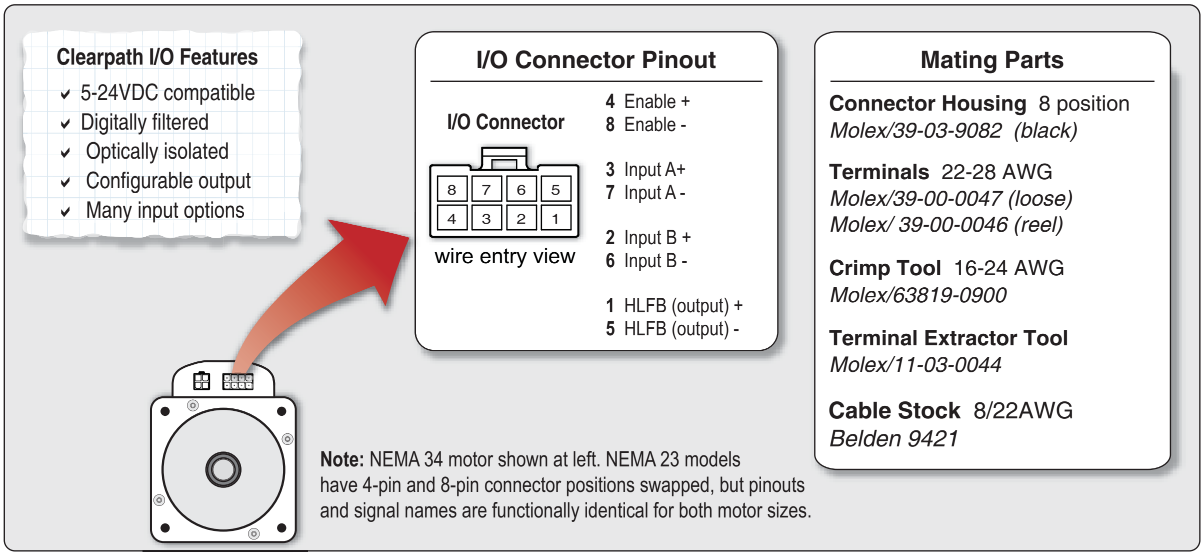
- **Do not connect more than two Power Hubs to a power supply.** Continuous and peak current usage must not exceed the power supply's specifications.

**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 their 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



**Clearpath I/O Features**

- ✓ 5-24VDC compatible
- ✓ Digitally filtered
- ✓ Optically isolated
- ✓ Configurable output
- ✓ Many input options

**I/O Connector Pinout**

**4** Enable +
**8** Enable -

**3** Input A+
**7** Input A -

**2** Input B +
**6** Input B -

**1** HLFB (output) +
**5** HLFB (output) -

**Mating Parts**

**Connector Housing** 8 position
*Molex/39-03-9082 (black)*

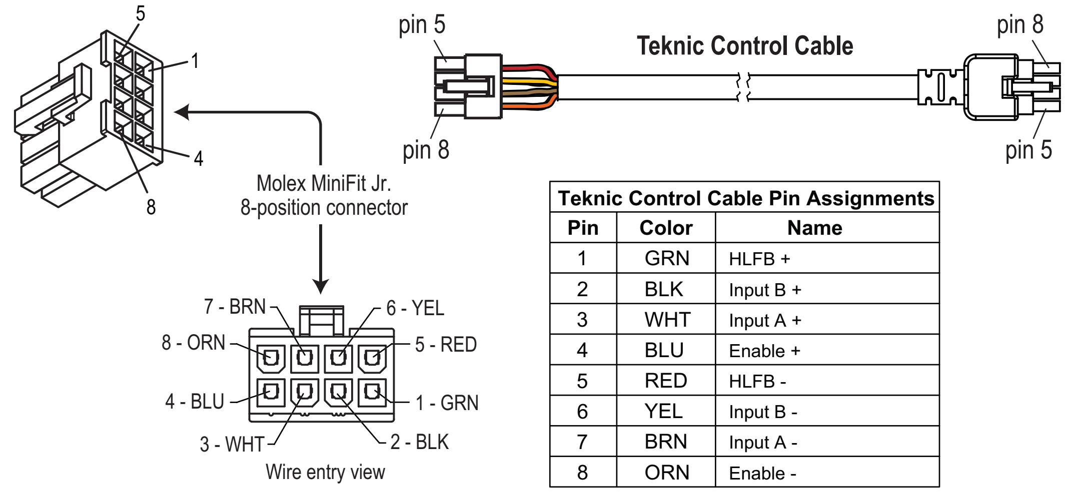
**Terminals** 22-28 AWG
*Molex/39-00-0047 (loose)*
*Molex/ 39-00-0046 (reel)*

**Crimp Tool** 16-24 AWG
*Molex/63819-0900*

**Terminal Extractor Tool**
*Molex/11-03-0044*

**Cable Stock** 8/22AWG
*Belden 9421*

**Note:** NEMA 34 motor shown at left. NEMA 23 models have 4-pin and 8-pin connector positions swapped, but pinouts and signal names are functionally identical for both motor sizes.



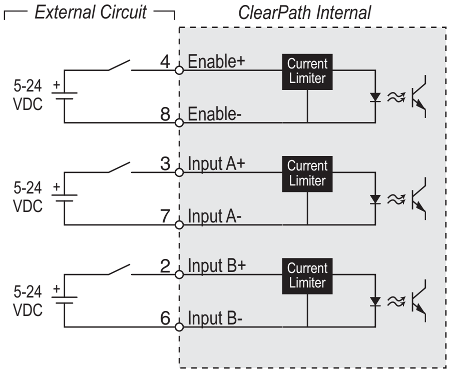
**Teknic Control Cable Pin Assignments**

| 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***

## CLEARPATH INPUTS

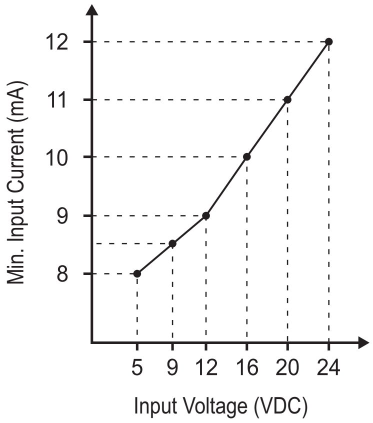
The three inputs, designated *Enable*, *Input A*, and *Input B*, are designed for use with 5-24VDC logic levels and pulses from a wide variety of signal sources and devices including PLCs, microcontrollers, and even mechanical switches, with no external resistors required.



***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 |

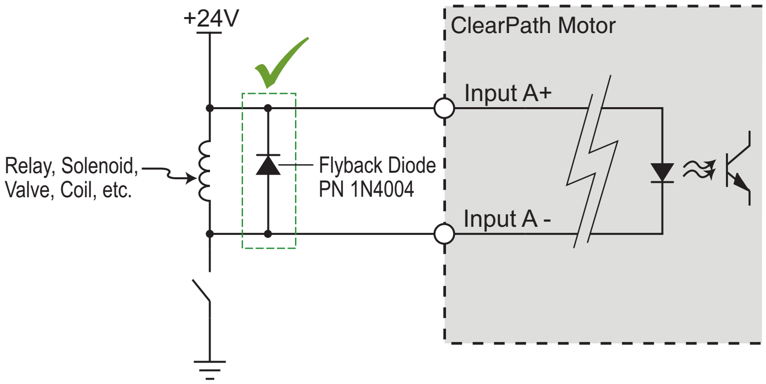
***Maximum input current draw at given input voltages***

## 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).



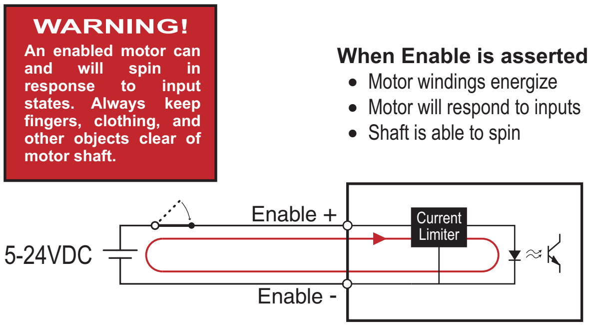
***Add a diode as shown if you have an external inductive load across a ClearPath input***

## 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 deasserted 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.



**WARNING!** An enabled motor can and will spin in response to input states. Always keep fingers, clothing, and other objects clear of motor shaft.

**When Enable is asserted:**

- Motor windings energize
- Motor will respond to inputs
- Shaft is able to spin

***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

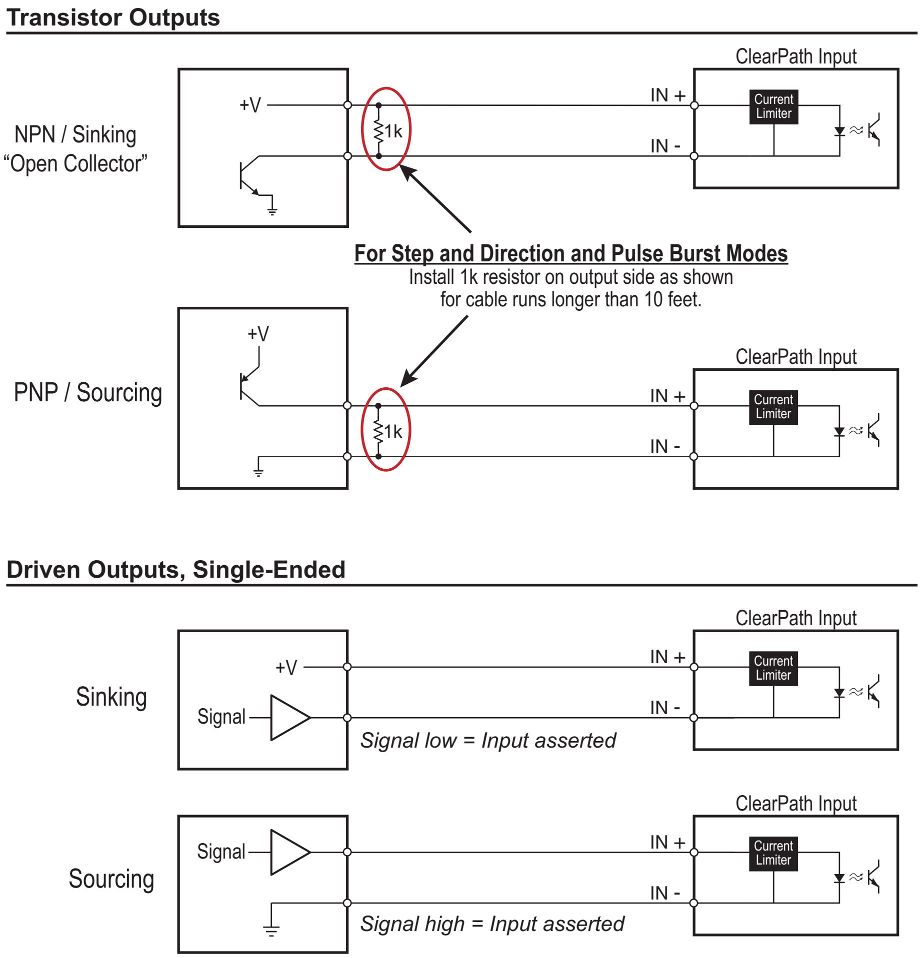
---

[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.



**For Step and Direction and Pulse Burst Modes**
Install 1k resistor on output side as shown for cable runs longer than 10 feet.

***Interfacing digital outputs to ClearPath Inputs***

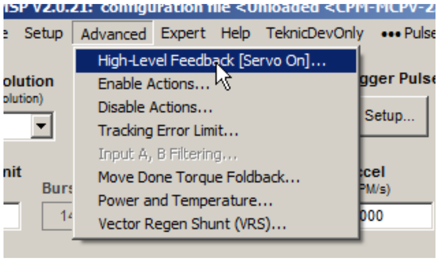
**Engineer's Note:** 5V differential outputs are not directly compatible with ClearPath I/O because differential drivers' guaranteed output voltage swing is typically not guaranteed to meet the ClearPath input minimum input voltage requirements.

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.

## CLEARPATH OUTPUT (HLFB)

ClearPath has one, user settable, multi-purpose, digital output called the HLFB Output (HLFB stands for "High-Level Feedback"). The HLFB output conveys motor and motion-related feedback to your PLC, microprocessor, or other control device.

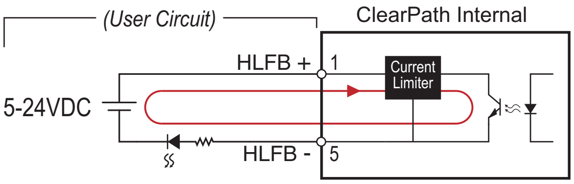
The HLFB configuration dialog is accessed from the Advanced menu as shown below. *Advanced>High-Level Feedback*.



**HLFB output can be used to signal:**

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

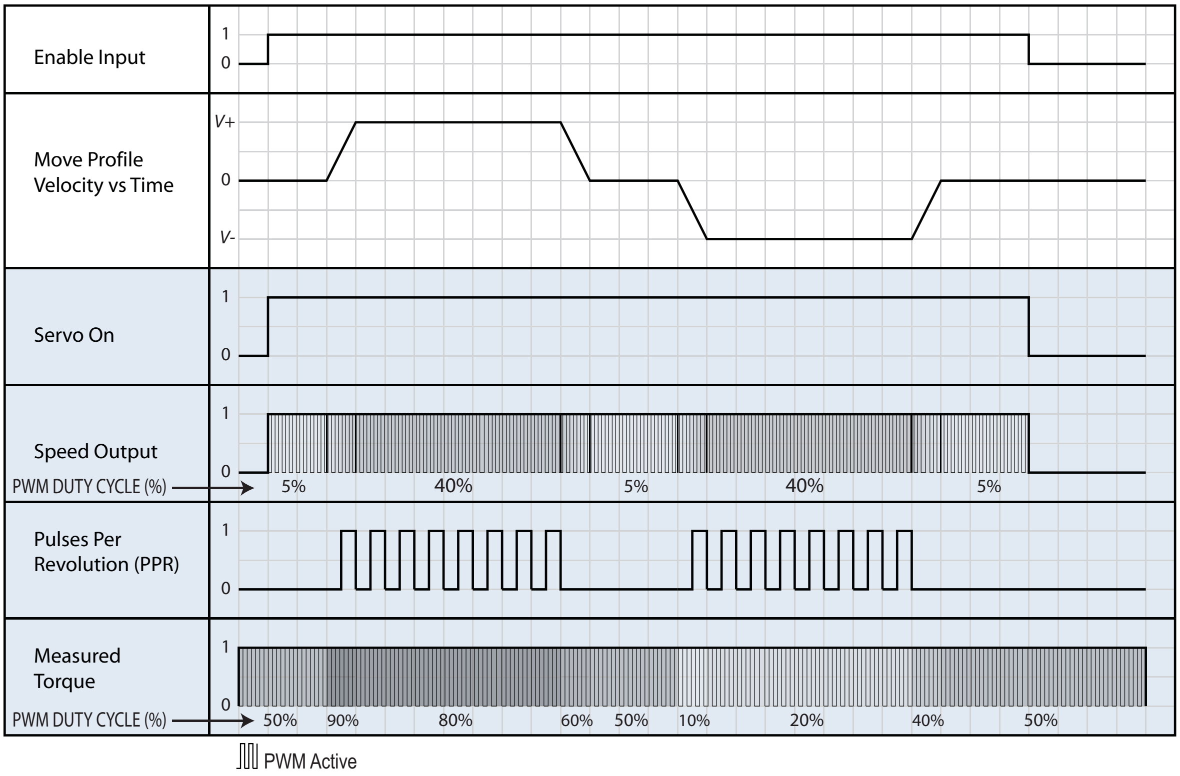
**Note:** The HLFB circuit is not internally powered; it requires an external 5–24VDC power supply capable of sourcing/sinking at least 1mA, non-inductive. In typical HLFB applications, power is supplied by the PLC, control board, or an external supply. See Appendix D for complete HLFB specifications.



*High-Level Feedback circuit*

## HLFB MODES: COMMON TO ALL CLEARPATH OP MODES

This section discusses HLFB modes that are available for *all* ClearPath operational modes. Later in this section we cover HLFB modes unique to Position, Velocity , and Torque operational modes.



***HLFB Timing: HLFB output modes available in all ClearPath op modes***

### 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. Note: the HLFB circuit cannot directly drive an external brake.

### SPEED OUTPUT

In Speed Output mode, the HLFB outputs a 45 Hz or 482 Hz (user selectable) PWM waveform whose duty cycle varies in proportion to actual motor speed. The duty cycle scales as a percentage of the maximum motor speed configured in the currently selected operating mode.

- 5% duty cycle = 0% max speed
- 95% duty cycle = 100% max speed

The HLFB output deasserts (i.e., 0% duty cycle, "off", non-conducting) when the motor is disabled or shutdown.

**Note:** Speed Output is not available in the Ramp to Selected Velocity and Step and Direction operating modes.

### PULSES PER REVOLUTION (PPR)

In Pulses Per Revolution (PPR) mode, the HLFB sends a user-selectable number of pulses for each revolution of the motor. The choices are: 1, 2, 4, 8, or 16 pulses per revolution.

**Notes**

- The frequency of output pulses is proportional to the speed of the motor.
- When motor speed is constant, the PPR pulses will exhibit a ~50% duty cycle.
- When the motor shaft is stopped, the HLFB output can be either "fixed" high or "fixed" low.
- As long as the motor maintains logic power, the output will produce pulses corresponding to motor shaft rotation, *even if the motor is disabled or in a shutdown*.

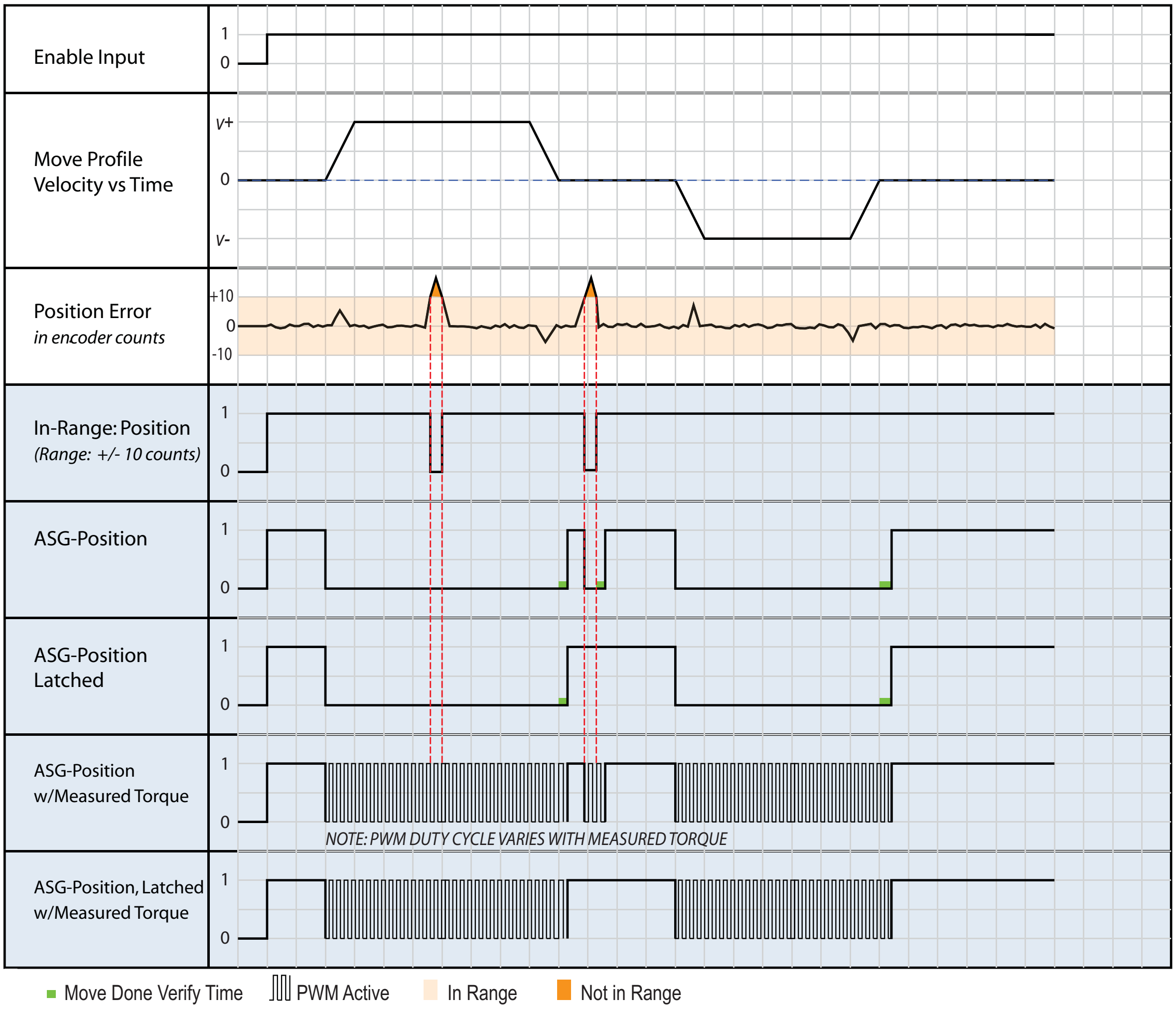
### MEASURED TORQUE

In Measured Torque mode, the HLFB outputs a 45 Hz *or* 482 Hz (user-selectable) 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 MODES: FOR CLEARPATH POSITIONING MODES

The following HLFB modes are available only in positioning op modes.



***HLFB Timing: HLFB output modes available only in ClearPath positioning op modes***

### IN RANGE-POSITION

The HLFB output asserts (conducts) when the motor is enabled, not shutdown, and the measured motor position is In Range (±X encoder counts) of the current commanded position. The In Range parameters are set in the HLFB Setup dialog.

### ASG (ALL SYSTEMS GO) - POSITION

In ASG-Position mode the HLFB output asserts (conducts) when the motor is enabled, not in a shutdown, and is considered "Move Done" (explained below).

**"Move Done"** occurs when the motor has settled within ±X encoder counts of the final target position, for at least Y milliseconds (where X and Y are user-settable in the HLFB Setup dialog).

**Note:** The HLFB output deasserts while moving, or if the motor's actual position falls out of the ±X encoder count In-Range window.

### ASG-POSITION LATCHED

ASG-Position Latched works in the same way as ASG-Position except that the HLFB output latches once asserted (conducting). The output remains asserted until the motor is disabled, goes into a shutdown, or receives a motion command.

Even if the motor is momentarily pushed "Out-of-Range" at the end of a move, the HLFB will remain asserted (conducting).

### ASG-POSITION WITH MEASURED TORQUE

ASG-Position with Measured Torque works in the same way as ASG-Position except during commanded motion, the HLFB outputs a 45 Hz or 482 Hz (user selectable) PWM waveform that varies in duty cycle between 5% and 95% to indicate direction and magnitude of motor shaft torque as follows:

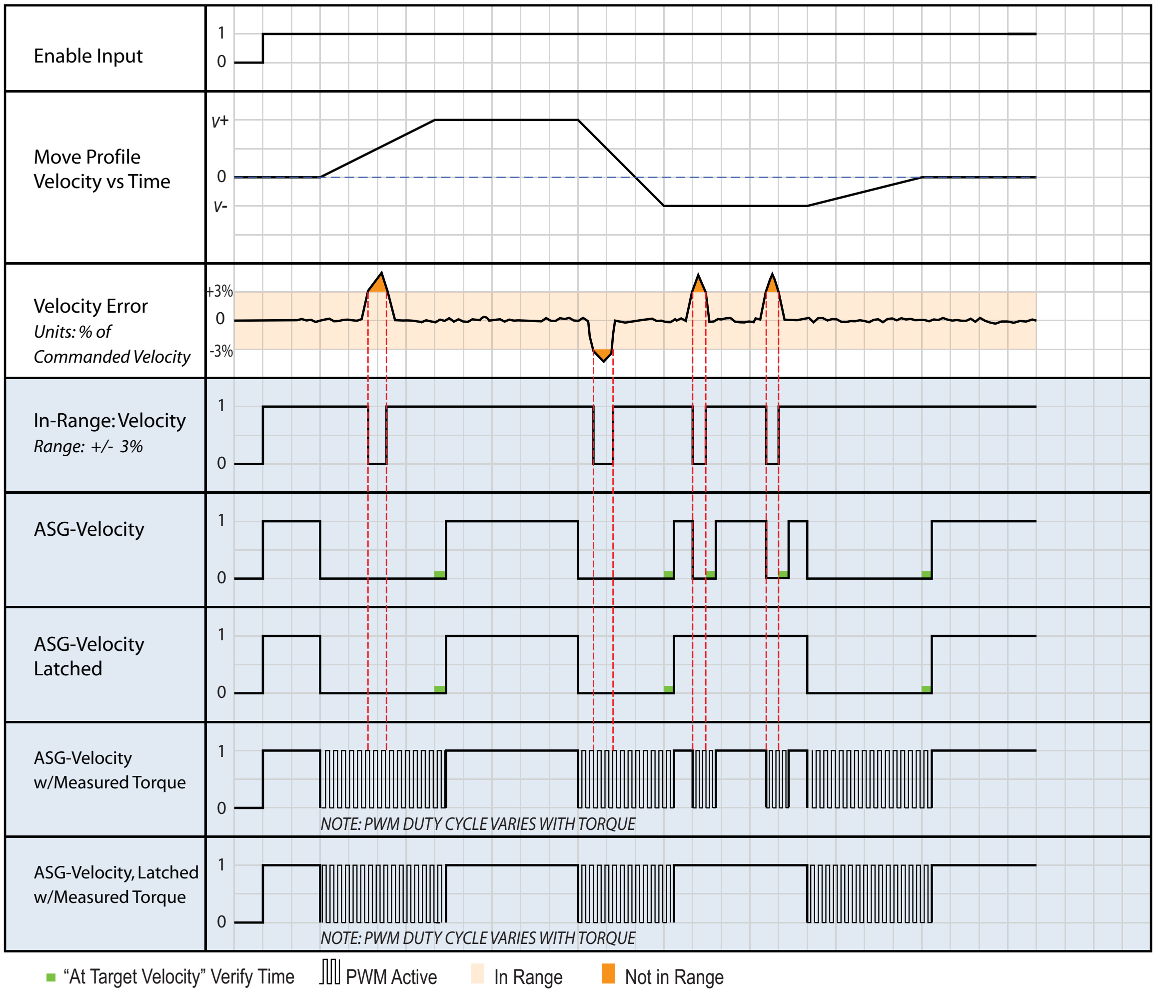
- 5% duty cycle = 100% peak torque, CW direction
- 50% duty cycle = zero torque
- 95% duty cycle = 100% peak torque CCW direction.

### ASG-POSITION LATCHED WITH MEASURED TORQUE

ASG-Position Latched with Measured Torque is a combination of all the previous ASG-Position modes. During commanded motion the HLFB outputs a PWM waveform to indicate motor shaft torque. Once the motor reaches "Move Done" at the target position, the HLFB output latches (stays on) even if the motor is pushed "Out-of-Range" until it is disabled, goes into a shutdown, or receives a motion command.

## HLFB Modes: For ClearPath Velocity Modes

Note: The following HLFB modes are available in Velocity operating modes only.



***HLFB Timing: HLFB output modes available only in ClearPath velocity op modes***

### ASG (All Systems Go) - Velocity

In ASG-Velocity mode the HLFB output asserts (conducts) when the motor is enabled, not shutdown, and is "At Target Velocity".

"At Target Velocity" occurs when the motor has settled within ±X% of the final target velocity, for at least Y milliseconds (where X and Y are user-settable through the MSP software).

**Note:** The HLFB output deasserts during periods of commanded acceleration and deceleration (i.e., when the velocity command is changing), or if the motor's actual position falls out of the ±X% In-Range window.

### ASG-VELOCITY LATCHED

ASG-Velocity Latched works in the same way as ASG-Velocity except that the HLFB output latches once asserted (conducting). The output remains asserted until the motor is disabled, goes into a shutdown, or receives a new velocity command.

Even if the motor is momentarily pushed out-of-range when being commanded to move at constant velocity, the HLFB will remain asserted (conducting).

### ASG-VELOCITY WITH MEASURED TORQUE

ASG-Velocity with Measured Torque works in the same way as ASG-Velocity except, during commanded acceleration and deceleration the HLFB outputs a 45 Hz or 482 Hz (user selectable) 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.

### ASG-VELOCITY LATCHED WITH MEASURED TORQUE

ASG-Velocity Latched with Measured Torque is a combination of all the previous ASG-Velocity modes. During commanded acceleration the HLFB outputs a PWM waveform to indicate motor shaft torque. Once the motor reaches "At Target Velocity", the HLFB output latches on (Conducting) even if the motor is momentarily pushed "Out-of-Range" until the motor is disabled, goes into a shutdown, or receives a new velocity command.

### IN RANGE - VELOCITY

During operation, HLFB asserts (conducts) when the motor is enabled, not shutdown, and the actual velocity is "In-Range" (±X%) of the commanded velocity. The "In-Range" window X, can be set through the MSP software.

## HLFB OUTPUT: FOR CLEARPATH TORQUE MODES

The following HLFB mode is available only in Torque operating modes.

### ASG (ALL SYSTEMS GO) - TORQUE

The HLFB output asserts (conducts) when the motor is enabled, not shutdown, and is producing the commanded torque.

The HLFB output deasserts (non-conducting) when the motor is disabled, shutdown, or if the motor cannot produce the commanded torque for one of the following reasons:

- The supplied bus voltage is not high enough for the motor to produce the commanded torque at the current motor velocity.
- The motor is at or above the max motor speed setting in MSP and motor torque is limited to prevent an over-speed shutdown.

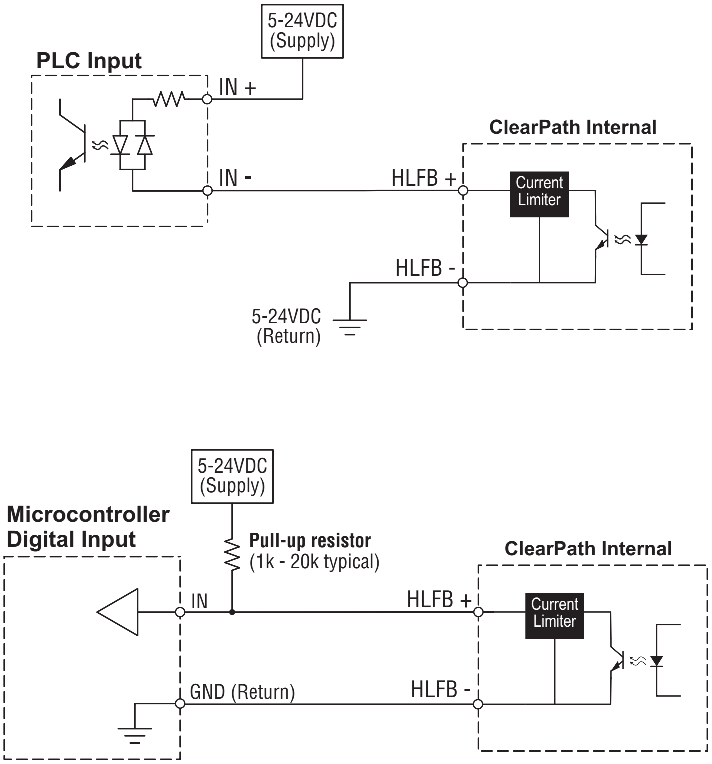
## HLFB OUTPUT WIRING EXAMPLES

Any external circuit or device to be connected to the ClearPath HLFB output should conform to the guidelines below. Proper circuit design/selection greatly reduces the probability of electrically damaging the output, particularly in the event of a common production mistake such as an accidental short or reversed wiring.

### HLFB AS A "SINKING" OUTPUT

The HLFB output can be used as a sinking output as shown below. This topology provides ClearPath with a high level of immunity from damage if, for example, the circuit is shorted to machine chassis. Such a short would simply make the output appear like a closed circuit.

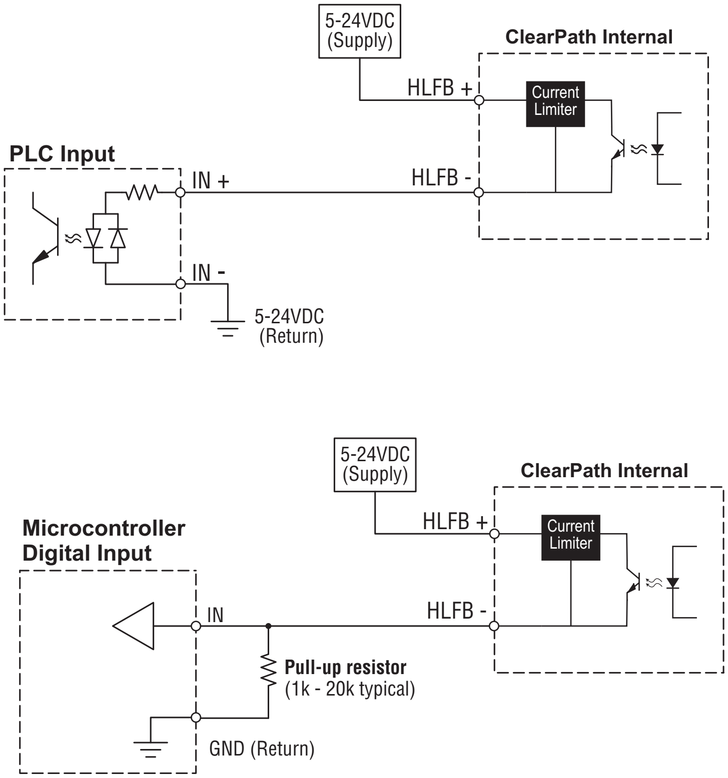
**Note:** the preceding assumes the DC supply return is connected to chassis ground at one location in the machine.



*HLFB as a sinking output*

## HLFB AS A "SOURCING" OUTPUT

The HLFB output can be used as a sourcing switch as shown below. When using a sourcing topology, place a fuse in series with the DC supply's positive output (prior to connection to the HLFB+ pin of the ClearPath). ***Use a fast acting fuse rated for 100mA max.***



***HLFB as a sourcing output***

### Current Limiting the HLFB Output

Whether you use sourcing or sinking topology, current supplied to the HLFB circuit from an external device should be limited to 30mA maximum. Although ClearPath includes built-in current limiting, a series connected, current limiting resistor may still be necessary to protect the HLFB Output's internal circuitry. A series resistor of 2000Ω @ 24VDC, 1100Ω @ 12VDC, 500Ω @ 5VDC can help prevent an overloaded or blown circuit.

**Note:** Any circuit or external device that you intend to connect to the HLFB output may already be appropriately current limited. Consult the device's user manual for its output current rating.

### 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. If a pull-up/pull-down is too large >10,000 Ω, an additional lower value resistor may be required.
- Most Arduinos 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**

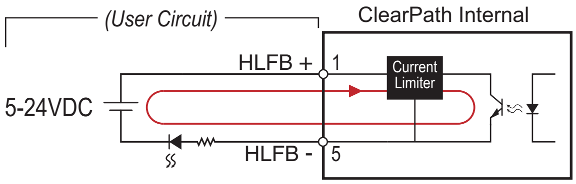
For more information related to Arduino digital inputs and pull-up resistors, check out the following link:

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

## HLFB APPLICATION EXAMPLES

### HLFB Driving a LED

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.

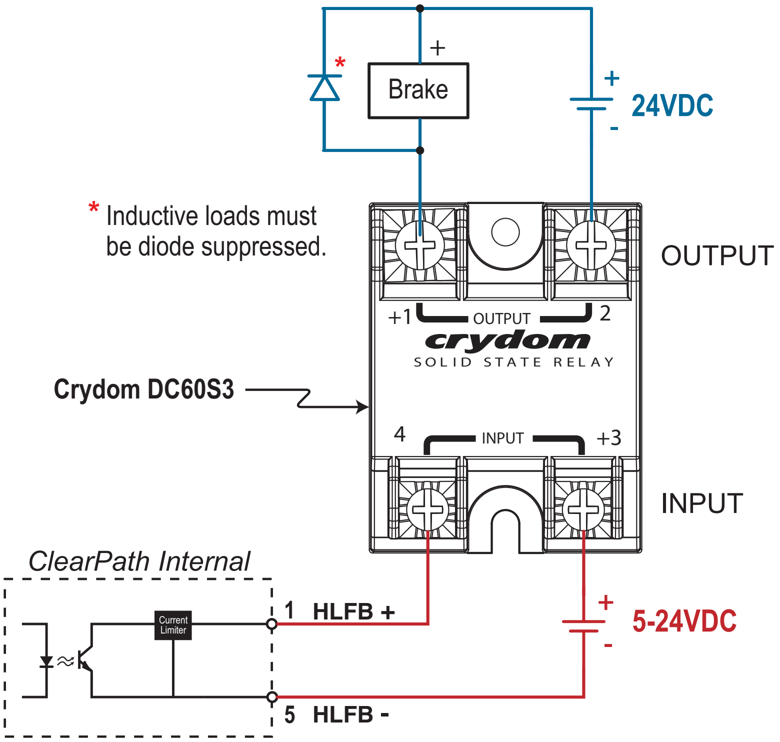


*HLFB Driving LED*

### HLFB Driving a Brake Via Solid State Relay

ClearPath's HLFB output circuit can directly drive the input of some solid state relays (SSRs) such as the ***Crydom DC60S3*** shown below.

Using the **Servo On** HLFB mode, ClearPath can indirectly control power to devices such as a 24V "power-off" brake. See sketch below for example wiring details.



***HLFB circuit controlling an SSR / brake setup***

# USER SOFTWARE (CLEARPATH MSP)

## SECTION OVERVIEW

This section includes information on the following topics:

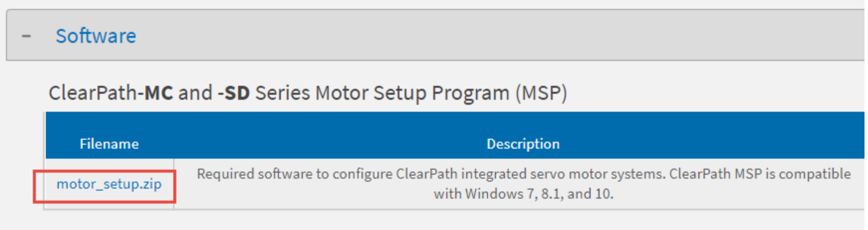
- ClearPath MSP System requirements
- Installing ClearPath MSP software
- Communicating with ClearPath
- Tour of ClearPath MSP
- Overview of ClearPath advanced features

## MSP 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

Download the MSP installer from Teknic's website. Follow the on-screen prompts to complete installation.



ClearPath-**MC** and -**SD** Series Motor Setup Program (MSP)

| Filename | Description |
|---|---|
| motor_setup.zip | Required software to configure ClearPath integrated servo motor systems. ClearPath MSP is compatible with Windows 7, 8.1, and 10. |

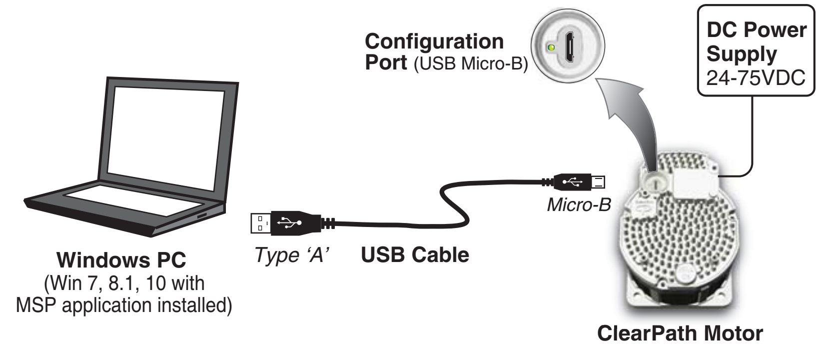
## COMMUNICATING WITH CLEARPATH VIA MSP

After 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) with appropriate cables
- A PC running Windows 7, 8.1, or 10 with ClearPath MSP installed
- A USB cable (Type A to Micro-B) configured for high speed data transfer. "Charging only" cables will not work.



*ClearPath Communication Setup*

## FIRST-TIME COMMUNICATION SETUP

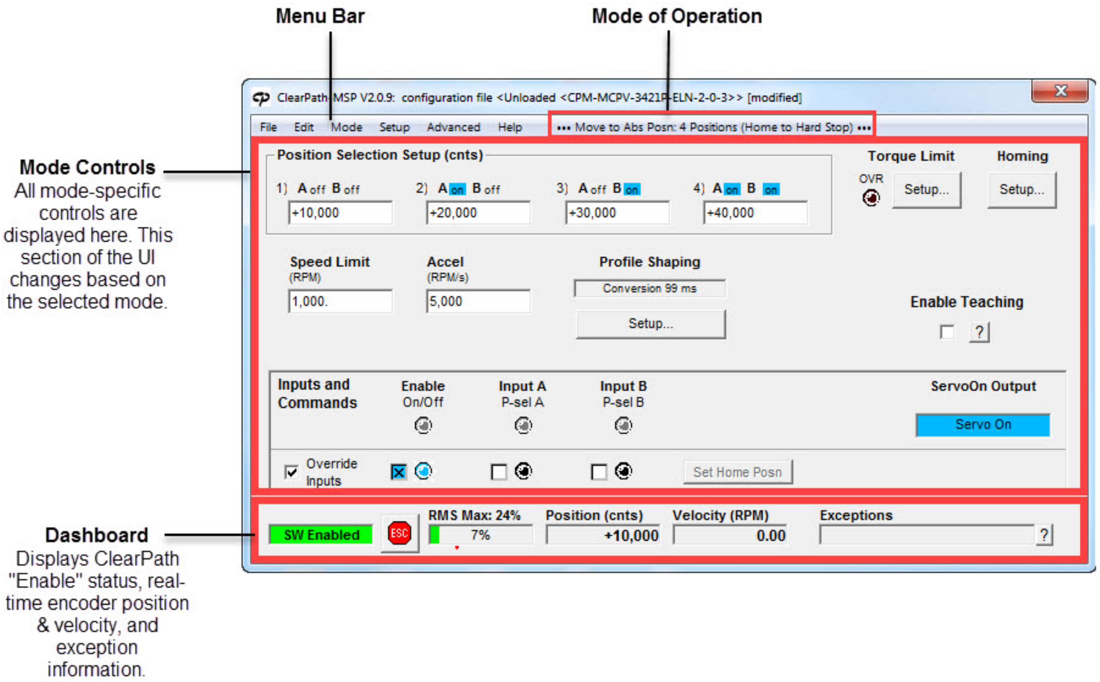
1. **Install MSP** software on a qualified Windows PC. See previous page for Minimum System Requirements.
2. **Power up ClearPath.** Apply 24-75VDC to the power input connector.
3. **Connect ClearPath to your PC** with a USB Type A to Micro-B cable.
4. **Wait!** In most cases Windows will detect the 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 and connected to a PC running MSP.
- ClearPath does not use a PC connection during normal machine operation. You *can* always connect your ClearPath to a PC at any time to use MSP's diagnostic and troubleshooting tools.

# TOUR OF CLEARPATH MSP SOFTWARE

## MAIN UI OVERVIEW


**Menu Bar**

**Mode of Operation**

**Mode Controls** All mode-specific controls are displayed here. This section of the UI changes based on the selected mode.

**Dashboard** Displays ClearPath "Enable" status, real-time encoder position & velocity, and exception information.

ClearPath MSP V2.0.9: configuration file <Unloaded <CPM-MCPV-3421P-ELN-2-0-3>> [modified]

••• Move to Abs Posn: 4 Positions (Home to Hard Stop) •••

Position Selection Setup (cnts)
1) A off B off: +10,000
2) A on B off: +20,000
3) A off B on: +30,000
4) A on B on: +40,000

Speed Limit (RPM): 1,000.
Accel (RPM/s): 5,000
Profile Shaping: Conversion 99 ms

Enable Teaching ☐

☑ Override Inputs

SW Enabled

RMS Max: 24% 7%
Position (cnts): +10,000
Velocity (RPM): 0.00
Exceptions

*MSP User Interface*

## MODE CONTROLS

The Mode Controls section contains settings specific to the currently active operational mode. Mode Controls automatically change whenever a different mode of operation is selected. The Mode Controls allow you to:

- **Enter motion parameters and settings** related to the currently selected mode. These parameters include position, acceleration, velocity, torque limits, homing parameters, and more.
- **Access Soft Controls.** Soft Controls allow you to spin your ClearPath with no external hardware required. With just MSP, a powered up ClearPath motor, and a USB cable you can enable the motor, turn the inputs on and off, command motion, and monitor the HLFB output state. Soft Controls are designed for configuration, testing, and troubleshooting tasks.
- **Set homing parameters**. Homing is discussed in a separate section later in this manual.
- **Set Torque limits.** The Torque Limit settings are explained below.

## TORQUE LIMIT SETUP

The Torque Limit Setup dialog lets you specify the maximum amount of torque that your motor is allowed to apply in either direction of rotation.

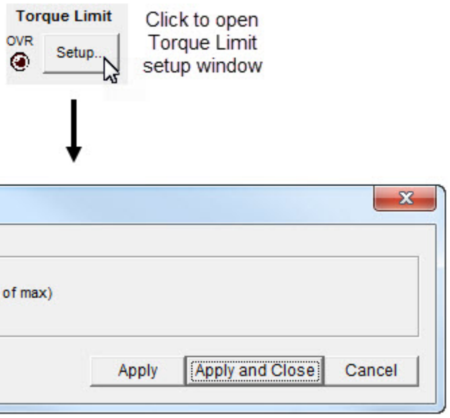
In addition, **Advanced Settings** allow you to specify different torque limits for each direction of travel, and dynamic torque limits based on motor position (Zone Limits).

To open the Torque Limit dialog, click the **Setup** button in the Mode Controls section (see figure below).

**Direction of Applied Torque**

**Positive torque, (+)** = torque applied in the **counterclockwise** direction of rotation (looking into the motor shaft).

**Negative torque (-)** = torque applied in the **clockwise** direction of rotation (looking into the motor shaft).



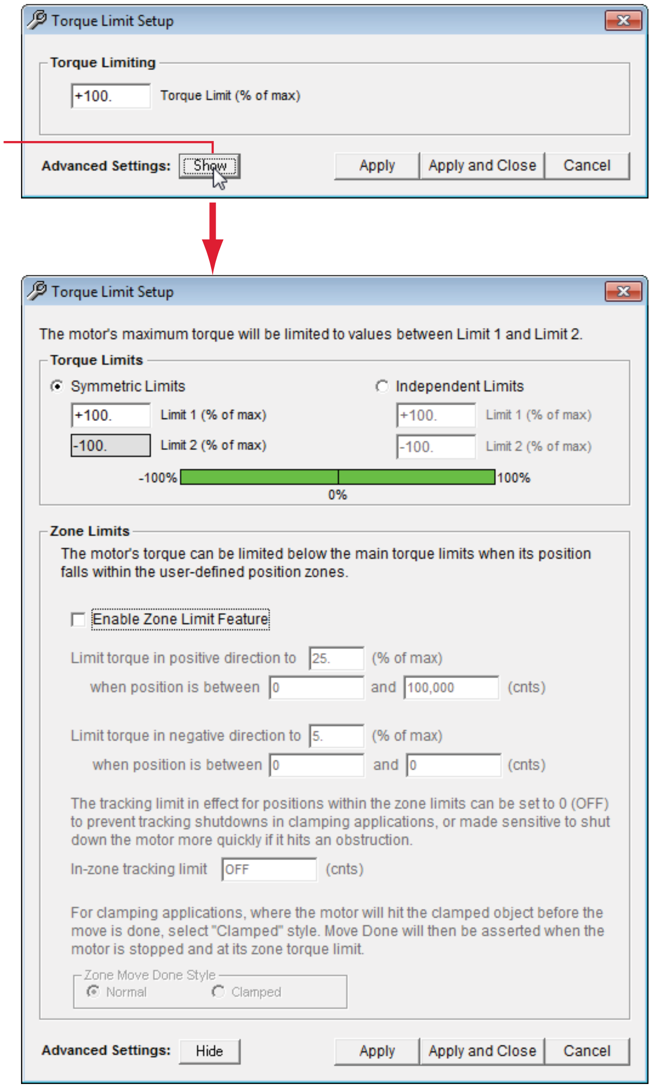
Click to open Torque Limit setup window

+100. Torque Limit (% of max)

*Torque Limit Setup dialog*

### ADVANCED TORQUE LIMIT SETTINGS

Select "Advanced Settings" to open additional torque limit settings, including **Torque Zone Limiting** and **Symmetric vs. Independent Torque Limiting** (more detail on these features below).



Click "Show" to open Advanced Torque Limit Settings

Torque Limit Setup

Torque Limiting

+100. Torque Limit (% of max)

Torque Limit Setup

The motor's maximum torque will be limited to values between Limit 1 and Limit 2.

Torque Limits

● Symmetric Limits

+100. Limit 1 (% of max)

-100. Limit 2 (% of max)

○ Independent Limits

+100. Limit 1 (% of max)

-100. Limit 2 (% of max)

Zone Limits

The motor's torque can be limited below the main torque limits when its position falls within the user-defined position zones.

☐ Enable Zone Limit Feature

Limit torque in positive direction to 25. (% of max)

when position is between 0 and 100,000 (cnts)

Limit torque in negative direction to 5. (% of max)

when position is between 0 and 0 (cnts)

The tracking limit in effect for positions within the zone limits can be set to 0 (OFF) to prevent tracking shutdowns in clamping applications, or made sensitive to shut down the motor more quickly if it hits an obstruction.

In-zone tracking limit OFF (cnts)

For clamping applications, where the motor will hit the clamped object before the move is done, select "Clamped" style. Move Done will then be asserted when the motor is stopped and at its zone torque limit.

Zone Move Done Style

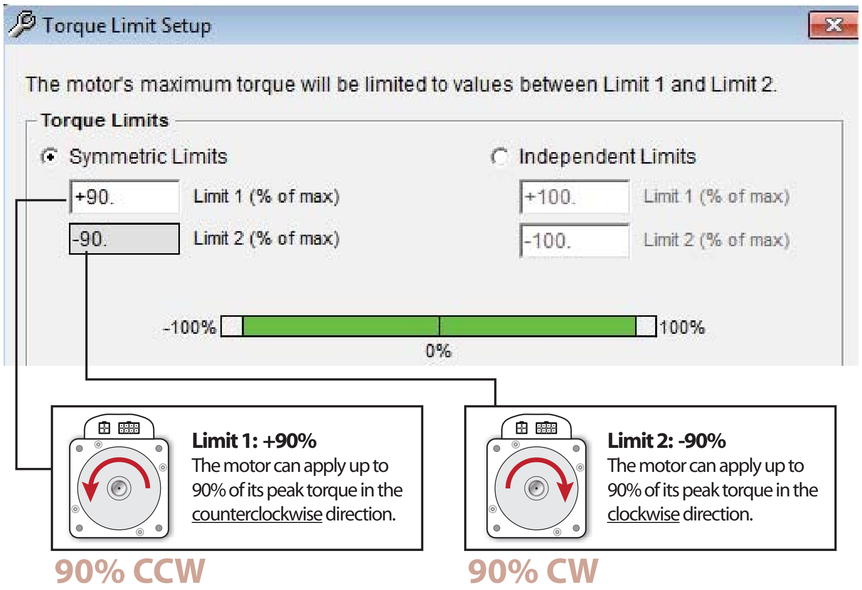
● Normal ○ Clamped

***Advanced Torque Limit Setup dialog***

### Symmetric Torque Limits

Select "Symmetric Limits" if you want the same torque limit for both directions of rotation.

In the example below, torque is capped at 90% of the motor's peak torque in both the CW (-) and CCW (+) directions of rotation.



Torque Limit Setup

The motor's maximum torque will be limited to values between Limit 1 and Limit 2.

**Torque Limits**

● Symmetric Limits
+90. Limit 1 (% of max)
-90. Limit 2 (% of max)

○ Independent Limits
+100. Limit 1 (% of max)
-100. Limit 2 (% of max)

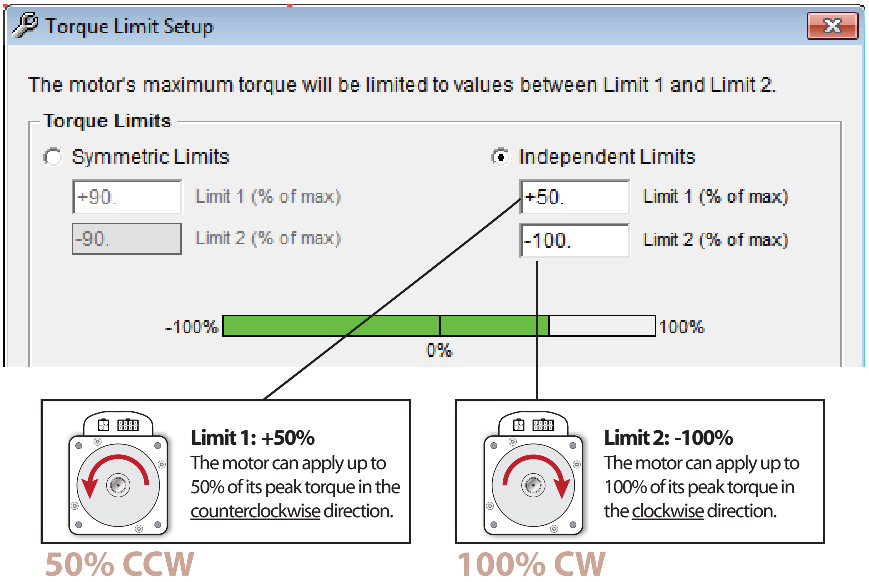
**Limit 1: +90%** The motor can apply up to 90% of its peak torque in the counterclockwise direction.

**Limit 2: -90%** The motor can apply up to 90% of its peak torque in the clockwise direction.

*Symmetric Torque Limits*

### Independent Torque Limits

Select "Independent Limits" if you want to set different torque limits for each direction of travel.



Torque Limit Setup

The motor's maximum torque will be limited to values between Limit 1 and Limit 2.

**Torque Limits**

○ Symmetric Limits
+90. Limit 1 (% of max)
-90. Limit 2 (% of max)

● Independent Limits
+50. Limit 1 (% of max)
-100. Limit 2 (% of max)

**Limit 1: +50%** The motor can apply up to 50% of its peak torque in the counterclockwise direction.

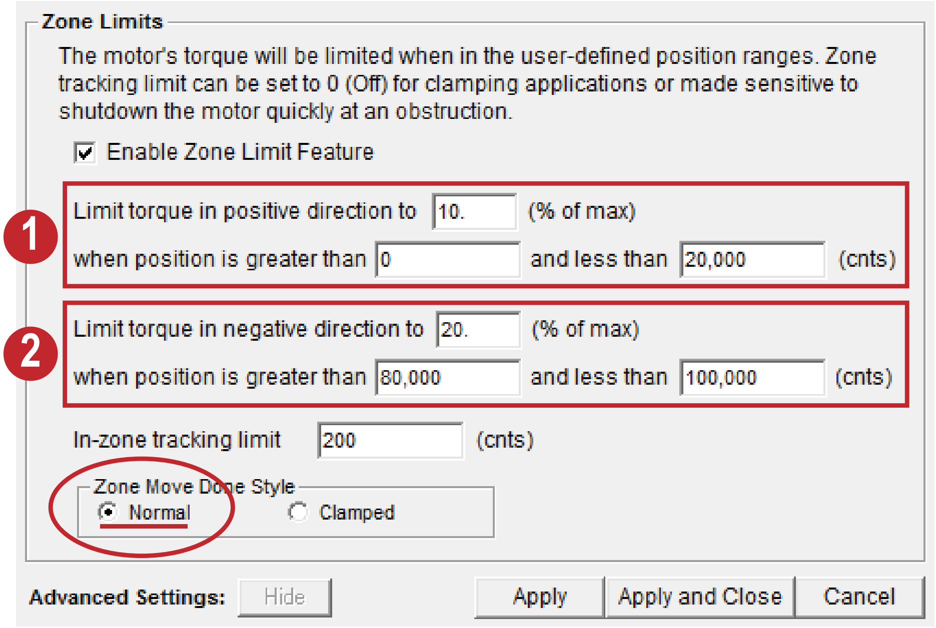
**Limit 2: -100%** The motor can apply up to 100% of its peak torque in the clockwise direction.

*Independent Torque Limits*

### Zone Limits (Normal)

Use the "Zone Limits" torque feature to set up directional torque limits in different user-defined position zones along an axis of travel. See example below.

**Note:** The ClearPath system *must be homed* to use Zone Limits.



**Zone Limits**

The motor's torque will be limited when in the user-defined position ranges. Zone tracking limit can be set to 0 (Off) for clamping applications or made sensitive to shutdown the motor quickly at an obstruction.

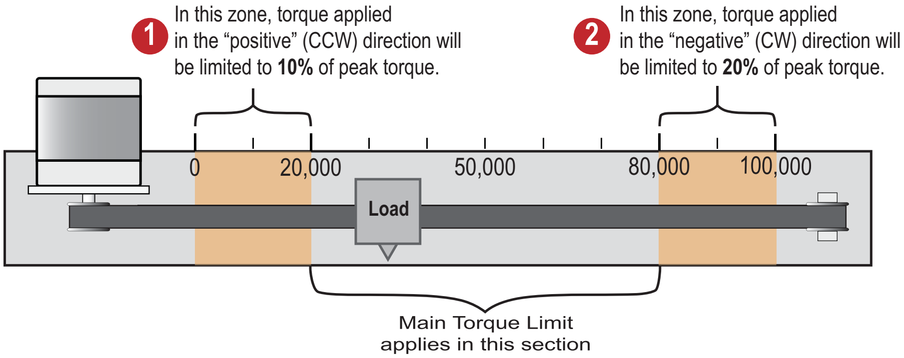
☑ Enable Zone Limit Feature

1. Limit torque in positive direction to 10. (% of max) when position is greater than 0 and less than 20,000 (cnts)

2. Limit torque in negative direction to 20. (% of max) when position is greater than 80,000 and less than 100,000 (cnts)

In-zone tracking limit 200 (cnts)

Zone Move Done Style: ● Normal ○ Clamped



① In this zone, torque applied in the "positive" (CCW) direction will be limited to **10%** of peak torque.

② In this zone, torque applied in the "negative" (CW) direction will be limited to **20%** of peak torque.

***Zone Torque Limits ("Normal" Zone Move Done Style)***

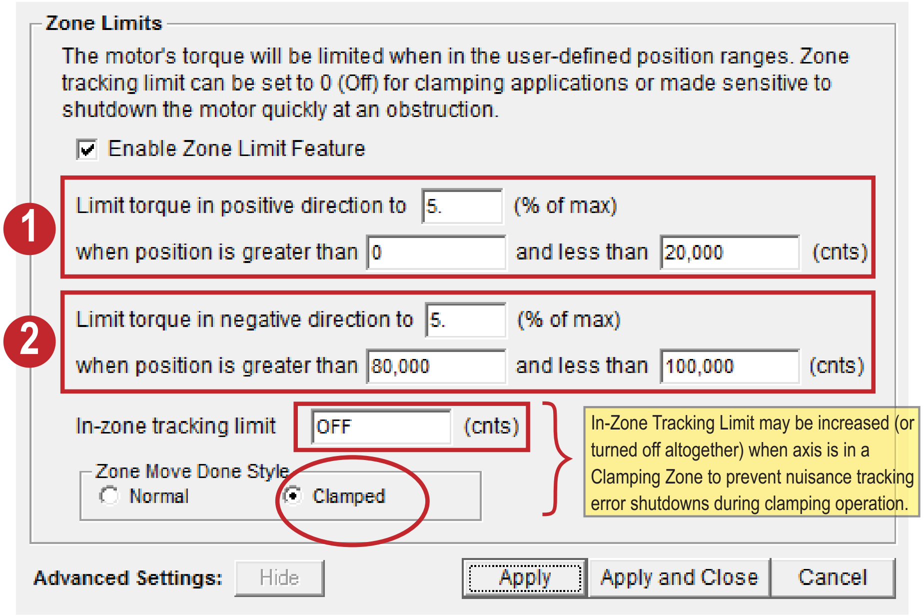
### Zone Limits (Clamped)

Zone Limits can be particularly useful in clamping applications. In the example below, the moving platform ("Load") is designed to move to the left or right to clamp a work piece against a fixed metal block.

To set up clamping:

1. Define your Zone Torque Limits as desired. See example below.
2. Set the "In-Zone Tracking Limit" to zero (OFF). This will prevent unwanted tracking error shutdowns from occurring during clamping.
3. Set Zone Move Done Style to "Clamped".

***Application Tip:*** *When moving the motor into a clamping position, you must send enough pulses to ensure that the motor is fully pressed into the object being clamped.*



**Zone Limits**

The motor's torque will be limited when in the user-defined position ranges. Zone tracking limit can be set to 0 (Off) for clamping applications or made sensitive to shutdown the motor quickly at an obstruction.

☑ Enable Zone Limit Feature

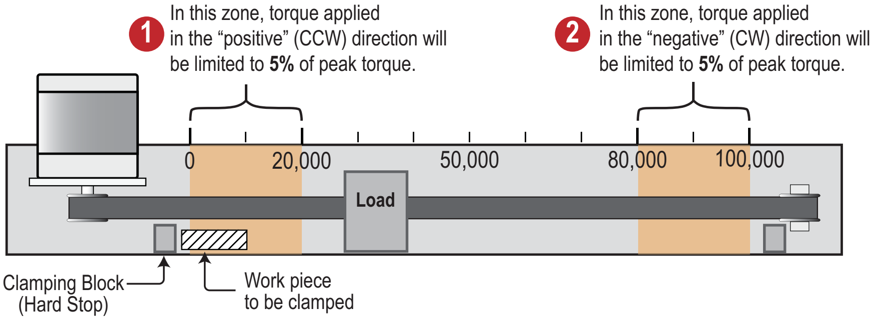
① Limit torque in positive direction to 5. (% of max)
when position is greater than 0 and less than 20,000 (cnts)

② Limit torque in negative direction to 5. (% of max)
when position is greater than 80,000 and less than 100,000 (cnts)

In-zone tracking limit OFF (cnts)

Zone Move Done Style
○ Normal ● Clamped

In-Zone Tracking Limit may be increased (or turned off altogether) when axis is in a Clamping Zone to prevent nuisance tracking error shutdowns during clamping operation.



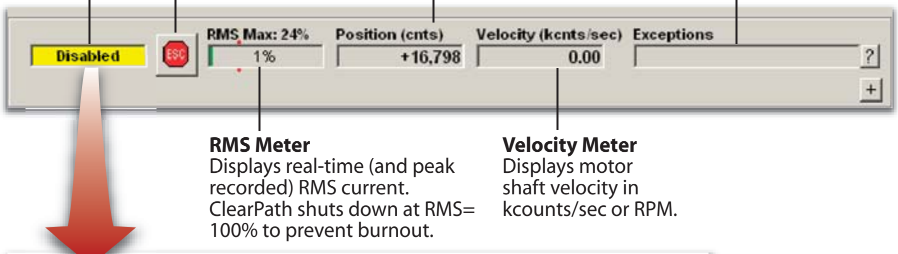
① In this zone, torque applied in the “positive” (CCW) direction will be limited to **5%** of peak torque.

② In this zone, torque applied in the “negative” (CW) direction will be limited to **5%** of peak torque.

***Zone Torque Limits (Clamped Move Done Style)***

## DASHBOARD

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



**Emergency Stop Button**
Click here (or hit "Esc" on keyboard) to de-energize motor coils. Toggle Enable to restore operation.

**Position Counter**
Displays position of motor shaft in encoder counts.

**Exception Messages**
Displays message associated with any active ClearPath exception condition.

**Motor Status**

**RMS Meter**
Displays real-time (and peak recorded) RMS current. ClearPath shuts down at RMS= 100% to prevent burnout.

**Velocity Meter**
Displays motor shaft velocity in kcounts/sec or RPM.

| **Motor Status** | **Description** |
|---|---|
| Enabled | ClearPath is enabled via user hardware.<br>**Caution:** Motor is energized and capable of motion. |
| SW Enabled | ClearPath is enabled via MSP software controls.<br>**Caution:** Motor is energized and capable of motion. |
| Disabled | ClearPath is disabled (Enable is de-asserted).<br>Motor coils are not energized. |
| Lockdown | ClearPath is in a lockdown state.<br>**Caution:** Motor is energized with shaft "locked". |
| Shutdown | ClearPath is in a shutdown state.<br>Motor coils are not energized. |
| No Power | ClearPath is connected to a PC but not powered up.<br>(This indicates low or no DC power.) |

## MSP MENUS

### FILE MENU

**Load Configuration (Ctrl+O)...** 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. I**mportant:** Resetting to factory defaults will cause the motor's existing configuration data to be overwritten.

**Export XML file (Ctrl+L)...** Teknic support use. This command exports an XML file containing a snapshot of the current Soft Scope data and system information.

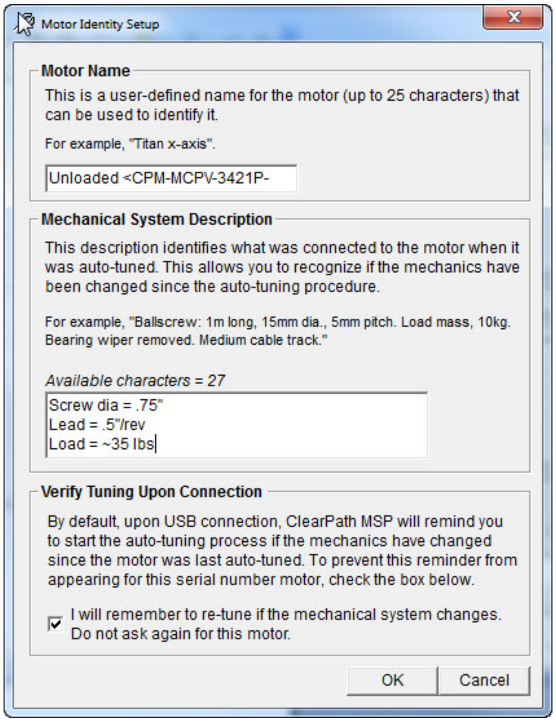
**Create Support Package...** Teknic support use. This command creates a .zip file containing comprehensive system diagnostic data typically for use by a Teknic engineer.

**Firmware Update...** Use this command to update your motor's firmware.

### 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.



Motor Name

This is a user-defined name for the motor (up to 25 characters) that can be used to identify it.

For example, "Titan x-axis".

Unloaded <CPM-MCPV-3421P-

Mechanical System Description

This description identifies what was connected to the motor when it was auto-tuned. This allows you to recognize if the mechanics have been changed since the auto-tuning procedure.

For example, "Ballscrew: 1m long, 15mm dia., 5mm pitch. Load mass, 10kg. Bearing wiper removed. Medium cable track."

*Available characters = 27*

Screw dia = .75"
Lead = .5"/rev
Load = ~35 lbs

Verify Tuning Upon Connection

By default, upon USB connection, ClearPath MSP will remind you to start the auto-tuning process if the mechanics have changed since the motor was last auto-tuned. To prevent this reminder from appearing for this serial number motor, check the box below.

☑ I will remember to re-tune if the mechanical system changes. Do not ask again for this motor.

***Motor Identity Setup Window***

**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.

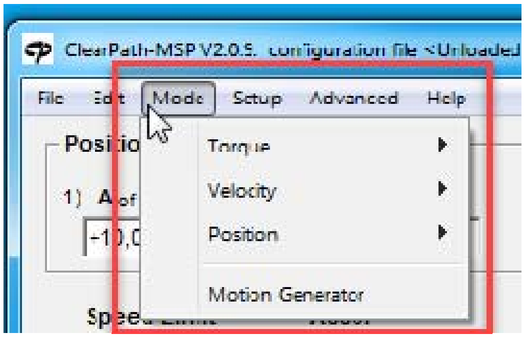
**Reset RMS Peak** This applies to the RMS Meter in the Dashboard section of MSP. Click this menu item to reset *RMS Max* (this is the maximum RMS value recorded since last motor reset).

## MODE MENU

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

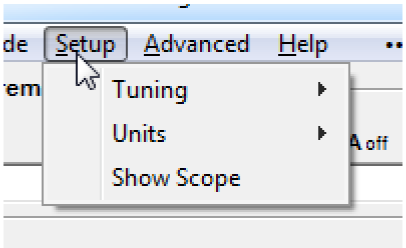
### Motion Generator

The Motion Generator is a special op mode that allows you to command test moves and jog your ClearPath motor using software controls only. This means you can exercise your motor and attached mechanics without wiring a single switch or sensor.



*Mode Menu*

## SETUP MENU

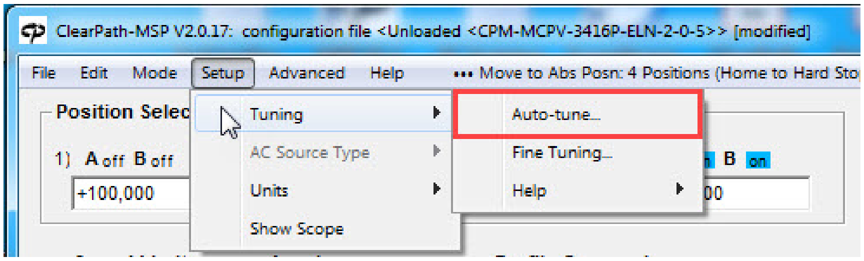


*Setup Menu*

### Tuning>Auto-tune...

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

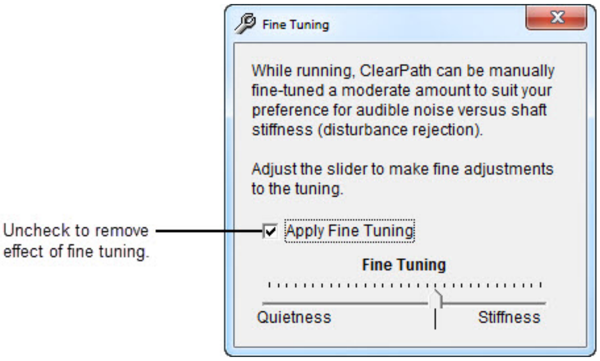
**Important:** To avoid personal injury, crashes, and machine damage, carefully read and follow all on-screen instructions presented during the Auto-Tune process.



*Auto-Tune in the Setup Menu*

### Tuning>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 Fine Tuning off.



While running, ClearPath can be manually fine-tuned a moderate amount to suit your preference for audible noise versus shaft stiffness (disturbance rejection).

Adjust the slider to make fine adjustments to the tuning.

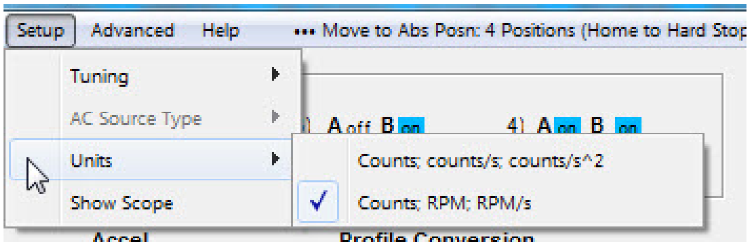
☑ Apply Fine Tuning

Uncheck to remove effect of fine tuning.

*Fine Tuning Control*

### Units

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



*Units Selection Menu*

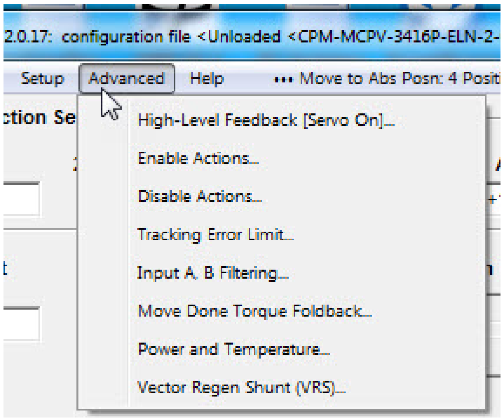
### Show Scope

This option opens MSP's built-in software oscilloscope ("Scope" for short) for troubleshooting and diagnostics.

**See section, " MSP Software Scope "**, for more detailed information on the features and functions of the MSP Scope.

## ADVANCED MENU

Advanced Menu item are described below. The Advanced menu provides access to additional specialized features and settings.

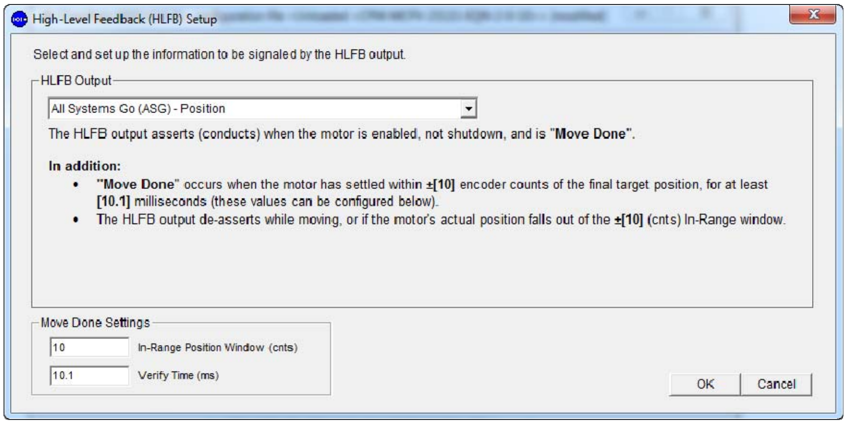


*Advanced Menu*

### High-Level Feedback...

(Abbreviated "HLFB".) This is ClearPath's digital output. The HLFB dialog lets you choose from several different HLFB modes. HLFB can send a signal to indicate things like move completion, turn on brake, motor has shut down, and several more.

For more details on HLFB modes and timing, please refer to the *Inputs and Outputs* chapter of this manual.



Select and set up the information to be signaled by the HLFB output.

HLFB Output

All Systems Go (ASG) - Position

The HLFB output asserts (conducts) when the motor is enabled, not shutdown, and is "**Move Done**".

**In addition:**

- "**Move Done**" occurs when the motor has settled within ±**[10]** encoder counts of the final target position, for at least **[10.1]** milliseconds (these values can be configured below).
- The HLFB output de-asserts while moving, or if the motor's actual position falls out of the ±**[10]** (cnts) In-Range window.

Move Done Settings

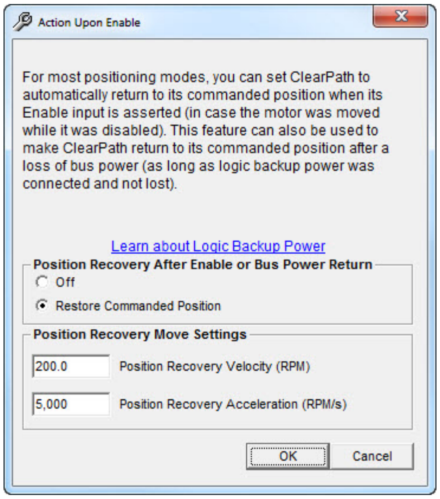
10 In-Range Position Window (cnts)

10.1 Verify Time (ms)

***High-Level Feedback dialog (set to ASG (All Systems Go) mode)***

### Enable Actions...

Select this menu item to configure ClearPath's **Position Recovery** feature. The Position Recovery feature returns your ClearPath motor to its last commanded position if it is moved while disabled, or if main DC bus power drops out temporarily. See use cases below.



For most positioning modes, you can set ClearPath to automatically return to its commanded position when its Enable input is asserted (in case the motor was moved while it was disabled). This feature can also be used to make ClearPath return to its commanded position after a loss of bus power (as long as logic backup power was connected and not lost).

Learn about Logic Backup Power

**Position Recovery After Enable or Bus Power Return**
○ Off
● Restore Commanded Position

**Position Recovery Move Settings**
200.0 Position Recovery Velocity (RPM)
5,000 Position Recovery Acceleration (RPM/s)

***Action Upon Enable dialog***

### Position Recovery: Example #1

*Your motor was operating normally, but then went "disabled" due to a shutdown. While disabled, it was moved an unknown distance from its last commanded position. You need it to return to its last known position the next time it is enabled. Note: Main DC bus power must be on at all times in this scenario.*

### Result

If Position Recovery is on, and if Homing is set to "Home on first enable after power up" (or turned off) enabling the motor will cause it to automatically return to its last commanded position at the specified velocity and acceleration.

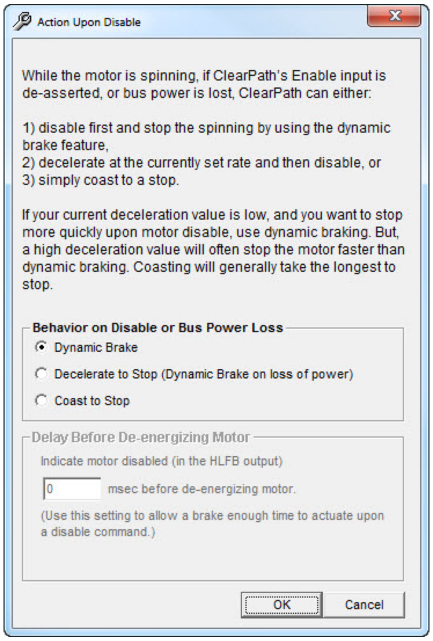
### Position Recovery: Example #2

*Your motor was operating but then loses DC bus power for a short period of time. You need the motor to return to its last commanded position when main DC power is restored. Note: a Power Hub with uninterrupted Logic Backup Power is required in this scenario.*

**Solution:** If Position Recovery is active, and the Logic Power Backup Supply from the Power Hub is uninterrupted, then when main DC bus power is restored the motor will automatically return to its last commanded position at the specified velocity and acceleration.

### Disable Actions...

This dialog lets you tell ClearPath what stopping method to use when the motor is disabled, either dynamic braking, decelerate under power, or coast to a stop.



While the motor is spinning, if ClearPath's Enable input is de-asserted, or bus power is lost, ClearPath can either:

1) disable first and stop the spinning by using the dynamic brake feature,
2) decelerate at the currently set rate and then disable, or
3) simply coast to a stop.

If your current deceleration value is low, and you want to stop more quickly upon motor disable, use dynamic braking. But, a high deceleration value will often stop the motor faster than dynamic braking. Coasting will generally take the longest to stop.

**Behavior on Disable or Bus Power Loss**

● Dynamic Brake
○ Decelerate to Stop (Dynamic Brake on loss of power)
○ Coast to Stop

Delay Before De-energizing Motor

Indicate motor disabled (in the HLFB output)

0 msec before de-energizing motor.

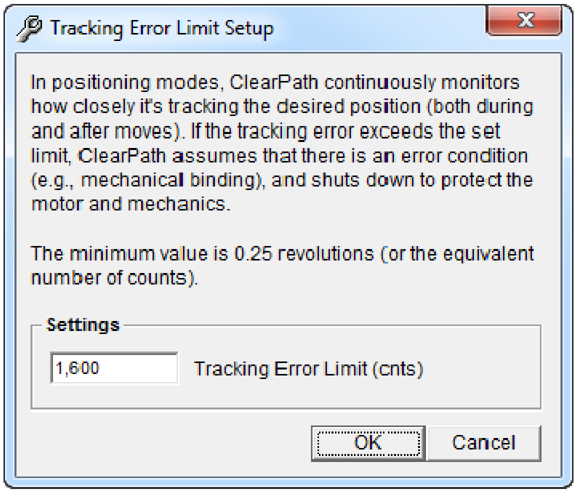
(Use this setting to allow a brake enough time to actuate upon a disable command.)

***Action Upon Disable***

### Tracking Error Limit...

The Tracking Error Limit tells ClearPath how much positional error to allow before throwing an exception and shutting down.

Tracking Error is the difference between ClearPath's *commanded* position and its *actual* position (in units of encoder counts). The phrase "Tracking error" is used interchangeably with the phrase "position error" throughout this manual.



In positioning modes, ClearPath continuously monitors how closely it's tracking the desired position (both during and after moves). If the tracking error exceeds the set limit, ClearPath assumes that there is an error condition (e.g., mechanical binding), and shuts down to protect the motor and mechanics.

The minimum value is 0.25 revolutions (or the equivalent number of counts).

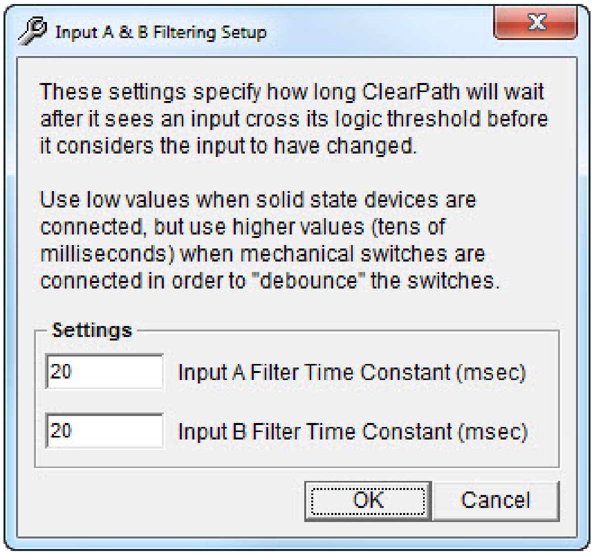
**Settings**

1,600 Tracking Error Limit (cnts)

*Tracking Error Limit Setup*

### Input A & B Filtering...

This dialog lets you independently set digital filtering for the two ClearPath inputs. This can be helpful when "bouncy" mechanical switches are wired to the inputs.



These settings specify how long ClearPath will wait after it sees an input cross its logic threshold before it considers the input to have changed.

Use low values when solid state devices are connected, but use higher values (tens of milliseconds) when mechanical switches are connected in order to "debounce" the switches.

**Settings**

20 Input A Filter Time Constant (msec)

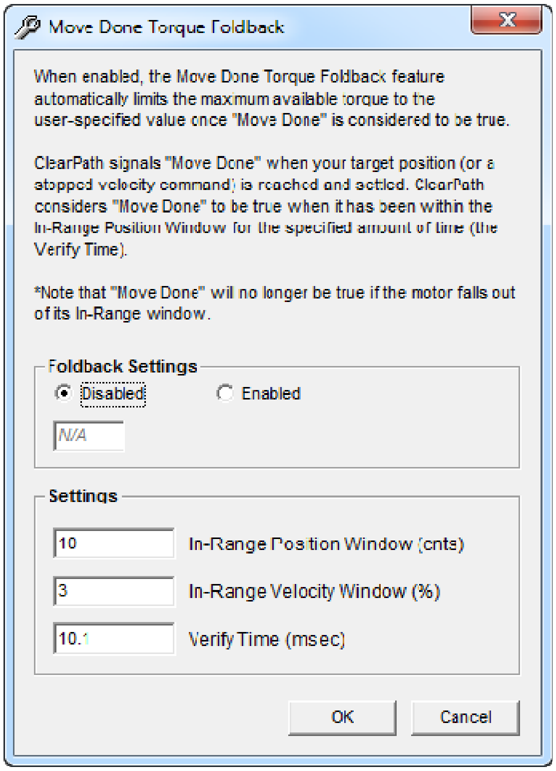
20 Input B Filter Time Constant (msec)

*Input Filtering Setup*

### Move Done Torque Foldback...

This dialog allows you to automatically limit ClearPath's available torque when ClearPath has achieved "Move Done" status.

The Move Done Criteria consist of two parameters: the “In-Range Window” and the “Verify Time”. For complete information, please read the dialog window below.



When enabled, the Move Done Torque Foldback feature automatically limits the maximum available torque to the user-specified value once "Move Done" is considered to be true.

ClearPath signals "Move Done" when your target position (or a stopped velocity command) is reached and settled. ClearPath considers "Move Done" to be true when it has been within the In-Range Position Window for the specified amount of time (the Verify Time).

*Note that "Move Done" will no longer be true if the motor falls out of its In-Range window.

**Foldback Settings**

● Disabled ○ Enabled

N/A

**Settings**

10 In-Range Position Window (cnts)

3 In-Range Velocity Window (%)

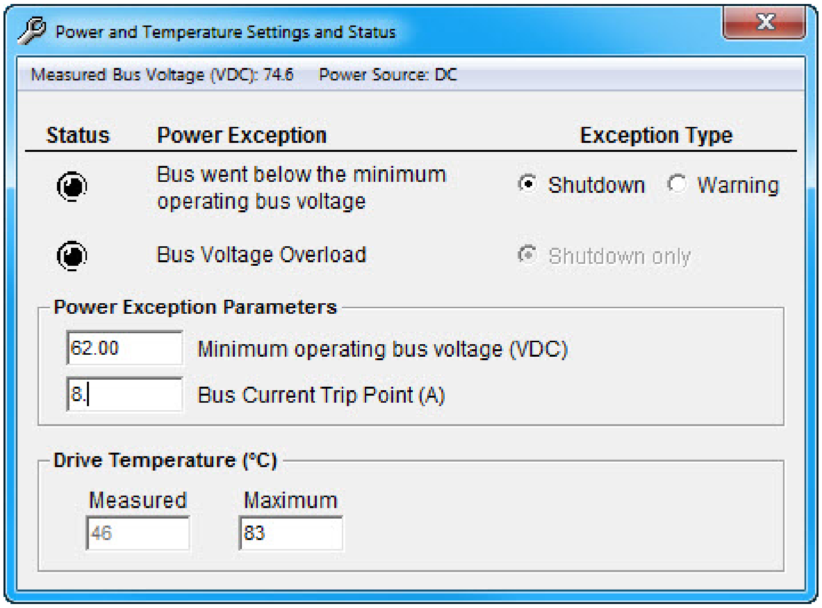
10.1 Verify Time (msec)

***Move Done Criteria Setup***

### Power and Temperature...

Use this dialog to:

- Tell ClearPath whether to shut down or just issue a warning when DC bus voltage falls below the minimum operating voltage setting as can happen when a power supply droops.
- View the temperature of your ClearPath motor's circuit 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

Measured Bus Voltage (VDC): 74.6    Power Source: DC

| Status | Power Exception | Exception Type |
|---|---|---|
| ● | Bus went below the minimum operating bus voltage | ● Shutdown ○ Warning |
| ● | Bus Voltage Overload | ● Shutdown only |

**Power Exception Parameters**

62.00 Minimum operating bus voltage (VDC)

8. Bus Current Trip Point (A)

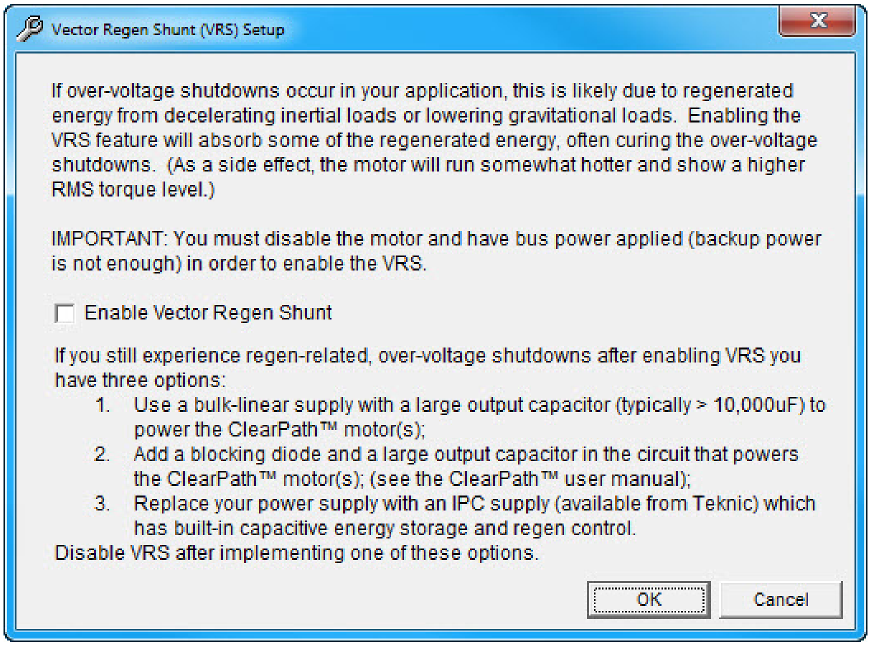
**Drive Temperature (°C)**

Measured: 46

Maximum: 83

***Power and Temperature Settings***

### Vector Regen Shunt (VRS)...



Vector Regen Shunt (VRS) Setup

If over-voltage shutdowns occur in your application, this is likely due to regenerated energy from decelerating inertial loads or lowering gravitational loads. Enabling the VRS feature will absorb some of the regenerated energy, often curing the over-voltage shutdowns. (As a side effect, the motor will run somewhat hotter and show a higher RMS torque level.)

IMPORTANT: You must disable the motor and have bus power applied (backup power is not enough) in order to enable the VRS.

☐ Enable Vector Regen Shunt

If you still experience regen-related, over-voltage shutdowns after enabling VRS you have three options:

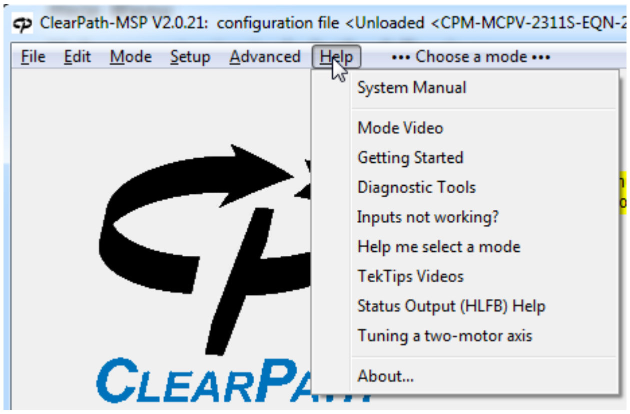
1. Use a bulk-linear supply with a large output capacitor (typically > 10,000uF) to power the ClearPath™ motor(s);
2. Add a blocking diode and a large output capacitor in the circuit that powers the ClearPath™ motor(s); (see the ClearPath™ user manual);
3. Replace your power supply with an IPC supply (available from Teknic) which has built-in capacitive energy storage and regen control.

Disable VRS after implementing one of these options.

*Vector Regen Shunt (VRS) Setup*

## HELP MENU

The Help menu provides additional resources for topics you may have questions on.



*Help Menu*

Help menu topics include the following:

- **System Manual:** Select this option to navigate directly to the user manual for your specific product.
- **Mode Video:** Select this option to navigate to the demo video or manual.
- **Getting Started:** This option will take you directly to a video that explains how to initially set up your ClearPath motor. The video walks you through different MSP features and parameters. The video also includes a brief demo of ClearPath testing with MSP.

- **Diagnostic Tools:** Click this option to watch a video that explains how to use MSP's built-in software oscilloscope and diagnostic tools for troubleshooting and performance measurement.
- **Inputs not working?:** This resource will take you to a simple step-by-step process for how to test the ClearPath inputs if you are trying to troubleshoot a potential issue.
- **Help Me Select a Mode:** Select this option to navigate to the Teknic "Videos" page. From there, you can view various demo videos featuring each ClearPath operational mode.
- **TekTips Videos:** This option will take you to the Teknic "Videos" page where you can watch different tutorials on topics ranging from Auto-Tune to Teknic's RAS feature to the differences between Stepper motors and ClearPath servo motors.
- **Status Output (HLFB) Help:** Click this menu item to be taken directly to the "HLFB" section in the ClearPath User Manual.
- **Tuning a two-motor axis:** Select this option to learn more about the process for tuning a dual-driven axis.
- **About...:** This menu item will give you a summary of your ClearPath specifications including the model number, hardware version, firmware version, MSP Installer version, serial number, and other useful information.

# MSP SOFTWARE SCOPE

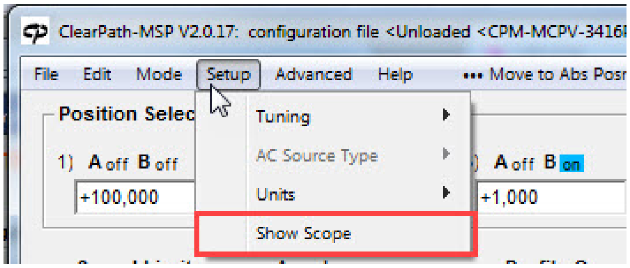
This section contains a discussion of the main features and functions of the MSP Scope.

## OVERVIEW

The MSP software oscilloscope (or just "scope") takes real-time streaming data from your ClearPath motor and plots it on a virtual display similar to that of a hardware oscilloscope.

The scope can be used to display your motor's real-time shaft torque, position error, commanded velocity, acceleration, and more. The scope is an indispensible tool for those who routinely analyze and troubleshoot electrical, mechanical, and motion-related problems on machines with ClearPath motors.

To open the scope in MSP navigate to ***Setup>Show Scope***.



*Opening the MSP Scope*

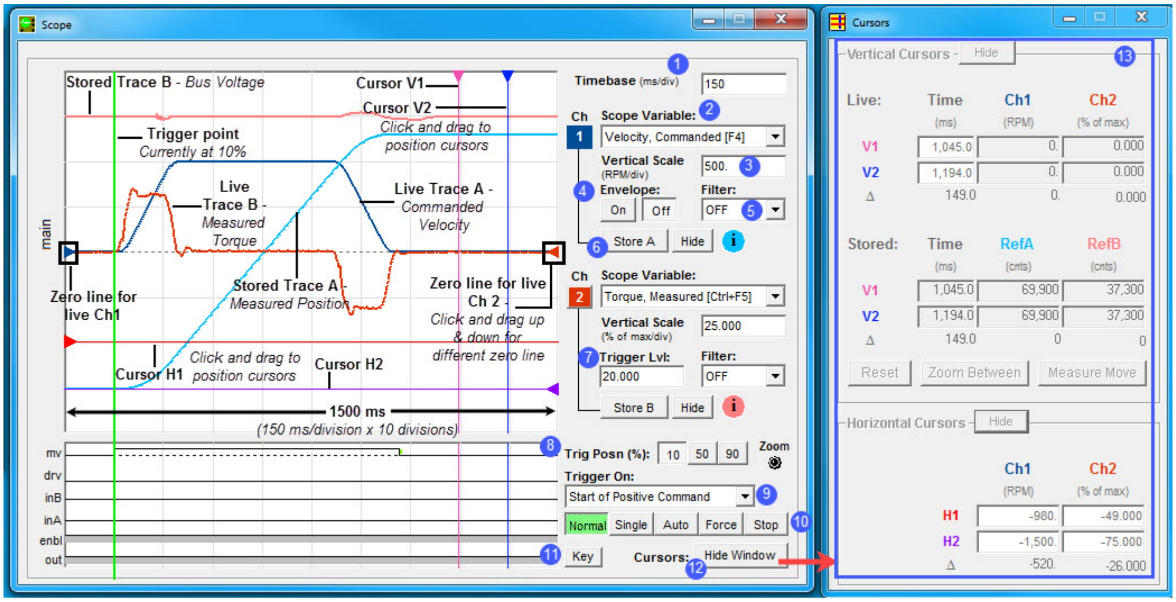
## SCOPE FEATURES

- 13 scope variables
- 4 trigger modes
- Adjustable time base, range, reference "zero" level, and trigger position
- Dual Trace Capability: 2 stored traces + 2 live traces.
- Twelve trigger source presets
- Click-and-drag cursors for precise time and amplitude measurements
- Strip Charts that synchronously display motion, drive, and I/O event timing
- Envelope mode that continuously stores and updates maximum and minimum trace values over a user-defined period of time.
- Cursor "Zoom" feature to help you quickly magnify a user-defined area of the scope display

## SCOPE USER INTERFACE & CONTROLS

The MSP Scope display was designed to look and work like a hardware oscilloscope. MSP Scope has 10 major vertical divisions (the time axis), and 8 major horizontal divisions (the amplitude axis).

See below for a list of MSP Scope features numbered on the figure below.



Timebase (ms/div): 150

Ch 1 Scope Variable: Velocity, Commanded [F4]

Vertical Scale (RPM/div): 500.

Envelope: On Off

Filter: OFF

Ch 2 Scope Variable: Torque, Measured [Ctrl+F5]

Vertical Scale (% of max/div): 25.000

Trigger Lvl: 20.000

Filter: OFF

Trig Posn (%): 10 50 90

Trigger On: Start of Positive Command

| Live: | Time (ms) | Ch1 (RPM) | Ch2 (% of max) |
|---|---|---|---|
| V1 | 1,045.0 | 0 | 0.000 |
| V2 | 1,194.0 | 0 | 0.000 |
| Δ | 149.0 | 0 | 0.000 |

| Stored: | Time (ms) | RefA (cnts) | RefB (cnts) |
|---|---|---|---|
| V1 | 1,045.0 | 69,900 | 37,300 |
| V2 | 1,194.0 | 69,900 | 37,300 |
| Δ | 149.0 | 0 | 0 |

| | Ch1 (RPM) | Ch2 (% of max) |
|---|---|---|
| H1 | -980. | -49.000 |
| H2 | -1,500. | -75.000 |
| Δ | -520. | -26.000 |

*MSP Scope and Cursors window*

1 **The Timebase** field lets you set the scale of the time axis (in units of ms/division). This setting lets you control how a waveform fits (horizontally) on the scope display.

2 **The Scope Variable** drop down menu lets you select any of 13 ClearPath motion control variables to display. The Scope variables are listed below and described in detail on the next page.

**MSP Scope Variables** *(see next page for full descriptions)*

- Position Error
- Commanded Velocity
- Measured Torque
- Utilized Torque
- Velocity Error
- Bus Voltage
- Max Phase Voltage
- Commanded Torque
- Measured Position
- Commanded Acceleration
- Commanded Jerk
- Torque Error
- Measured Velocity

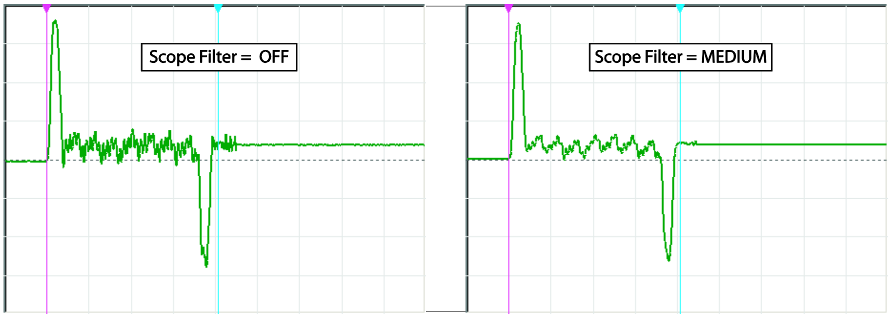
| **Scope Variable** | **Definition** |
|---|---|
| Position Error [F3] | Position Error (also referred to as "Tracking Error") displays the difference between commanded position and actual position. |
| Velocity, Commanded [F4] | Commanded Velocity displays the actual commanded velocity vs. time motion profile coming from your controller or MSP. |
| Torque, Measured [F5] | Measured Torque graphs the actual torque that the motor is using during (as a percentage of peak torque). |
| Torque Utilization [F6] | Torque Utilization plots the percentage of *available* peak torque in use over time. This is particularly useful if you have a power limited motor and need to know how close to available peak torque the motor is operating. |
| Velocity Error (Gated) | Velocity Error shows the difference between commanded velocity and actual velocity during constant velocity command. |
| Bus Voltage | Bus Voltage displays ClearPath's DC bus voltage in real time. |
| Max Phase Voltage | Max Phase Voltage displays the greatest voltage running through ClearPath's phase wires. |
| Torque, Commanded | Commanded torque displays the required torque to complete the given command from your controller or MSP. |
| Position, Measured | Measured Position displays the actual position of ClearPath in terms of encoder counts. |
| Acceleration, Commanded | Commanded Acceleration shows the actual acceleration command coming from your controller or MSP. |
| Jerk, Commanded | Commanded Jerk displays the derivative of the commanded acceleration. |
| Torque Error (peak) | Torque Error displays the difference between commanded and actual torque. |
| Velocity, Measured | Measured Velocity displays ClearPath shaft velocity in either RPM or encoder counts per second. |

3 **The Vertical Scale** lets you change the scale of the amplitude axis in terms of units per division. This allows you to control how a waveform fits (vertically) on the Scope display.

4 **Envelope Mode** allows you to capture the minimum and maximum amplitude envelope of a displayed variable, typically generated over many sweeps of the scope.

**Important note:** *To use Envelope Mode,* ***you must be on Channel 1****, and running a repeat move, and have the scope's trigger mode set to "Normal".*

5 **Filter** “cleans up” the appearance of the live trace by removing higher frequency data content. This has an averaging effect on the displayed waveform that will generally reduce visual clutter.



***Effect of Scope Filter on trace display***

**Note:** The Scope Filter has no effect on motor performance. *It only changes the appearance of displayed scope data.*

**Note:** Be careful! A high filter setting may filter out meaningful data (fast peaks in particular).

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

6 **Trace Storage controls** allow you to save and display one trace per channel on the scope display. Just capture a waveform and click either the "Store A" or "Store B" button. The selected trace is then stored and displayed in either pink (Store A) or blue (Store B). Hide or show either stored trace by clicking its associated Show/Hide button.

7 **The Trigger Level** lets you select the amplitude (of the variable you are currently measuring) 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.

8 **Trigger Position** buttons allow you to place the trigger point on the left, middle, or right side of the scope display grid. This is useful for viewing events on the scope that occur before, during, or after the trigger event.

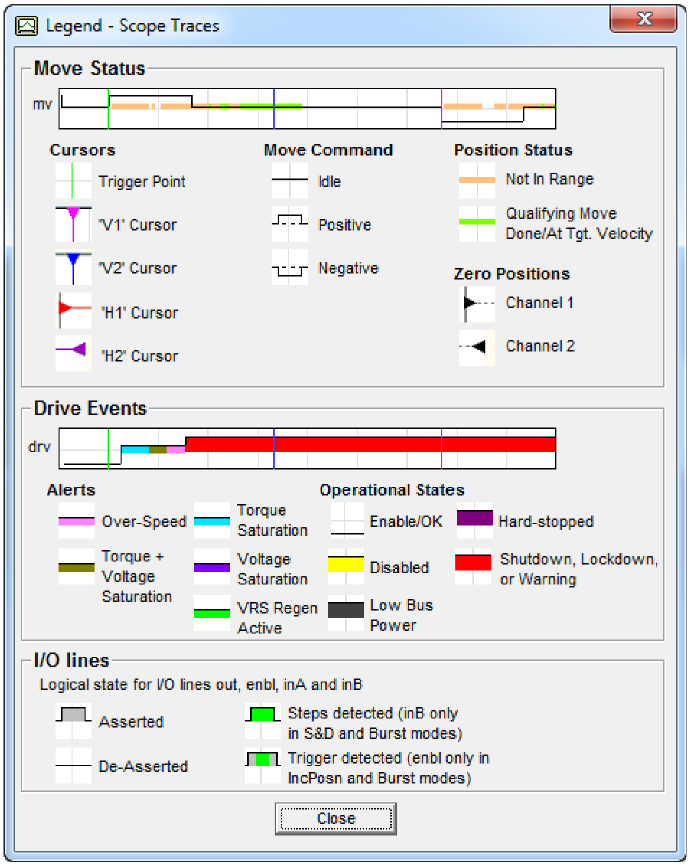
9 **The Trigger Source ("Trigger On")** drop down menu lets you choose what condition(s) must be met before scope data collection begins. The following Trigger Source options are available:

| 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. |

10 **Trigger Mode** settings allow you to specify exactly when to start data acquisition. These controls are analogous to the trigger modes found on a hardware o-scope.

- **Normal** - Causes scope data collection to start 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 scrolling, "always on" setting. Data is continuously collected, refreshed, and displayed regardless of the trigger source setting.
- **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.

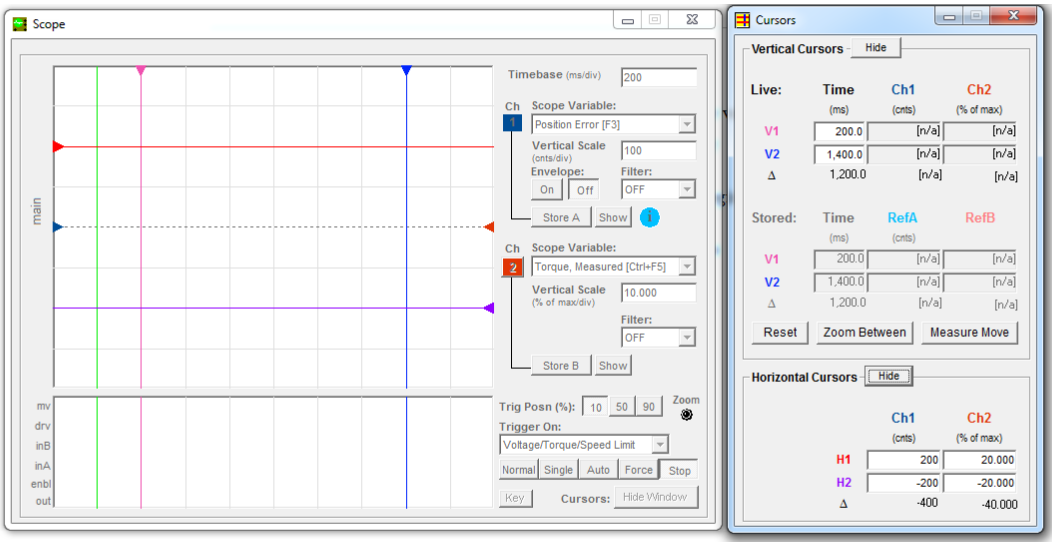
11 **Legend - Scope Traces -** This is a visual key to the symbols you will see on the MSP Scope display.



*MSP Scope Legend*

12 **Show/Hide Window** opens or closes Cursor Control Window.

## 13 **Cursors Window** *(see window at right.)*



Timebase (ms/div): 200

Ch 1 Scope Variable: Position Error [F3]

Vertical Scale (cnts/div): 100

Envelope: Off

Filter: OFF

Ch 2 Scope Variable: Torque, Measured [Ctrl+F5]

Vertical Scale (% of max/div): 10.000

Filter: OFF

Trig Posn (%): 10

Trigger On: Voltage/Torque/Speed Limit

Vertical Cursors

| Live: | Time (ms) | Ch1 (cnts) | Ch2 (% of max) |
|---|---|---|---|
| V1 | 200.0 | [n/a] | [n/a] |
| V2 | 1,400.0 | [n/a] | [n/a] |
| Δ | 1,200.0 | [n/a] | [n/a] |

| Stored: | Time (ms) | RefA (cnts) | RefB |
|---|---|---|---|
| V1 | 200.0 | [n/a] | [n/a] |
| V2 | 1,400.0 | [n/a] | [n/a] |
| Δ | 1,200.0 | [n/a] | [n/a] |

Horizontal Cursors

| | Ch1 (cnts) | Ch2 (% of max) |
|---|---|---|
| H1 | 200 | 20.000 |
| H2 | -200 | -20.000 |
| Δ | -400 | -40.000 |

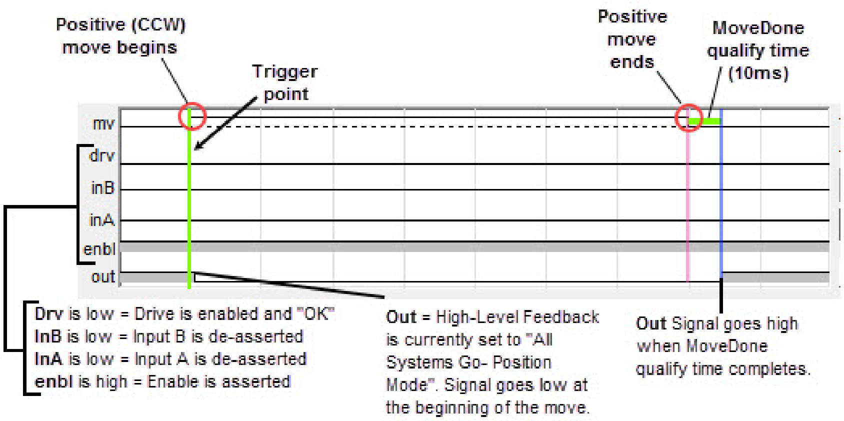
***MSP Scope Display (left) and Cursors window (right)***

The Cursors window features:

- **Real-time, numeric display** of cursor data, including delta calculation showing the difference between cursor values.
- **"Zoom Between" button** allows one-click magnification of the area of the scope display between the vertical cursors.
- **"Measure Move" button** automatically places the vertical cursors at the beginning and end of a "live" move.
- **"Hide" and "Show" buttons** let you view or hide vertical and/or horizontal cursors as desired.
- **"Reset" button** automagically relocates cursors to their default, initial positions.

## 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*

# OPERATIONAL MODES: MCVC AND MCPV

## TABLE OF OPERATIONAL MODES: MODELS MCVC AND MCPV

This section lists the operational modes for ClearPath models **MCVC and MCPV** only. ClearPath SD (step & direction) models are covered in the section *Operational Modes: SDSK and SDHP* (which follows this section).

| ClearPath Models MCVC and MCPV Operational Modes List | | | |
|---|---|---|---|
| ***Velocity Control Modes*** | ***MCVC*** | ***MCPV*** | ***Description*** |
| **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**<br>*Bipolar PWM Command (with Inhibit)* | ✓ | ✓ | 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**<br>*Bipolar PWM Command with Variable Torque* | ✓ | ✓ | |
| **Follow Digital Velocity Command**<br>*Unipolar PWM Command* | ✓ | ✓ | |
| **Follow Digital Velocity Command**<br>*Frequency Command* | ✓ | ✓ | |
| ***Torque Control Modes*** | ***MCVC*** | ***MCPV*** | ***Description*** |
| **Follow Digital Torque Command**<br>*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**<br>*Unipolar PWM Command* | ✓ | ✓ | |
| **Follow Digital Torque Command**<br>*Frequency Command* | ✓ | ✓ | |
| ***Positioning Modes*** | ***MCVC*** | ***MCPV*** | ***Description*** |
| **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. |
| **Multi-Sensor Positioning: Bi-directional**<br>*Home to Hard Stop* | ✗ | ✓ | A trigger pulse starts ClearPath moving in the direction signaled on Input A. When Input B sees a count of transitions equal to the count of trigger pulses, ClearPath will ramp to a stop at the user-defined rate. (These transitions are typically switch closures or sensor interruptions.) |

| ***Positioning Modes (cont'd)*** | **MCVC** | **MCPV** | **Description** |
|---|---|---|---|
| **Multi-Sensor Positioning: Unidirectional**<br>*Sensorless Homing* | ✗ | ✓ | This mode starts by finding a user-defined, shaft angle home position. Then, upon seeing a transition on Input A, ClearPath will start to move in one, fixed, user-defined direction, at one of two velocities. ClearPath will ramp to a stop at the user-defined rate when Input B has seen a count of transitions equal to the count of transitions on Input A. (These transitions are typically switch closures or sensor interruptions.) |
| **Multi-Sensor Positioning: Unidirectional**<br>*Home to Sensor* | ✗ | ✓ | Use simple I/O from your PLC, microcontroller etc. to command ClearPath to move to the sensor or switch of your choosing. Direction, speed, and acceleration are all user-defined in MSP. Optional homing (home-to-sensor) is available. |
| **Move to Absolute Position: 2 Positions**<br>*Home to Switch* | ✓ | ✓ | 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**<br>*Home to Hard Stop* | ✗ | ✓ | 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 to Absolute Position: 16 Positions**<br>*Home to Hard Stop* | ✗ | ✓ | ClearPath will move to one of sixteen user-defined positions when Input A is asserted, depending on the number of times Input B is pulsed. ClearPath can seek for the hard stop home position the first time it is enabled after power up, or each time it is enabled. |
| **Move Incremental Distance: 1 Increment**<br>*Home to Switch* | ✗ | ✓ | ClearPath will make an incremental move when the state of Input A changes. If automatic homing is on, ClearPath will seek for the home switch connected to Input B the first time it is enabled after power up, or, if desired, each time it is enabled. |
| **Move Incremental Distance: 2 Increments**<br>*Home to Switch* | ✗ | ✓ | 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: 2 Increments**<br>*Home to Hard Stop* | ✗ | ✓ | ClearPath will make one of two incremental moves (based on the Input B setting) when Input A changes state. If automatic homing is on, ClearPath will seek for the hard stop home position the first time it is enabled after power up, or, if desired, each time it is enabled. |
| **Move Incremental Distance: 4 Increments**<br>*Home to Hard Stop* | ✗ | ✓ | 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. |
| **Follow Digital Position Command**<br>*Unipolar PWM Command* | ✗ | ✓ | ClearPath will servo to a position between two user-defined limits proportional to the PWM duty cycle of the signal on Input B. |
| **Follow Digital Position Command**<br>*Frequency Command* | ✗ | ✓ | ClearPath will servo to a position between two user-defined limits based on the frequency of the signal on Input B. |
| **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. |

# Follow Digital Torque Command (Bi-Polar PWM Command)

Available on
MCVC + MCPV

## Mode Description

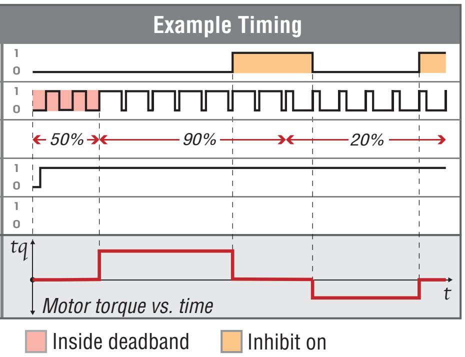
Connect a digital PWM waveform from your PLC or other device, and ClearPath will produce torque proportional to the duty cycle of the PWM waveform.

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.



## I/O Functions

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input forces the torque to zero regardless of the input PWM duty cycle.

**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired torque.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

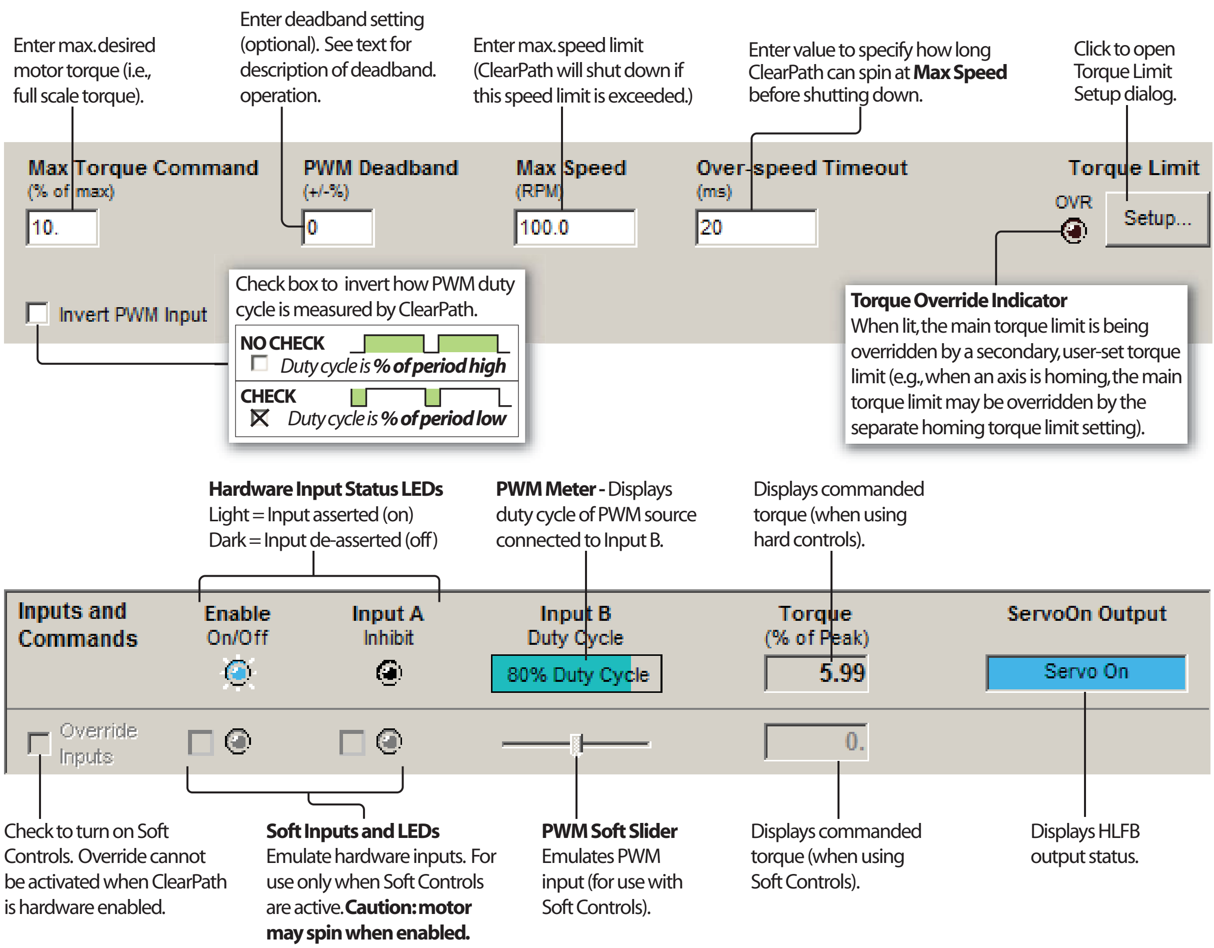
- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

- To command ClearPath to zero torque, assert the Inhibit): Input (Input A). Deassert 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



Enter max. desired motor torque (i.e., full scale torque).

Enter deadband setting (optional). See text for description of deadband. operation.

Enter max. speed limit (ClearPath will shut down if this speed limit is exceeded.)

Enter value to specify how long ClearPath can spin at **Max Speed** before shutting down.

Click to open Torque Limit Setup dialog.

Max Torque Command (% of max): 10.

PWM Deadband (+/-%): 0

Max Speed (RPM): 100.0

Over-speed Timeout (ms): 20

☐ Invert PWM Input

Check box to invert how PWM duty cycle is measured by ClearPath.

**NO CHECK**
☐ *Duty cycle is **% of period high***

**CHECK**
☒ *Duty cycle is **% of period low***

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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

**PWM Meter -** Displays duty cycle of PWM source connected to Input B.

Displays commanded torque (when using hard controls).

Input B Duty Cycle: 80% Duty Cycle

Torque (% of Peak): 5.99

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.**

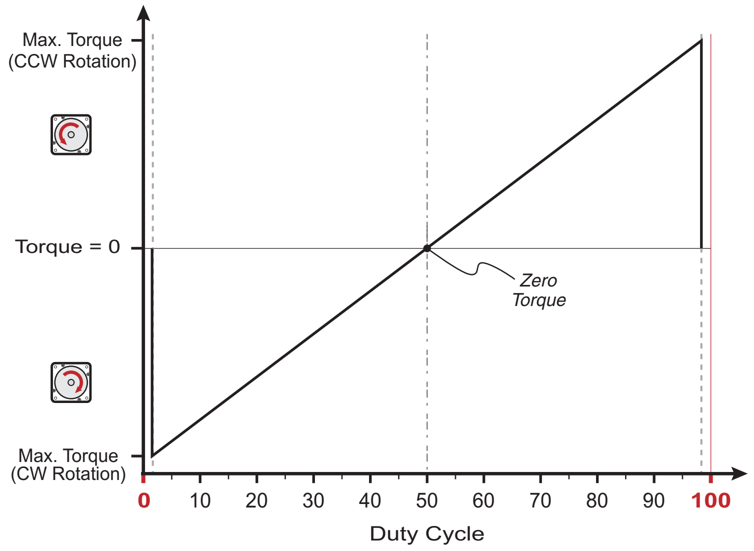
**PWM Soft Slider**
Emulates PWM input (for use with Soft Controls).

Displays commanded torque (when using Soft Controls).

Displays HLFB output status.

### Relationship of PWM duty cycle to motor torque

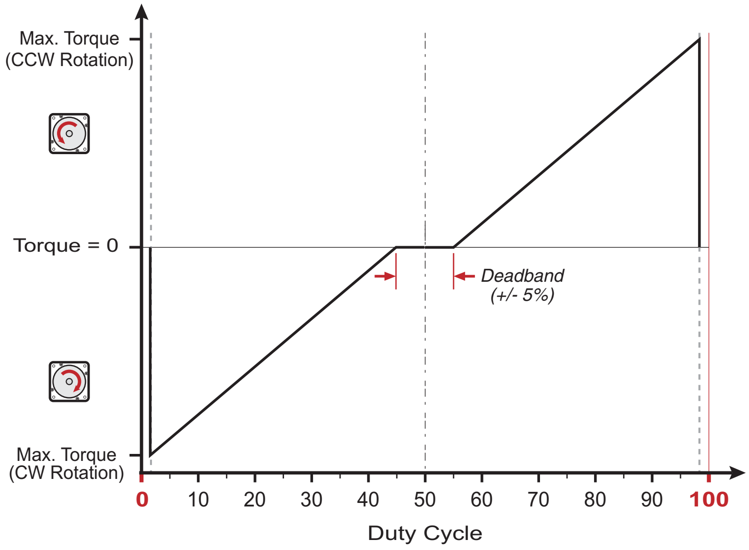
- Shaft torque increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft torque increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50% from either direction, motor torque approaches 0.
- 0% and 100% duty cycle (static low 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%.



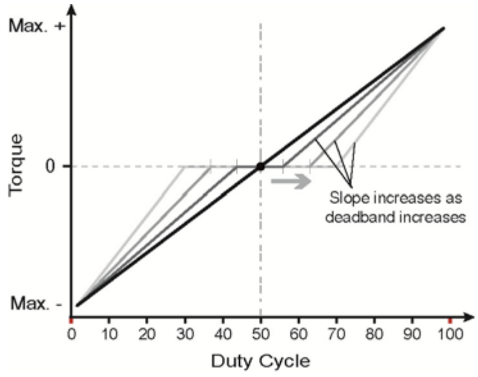
***+/- 5% PWM deadband setting***

**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 COMMAND)

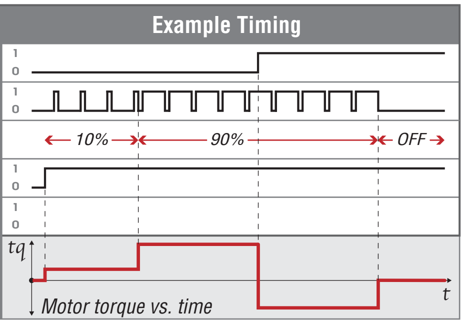
Available on
**MCVC + MCPV**

## MODE DESCRIPTION

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.

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:** | | | |

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input selects the direction of the applied torque.

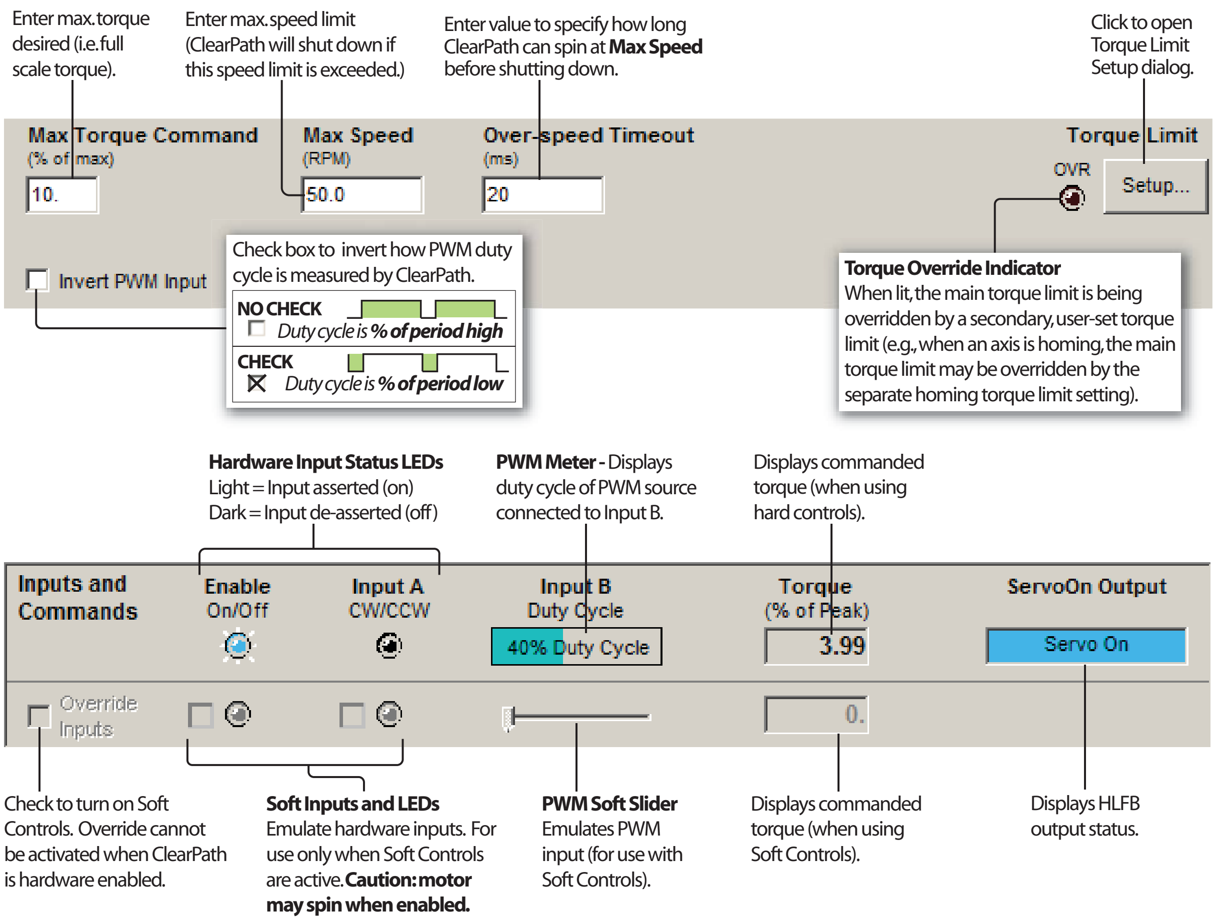
**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired torque.

**Output (HLFB) -** See HLFB section for available modes.

**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



Enter max. torque desired (i.e. full scale torque).

Enter max. speed limit (ClearPath will shut down if this speed limit is exceeded.)

Enter value to specify how long ClearPath can spin at **Max Speed** before shutting down.

Click to open Torque Limit Setup dialog.

Max Torque Command (% of max): 10.

Max Speed (RPM): 50.0

Over-speed Timeout (ms): 20

Check box to invert how PWM duty cycle is measured by ClearPath.

**NO CHECK** ☐ *Duty cycle is **% of period high***

**CHECK** ☒ *Duty cycle is **% of period low***

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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

**PWM Meter -** Displays duty cycle of PWM source connected to Input B.

Displays commanded torque (when using hard controls).

Input B Duty Cycle: 40% Duty Cycle

Torque (% of Peak): 3.99

ServoOn Output: Servo On

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.**

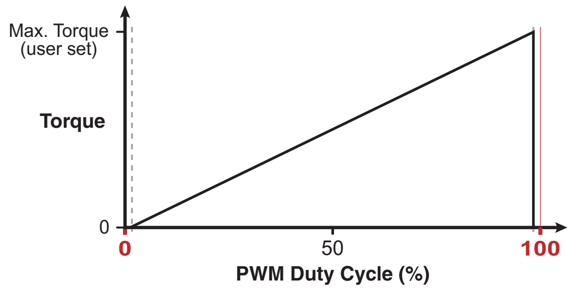
**PWM Soft Slider**
Emulates PWM input (for use with Soft Controls).

Displays commanded torque (when using Soft Controls).

Displays HLFB output status.

**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 Command)

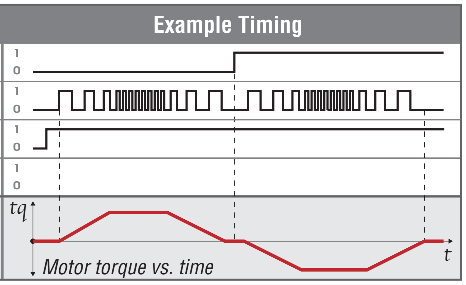
Available on
**MCVC + MCPV**

## Mode Description

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.

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:** | | | |

## I/O Functions

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input selects the direction of the applied torque.

**Input B -** This input is connected to a pulse train whose frequency represents the desired torque.

**Output (HLFB) -** See HLFB section for available modes.

**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

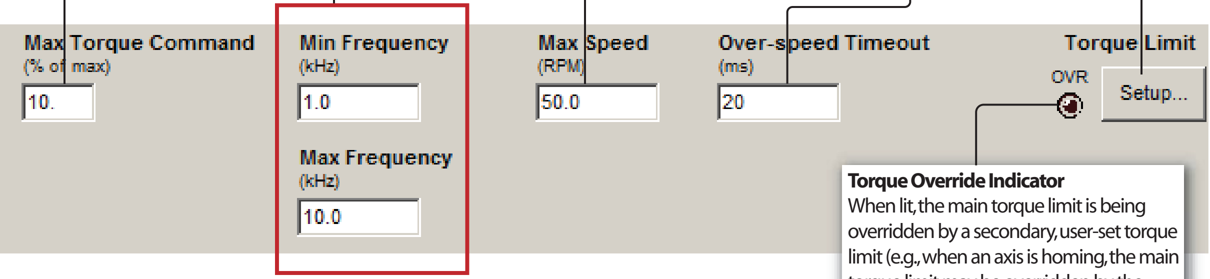
Enter max. desired motor torque (i.e., full scale torque).

**Set Min/Max Frequency**. During operation, motor torque is controlled by Input B signal frequency. With settings shown below, a 10 kHz input signal will command the motor to its Max Torque Command (10% of peak), and a signal of 1kHz or less will command zero torque.

Enter max. speed limit (ClearPath will shut down if this speed limit is exceeded.)

Enter value to specify how long ClearPath can spin at **Max Speed** before shutting down.

Click to open Torque Limit Setup dialog.



Max Torque Command (% of max): 10.

Min Frequency (kHz): 1.0

Max Frequency (kHz): 10.0

Max Speed (RPM): 50.0

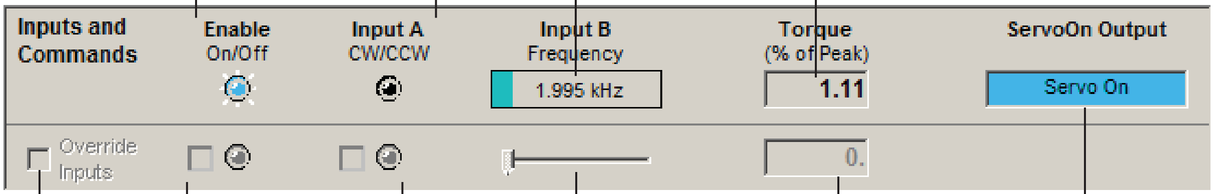
Over-speed Timeout (ms): 20

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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

**Frequency Meter**
Displays frequency of signal connected to Input B.

Displays commanded torque (when using hard controls).



Input B Frequency: 1.995 kHz

Torque (% of Peak): 1.11

0.

ServoOn Output: Servo On

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.**

**PWM Soft Slider**
Emulates PWM input (for use with Soft Controls).

Displays commanded torque (when using Soft Controls).

Displays HLFB output status.

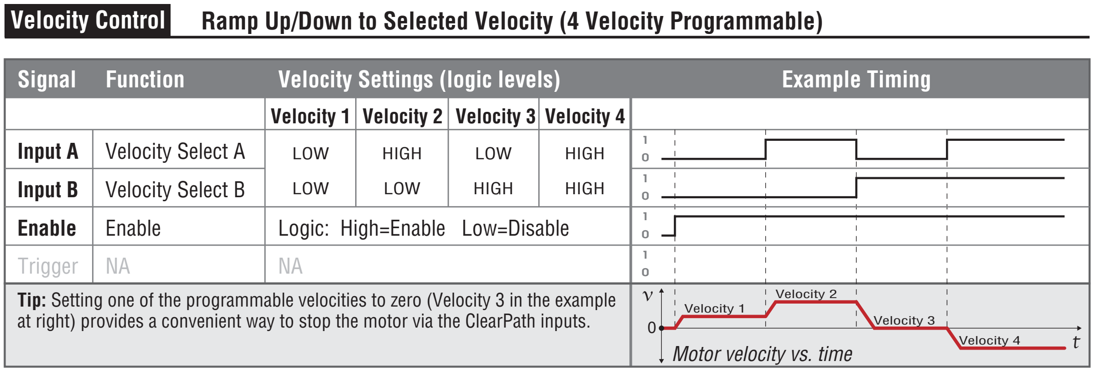
# RAMP UP/DOWN TO SELECTED VELOCITY

Available on
MCVC + MCPV

## MODE DESCRIPTION

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

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*

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input, along with Input B, selects which of the four defined velocities ClearPath will run at.

**Input B -** This input, along with Input A, selects which of the four defined velocities ClearPath will run at.

**Output (HLFB) -** See HLFB section for available modes.

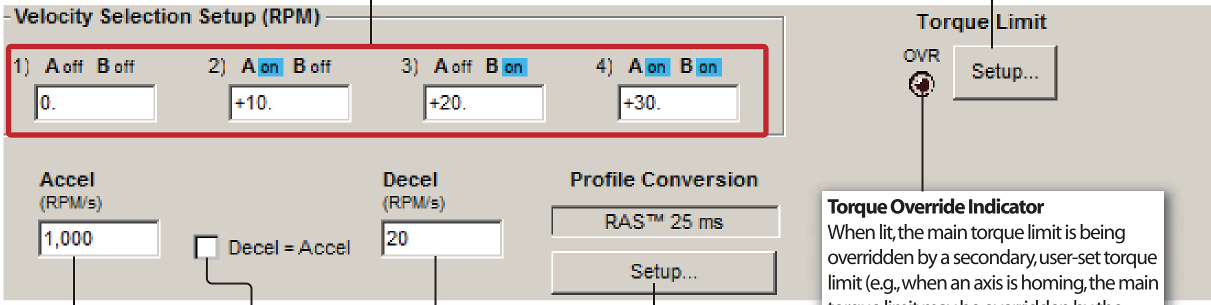
**Notes:**

- 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.



Velocity Selection Setup (RPM)

| 1) A off B off | 2) A on B off | 3) A off B on | 4) A on B on |
|---|---|---|---|
| 0. | +10. | +20. | +30. |

Accel (RPM/s): 1,000

☐ Decel = Accel

Decel (RPM/s): 20

Profile Conversion: RAS™ 25 ms

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Enter maximum desired motor acceleration rate.

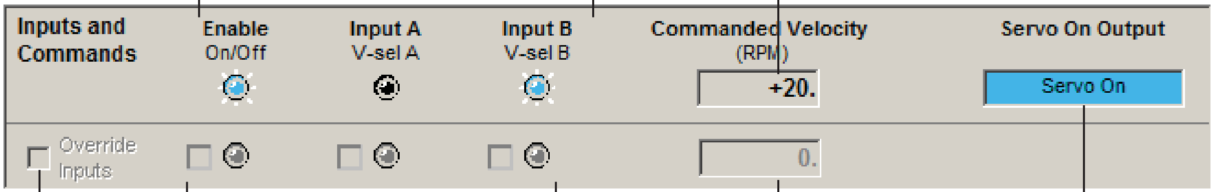
Check here to set motor deceleration rate to same value as acceleration rate.

Enter maximum desired motor deceleration rate..

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

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

Displays commanded velocity (when using hard inputs).



Commanded Velocity (RPM): +20.

Servo On Output: Servo On

☐ Override Inputs

Soft commanded velocity: 0.

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.

# Spin On Power Up

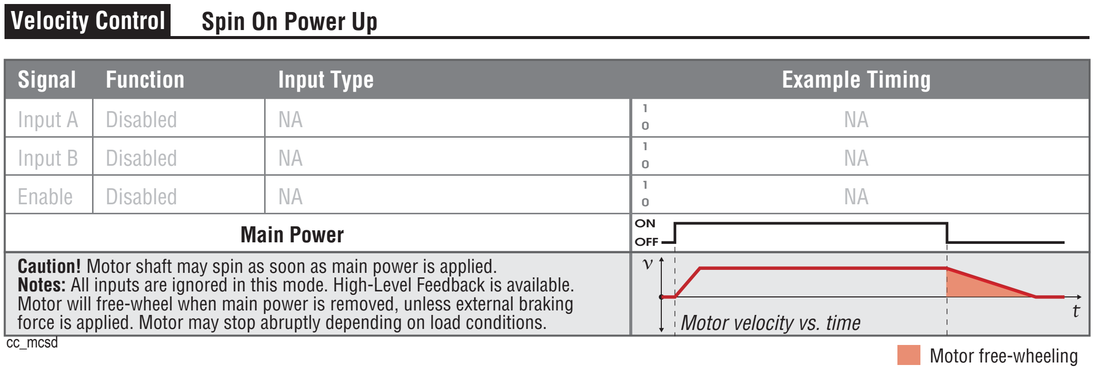
Available on
**MCVC + MCPV**

## Mode Description

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.

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 Power | | | |
| **Caution!** Motor shaft may spin as soon as main power is applied.<br>**Notes:** All inputs are ignored in this mode. High-Level Feedback is available. Motor will free-wheel when main power is removed, unless external braking force is applied. Motor may stop abruptly depending on load conditions. | | | |

cc_mcsd

🟧 Motor free-wheeling

## I/O Functions

**Enable Input -** Not used.

**Input A -** Not used.

**Input B -** Not used.

**Output (HLFB) -** See HLFB section for available modes.

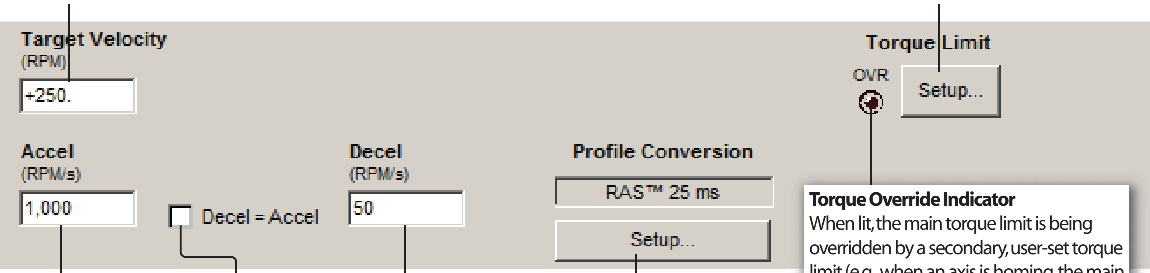
**Notes:**

- To stop the motor, simply remove power and the motor will stop.
- Other speed modes give you more control of motor behavior, but require a little more wiring. This mode is the simplest way to get constant, servo-controlled motion from a brushless motor."
- Disable time = 10 mS

## MODE CONTROLS

Enter target velocity.

Click to open Torque Limit Setup dialog.



**Target Velocity** (RPM): +250.

**Accel** (RPM/s): 1,000

☐ Decel = Accel

**Decel** (RPM/s): 50

**Profile Conversion**: RAS™ 25 ms

Enter maximum desired motor acceleration rate.

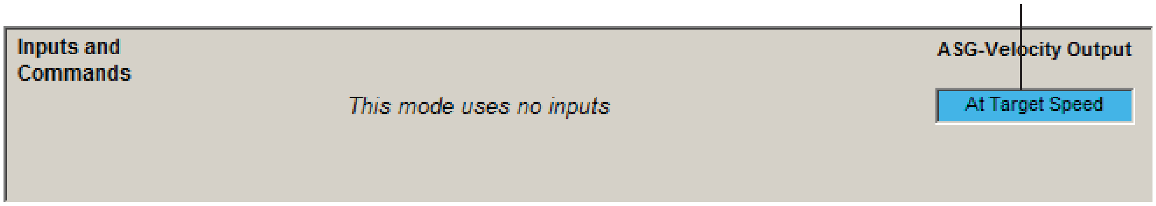
Check here to set motor deceleration rate to same value as acceleration rate.

Enter maximum desired motor deceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Displays HLFB output status.



**Inputs and Commands**

*This mode uses no inputs*

**ASG-Velocity Output**: At Target Speed

# MANUAL VELOCITY CONTROL

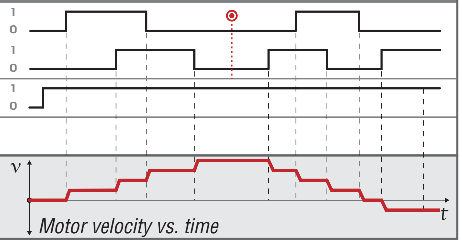
Available on
MCVC + MCPV

## MODE DESCRIPTION

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).

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 | Example Timing |
|---|---|---|---|
| **Input A** | Velocity Control A | Quadrature |  |
| **Input B** | Velocity Control B | Quadrature | |
| **Enable** | Enable | Logic: High=Enable Low=Disable | |
| Trigger | NA | NA | |
| **Notes:** | | | |

⊙ *Knob/encoder rotation reversed*

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input is connected to one of the channels of the quadrature output device.

**Input B -** This input is connected to the other channel of the quadrature output device.

**Output (HLFB) -** See HLFB section for available modes.

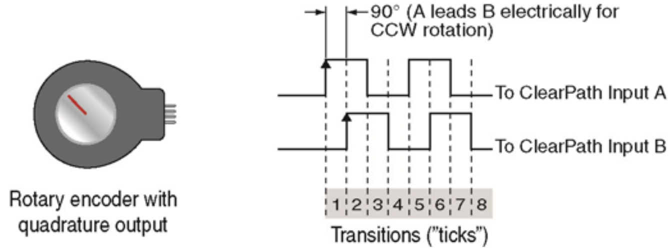
**Notes:**

- Disable time = 10 mS
- Rotating the quadrature knob in a given direction will cause an increase in speed; the other direction causes a decrease (which can be thought of as an increase in the opposite direction).
- If you want to only spin in only one direction, set one of the Max Velocity values (CW or CCW) to zero.
- The motor will accelerate faster if you spin the knob faster, but you can set a "traction control" (Acceleration) limit so that you don't accidentally command an acceleration that the motor can

not do (which might cause the motor to protectively shut down)."

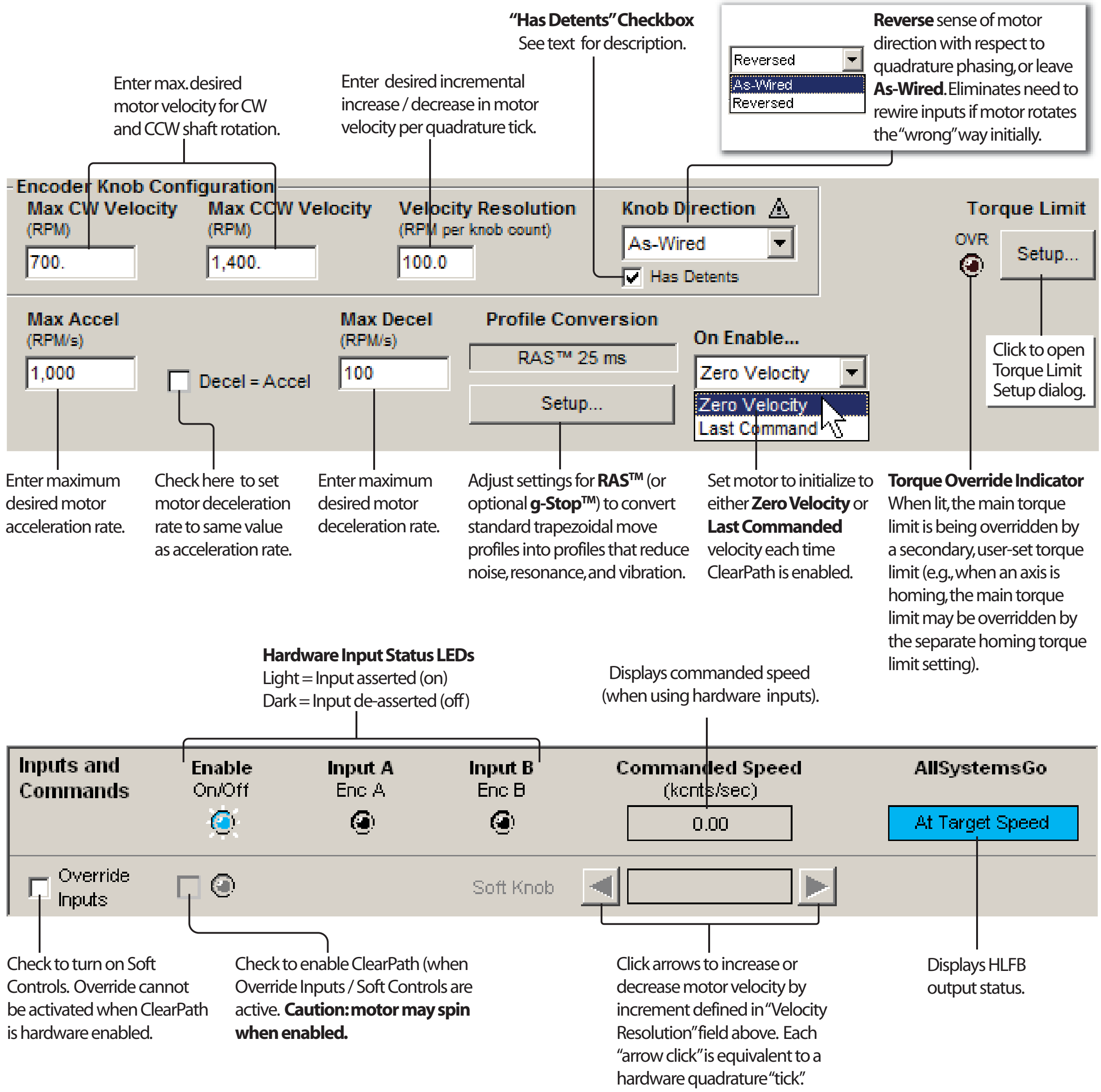
### THE QUADRATURE SIGNAL SOURCE

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



**Encoder Knob Configuration**

Max CW Velocity (RPM): 700.

Max CCW Velocity (RPM): 1,400.

Velocity Resolution (RPM per knob count): 100.0

Knob Direction: As-Wired

☑ Has Detents

Max Accel (RPM/s): 1,000

☐ Decel = Accel

Max Decel (RPM/s): 100

Profile Conversion: RAS™ 25 ms

On Enable...: Zero Velocity

**Inputs and Commands**

Commanded Speed (kcnts/sec): 0.00

AllSystemsGo: At Target Speed

☐ Override Inputs

**"Has Detents" Checkbox** See text for description.

**Reverse** sense of motor direction with respect to quadrature phasing, or leave **As-Wired**. Eliminates need to rewire inputs if motor rotates the "wrong" way initially.

Enter max. desired motor velocity for CW and CCW shaft rotation.

Enter desired incremental increase / decrease in motor velocity per quadrature tick.

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.

Adjust settings for **RAS**™ (or optional **g-Stop**™) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Set motor to initialize to either **Zero Velocity** or **Last Commanded** velocity each time ClearPath is enabled.

**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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

Displays commanded speed (when using hardware inputs).

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

Check to enable ClearPath (when Override Inputs / Soft Controls are active. **Caution: motor may spin when enabled.**

Click arrows to increase or decrease motor velocity by increment defined in "Velocity Resolution" field above. Each "arrow click" is equivalent to a hardware quadrature "tick."

Displays HLFB output status.

## 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 causes 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 causes 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

This setting allows 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 4th 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.

# FOLLOW DIGITAL VELOCITY COMMAND (BI-POLAR PWM COMMAND WITH INHIBIT)

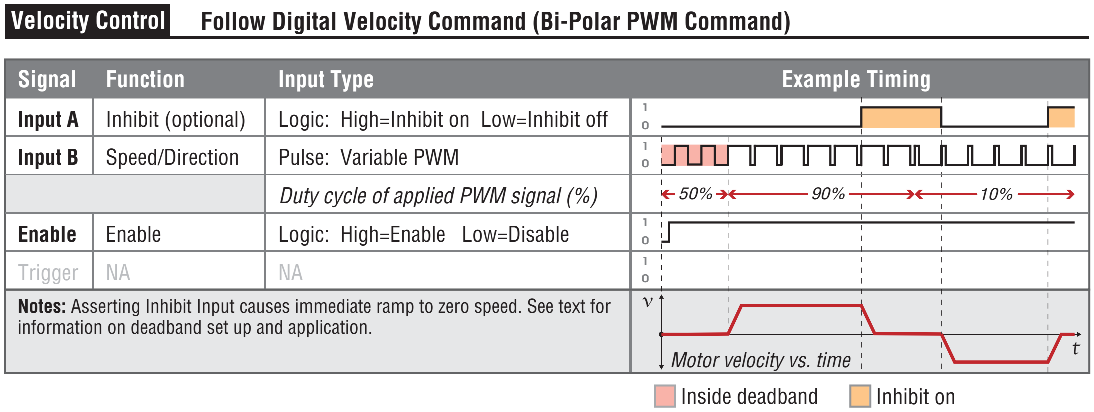
Available on

**MCVC + MCPV**

## MODE DESCRIPTION

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.

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.

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input forces the speed to zero regardless of the input PWM duty cycle.

**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired velocity.

**Output (HLFB) -** See HLFB section for available modes.

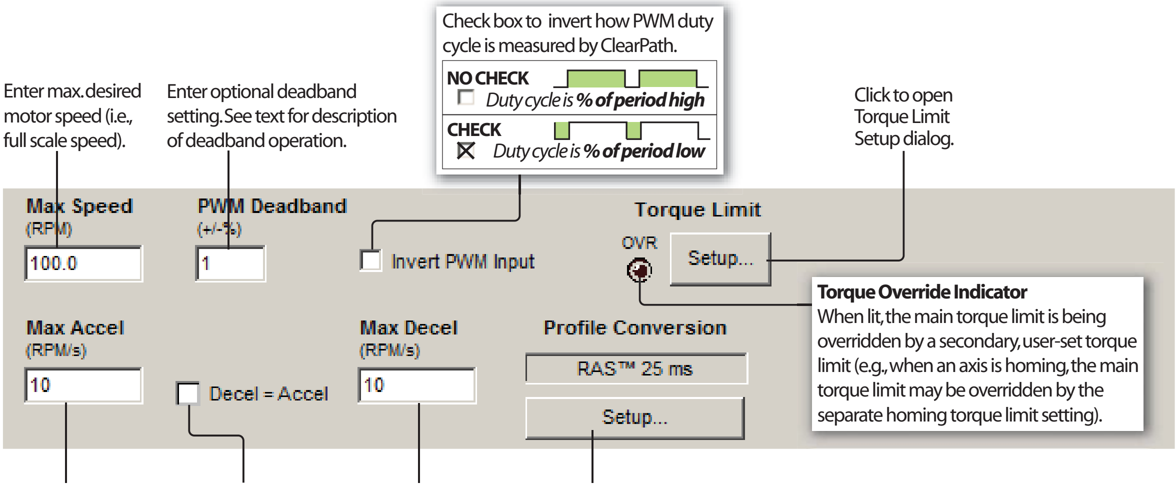
**Notes:**

- PWM input frequency range: 20 Hz up to 30 kHz.
- The output of a standard H-bridge driver for a DC brush motor is bipolar PWM, so it can be used to allow ClearPath to replace a DC brush motor without changing anything else in the system.
- A 50% PWM duty cycle means zero speed; near 100% and near 0% duty cycle correspond to opposite directions at the user-defined maximum speed.
- Input A can be used to command zero speed at any time (overriding the PWM). Or, if duty cycle drift is preventing the

axis from stopping when it should, a deadband can be specified so that any duty cycle that falls within +/- the deadband amount from 50% is considered a command for zero speed.

- 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
- For applications with the highest sensitivity to velocity accuracy, consider using frequency input control (described later in this manual).

### MODE CONTROLS



Max Speed (RPM): 100.0
PWM Deadband (+/-%): 1
☐ Invert PWM Input
Max Accel (RPM/s): 10
☐ Decel = Accel
Max Decel (RPM/s): 10

Enter max. desired motor speed (i.e., full scale speed).

Enter optional deadband setting. See text for description of deadband operation.

Check box to invert how PWM duty cycle is measured by ClearPath.

**NO CHECK** ☐ *Duty cycle is **% of period high***

**CHECK** ☒ *Duty cycle is **% of period low***

Click to open Torque Limit Setup dialog.

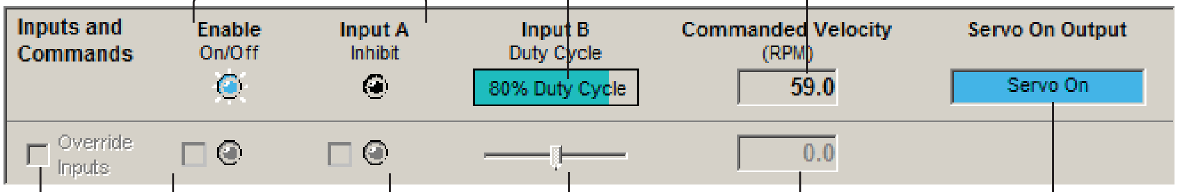
**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.



Input B Duty Cycle: 80% Duty Cycle
Commanded Velocity (RPM): 59.0
Soft commanded velocity: 0.0
☐ Override Inputs

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

**PWM Meter -** Displays duty cycle of PWM source connected to Input B.

Displays commanded velocity (when using hard controls).

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.**

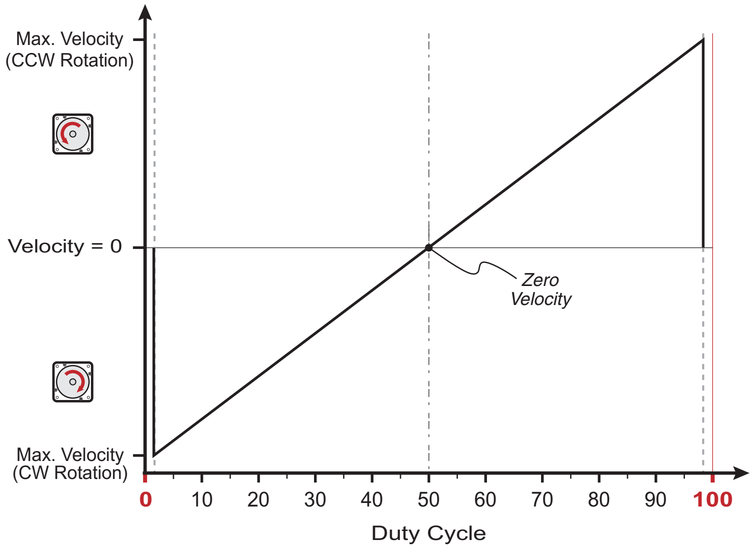
**PWM Soft Slider**
Emulates PWM input (for use with Soft Controls).

Displays commanded velocity (when using Soft Controls).

Displays HLFB output status

### Relationship of PWM duty cycle to motor velocity

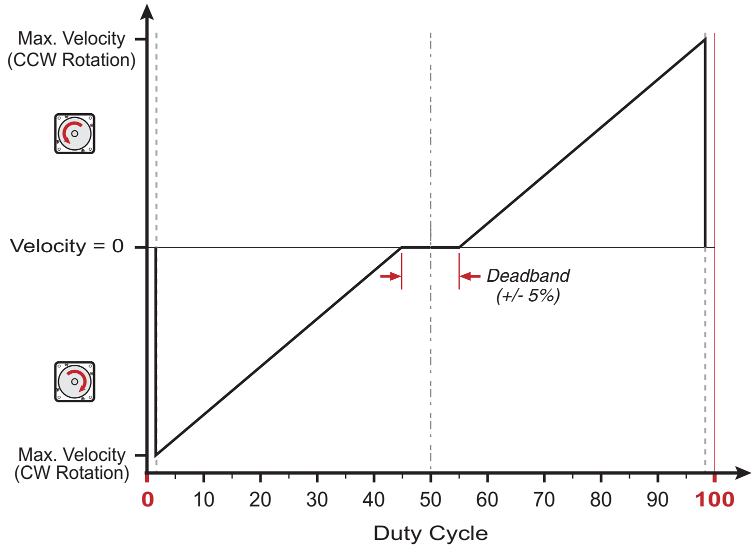
- Shaft velocity increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft velocity increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50%—from either direction—motor velocity approaches 0.
- In practice, O% and 100% (static 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%.



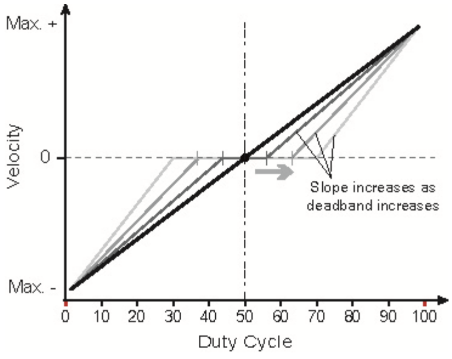
***+/- 5% PWM dead band setting***

**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)

Available on
MCVC + MCPV

### MODE DESCRIPTION

Control velocity and maximum torque independently and 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.

### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input is connected to a signal whose level or PWM duty cycle represents the desired torque limit.

**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired velocity.

**Output (HLFB) -** See HLFB section for available modes.

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:

- Deassert input A to operate using purely the "standard" Torque Limits.

- Assert input A to operate using purely the Alternate Torque Limits.

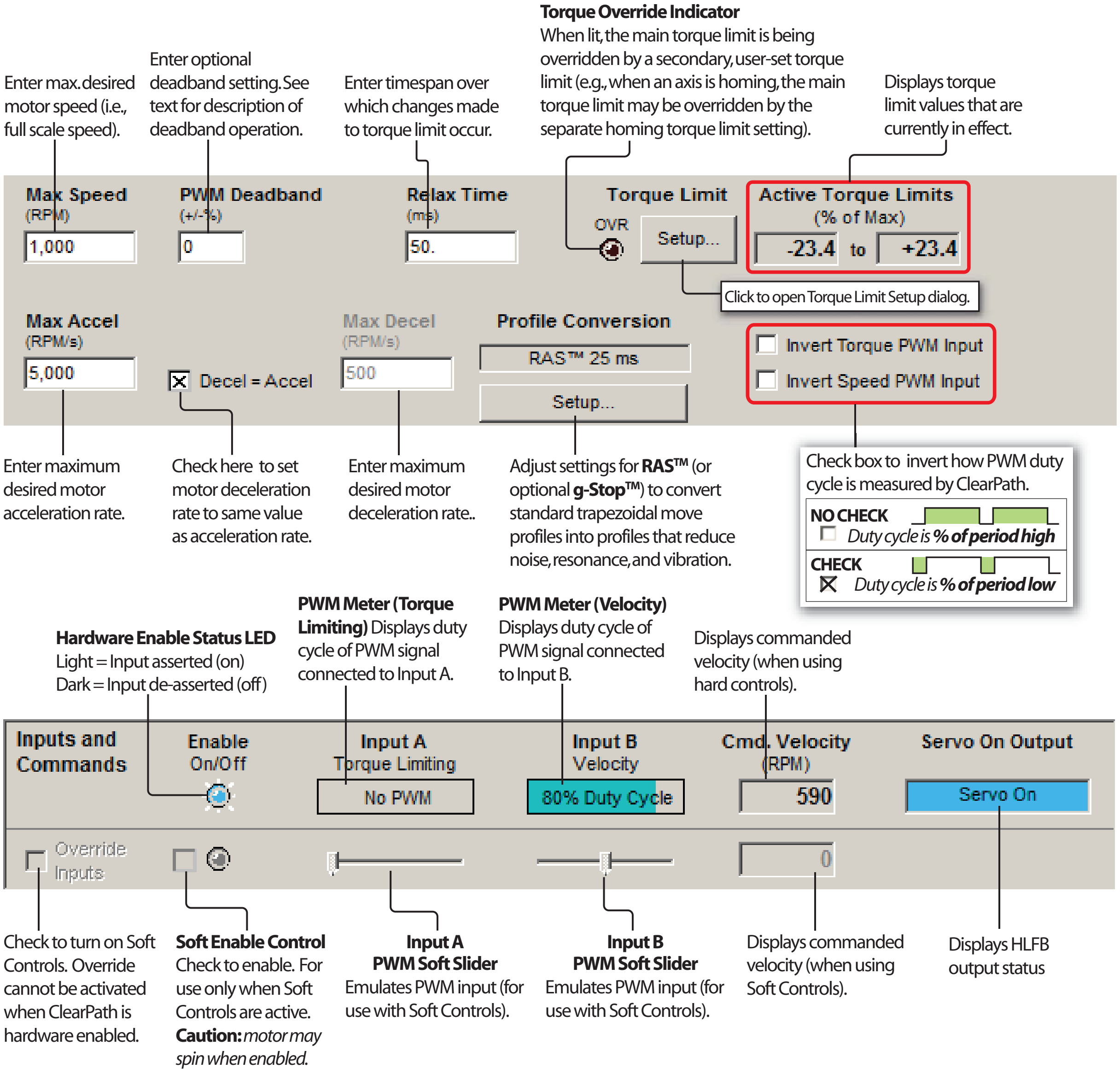
For **PWM torque limit control**, you can vary the active torque limit linearly between the two torque limit settings by varying the PWM duty cycle sent to Input A as follows:

- 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



Enter max. desired motor speed (i.e., full scale speed).

Enter optional deadband setting. See text for description of deadband operation.

Enter timespan over which changes made to torque limit occur.

**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Displays torque limit values that are currently in effect.

Max Speed (RPM): 1,000

PWM Deadband (+/-%): 0

Relax Time (ms): 50.

Active Torque Limits (% of Max): -23.4 to +23.4

Click to open Torque Limit Setup dialog.

Max Accel (RPM/s): 5,000

☒ Decel = Accel

Max Decel (RPM/s): 500

Profile Conversion: RAS™ 25 ms

☐ Invert Torque PWM Input

☐ Invert Speed PWM Input

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..

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Check box to invert how PWM duty cycle is measured by ClearPath.

**NO CHECK**
☐ *Duty cycle is **% of period high***

**CHECK**
☒ *Duty cycle is **% of period low***

**Hardware Enable Status LED** Light = Input asserted (on) Dark = Input de-asserted (off)

**PWM Meter (Torque Limiting)** Displays duty cycle of PWM signal connected to Input A.

**PWM Meter (Velocity)** Displays duty cycle of PWM signal connected to Input B.

Displays commanded velocity (when using hard controls).

Input A Torque Limiting: No PWM

Input B Velocity: 80% Duty Cycle

Cmd. Velocity (RPM): 590

Servo On Output: Servo On

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

**Soft Enable Control** Check to enable. For use only when Soft Controls are active. **Caution:** *motor may spin when enabled.*

**Input A PWM Soft Slider** Emulates PWM input (for use with Soft Controls).

**Input B PWM Soft Slider** Emulates PWM input (for use with Soft Controls).

Displays commanded velocity (when using Soft Controls).

Displays HLFB output status

# FOLLOW DIGITAL VELOCITY COMMAND (UNIPOLAR PWM INPUT)

Available on
MCVC + MCPV

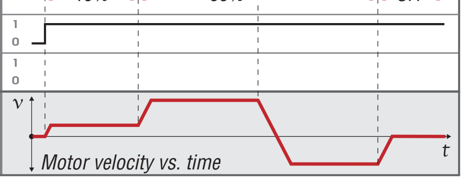
## MODE DESCRIPTION

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.

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:** | | | |

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input selects the direction of rotation.

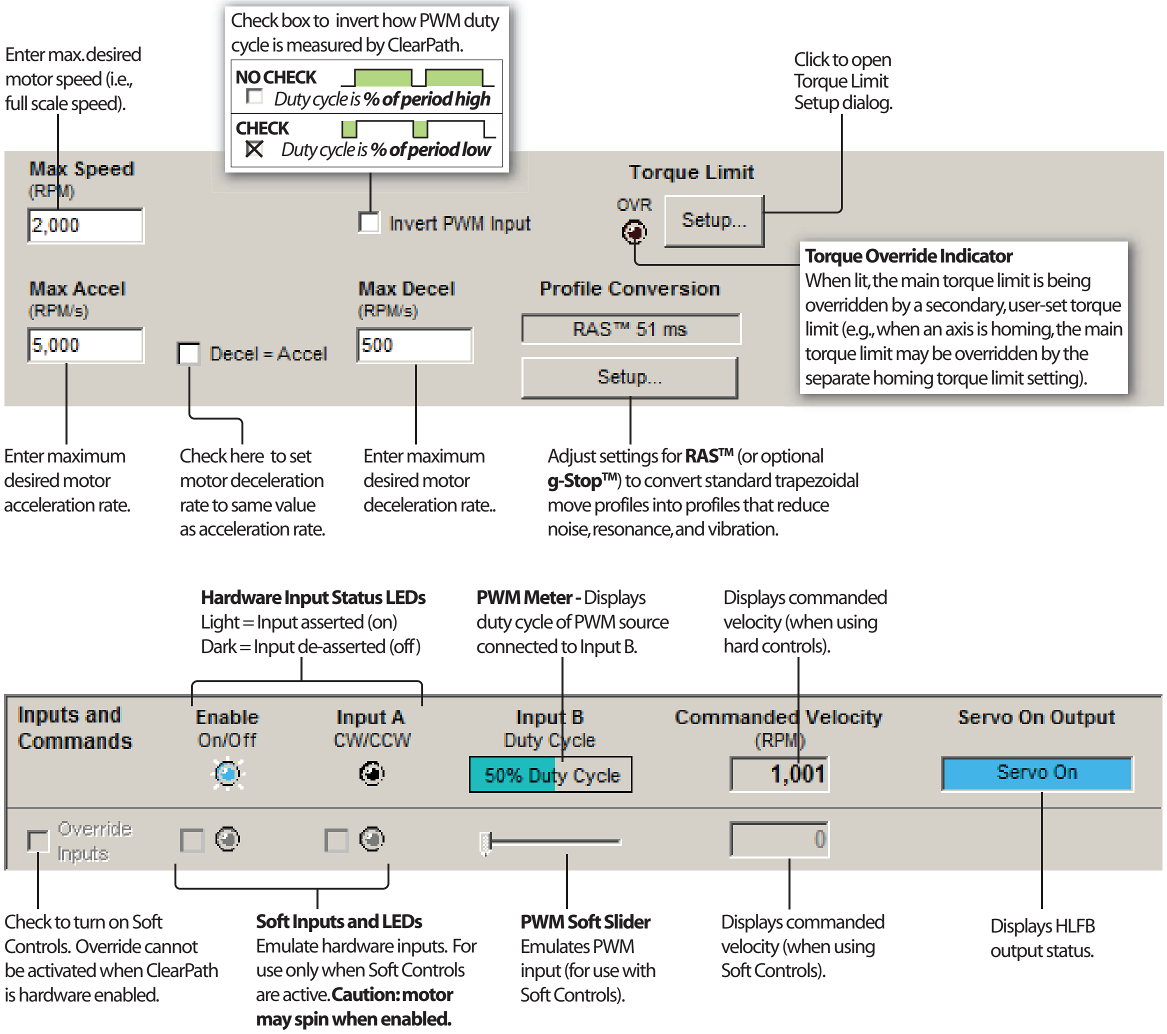
**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired speed.

**Output (HLFB) -** See HLFB section for available modes.

**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
- For applications with the highest sensitivity to velocity accuracy, consider using frequency input control (described in next section).

## MODE CONTROLS



Enter max.desired motor speed (i.e., full scale speed).

Check box to invert how PWM duty cycle is measured by ClearPath.

**NO CHECK** ☐ *Duty cycle is **% of period high***

**CHECK** ☒ *Duty cycle is **% of period low***

Click to open Torque Limit Setup dialog.

Max Speed (RPM): 2,000

☐ Invert PWM Input

Torque Limit

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Max Accel (RPM/s): 5,000

☐ Decel = Accel

Max Decel (RPM/s): 500

Profile Conversion: RAS™ 51 ms

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..

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

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

**PWM Meter -** Displays duty cycle of PWM source connected to Input B.

Displays commanded velocity (when using hard controls).

Inputs and Commands

Input B Duty Cycle: 50% Duty Cycle

Commanded Velocity (RPM): 1,001

Servo On Output: Servo On

☐ Override 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.**

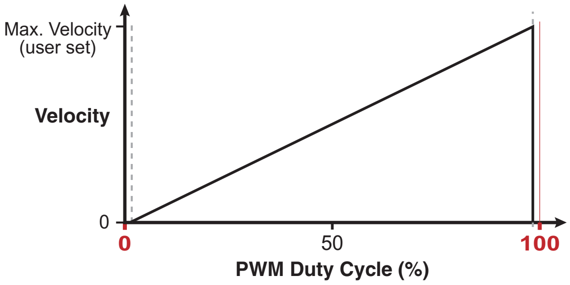
**PWM Soft Slider**
Emulates PWM input (for use with Soft Controls).

Displays commanded velocity (when using Soft Controls).

Displays HLFB output status.

**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)

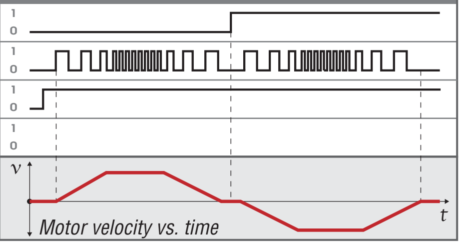
Available on
MCVC + MCPV

## MODE DESCRIPTION

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.

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:** | | | |

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input selects the direction of rotation.

**Input B -** This input is connected to a pulse train whose frequency represents the desired speed.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

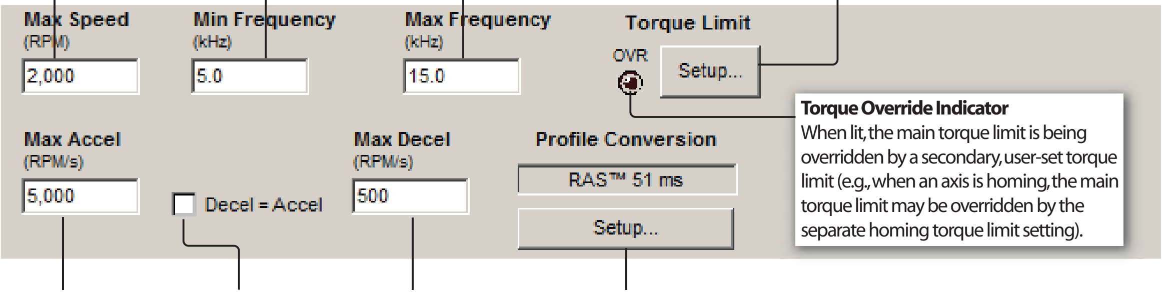
- Input frequency range: 20 Hz to 500 kHz.
- Actual motor speed in RPM is given by the following equation [(Input Freq. - Min Freq.) / (Max Freq. - Min Freq.) * User Defined Max Velocity. For **Example,** a 120 kHz pulse train with 100 kHz Min Frequency and 200 kHz Max frequency will result in a rotational 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

Enter max. desired motor speed (i.e., full scale speed).

**Set Min/Max Frequency**. During operation, motor speed is controlled by Input B signal frequency. With the settings below, a 15kHz signal at Input B will cause the motor to spin at the Max Speed setting (2000 RPM); a 5 kHz (or lower) signal will command zero speed.

Click to open Torque Limit Setup dialog.



Max Speed (RPM): 2,000

Min Frequency (kHz): 5.0

Max Frequency (kHz): 15.0

Max Accel (RPM/s): 5,000

☐ Decel = Accel

Max Decel (RPM/s): 500

Profile Conversion: RAS™ 51 ms

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Enter maximum desired motor acceleration rate.

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

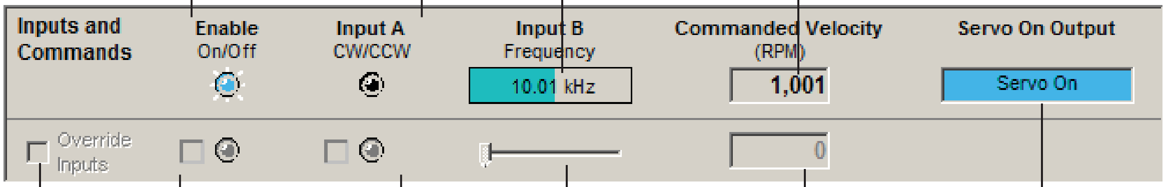
Enter maximum desired motor deceleration rate..

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

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

**Frequency Meter**
Displays frequency of input signal source connected to Input B.

Displays commanded velocity (when using hard controls).



Input B Frequency: 10.01 kHz

Commanded Velocity (RPM): 1,001

Servo On Output: Servo On

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.**

**Frequency Soft Slider**
Emulates frequency input source (for use with Soft Controls).

Displays commanded velocity (when using Soft Controls).

Displays HLFB output status.

## MOVE TO SENSOR POSITION

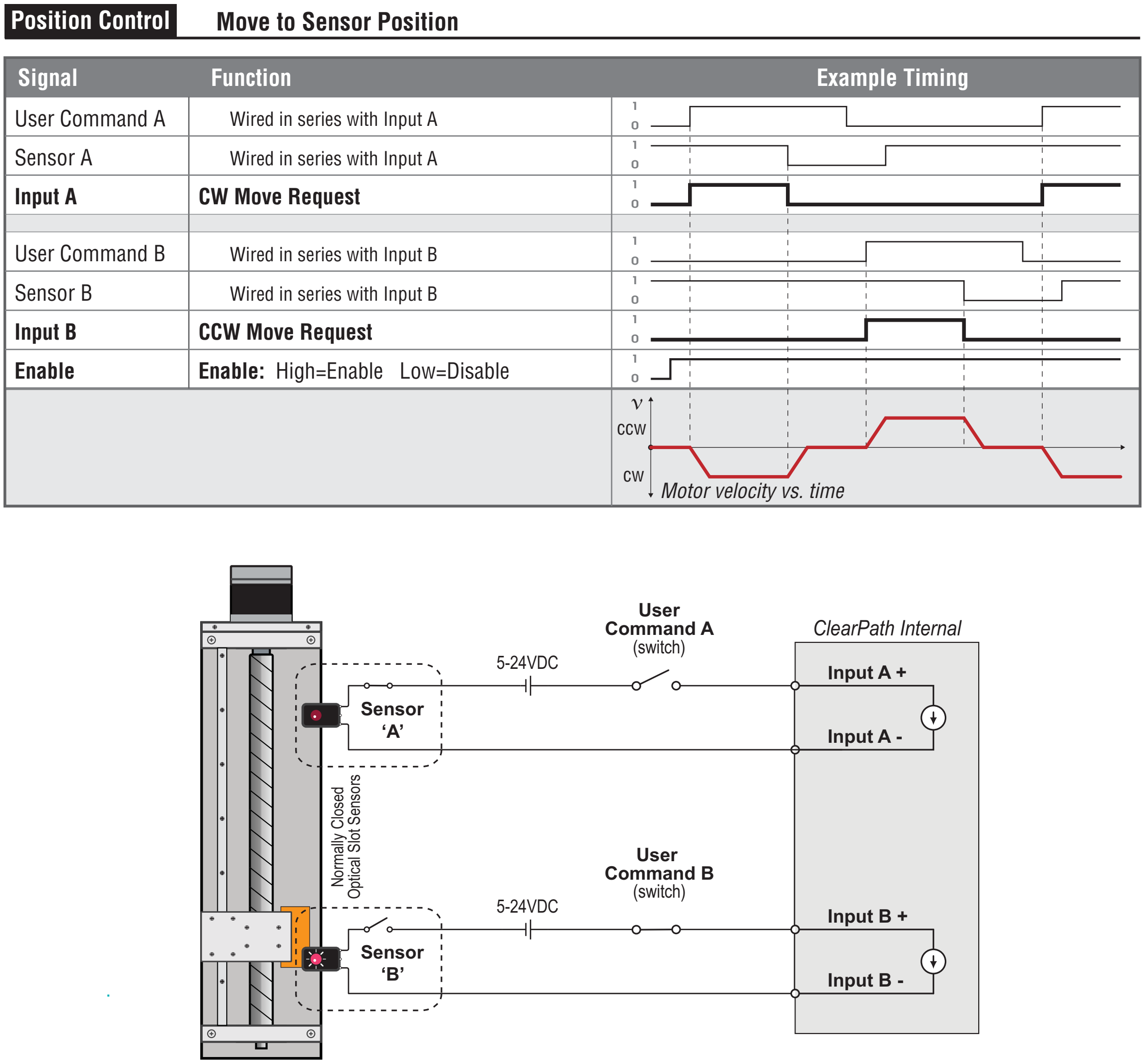
Available on **MCVC + MCPV**

### MODE DESCRIPTION

This mode is mainly intended to be used in two-position back and forth applications (like replacing a pneumatic cylinder). Use ClearPath digital inputs to spin the shaft CW or CCW. Wire position sensors or switches in series with ClearPath inputs to make an inexpensive two position actuator.

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***

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input is used to make the motor spin in the CW (clockwise) direction.

**Input B -** This input is used to make the motor spin in the CCW (counterclockwise) direction.

**Output (HLFB) -** See HLFB section for available modes.

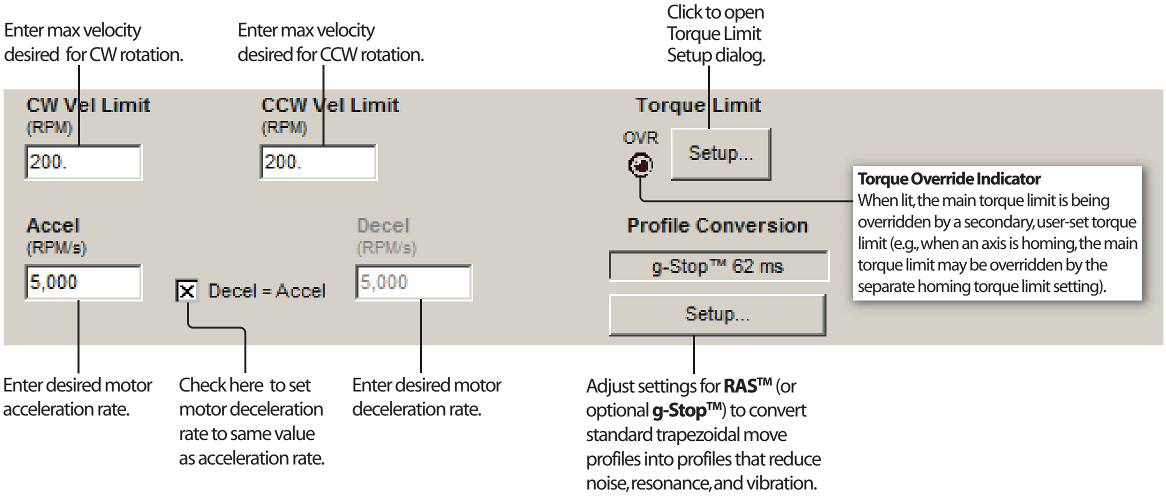
**Notes:**

- Position sensors (switches) are used to set the stopping points.
- In the typical application, the switch that detects the end of CW travel is wired in series with Input A so that the command to move is interrupted and the motor stops at the desired location. The CCW switch is similarly wired in series with Input B.
- CCW (counterclockwise) and CW (clockwise) are defined when you view the motor with the shaft pointing toward you.
- When a switch interrupts the move input, the motor will begin to decelerate, so the stopped position will be a repeatable distance beyond the switch. Make sure you leave enough room after the sensor to avoid hitting the end stops.
- ClearPath will not allow two successive moves in the same direction, so you don't have to worry about the motor moving past the switch as it decelerates (and thereby re-asserting the move input).
- 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[3] is received.
- Disable time = 10 mS

---

[3] 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.

## MODE CONTROLS



Enter max velocity desired for CW rotation.

Enter max velocity desired for CCW rotation.

Click to open Torque Limit Setup dialog.

CW Vel Limit (RPM): 200.

CCW Vel Limit (RPM): 200.

Accel (RPM/s): 5,000

☒ Decel = Accel

Decel (RPM/s): 5,000

Profile Conversion: g-Stop™ 62 ms

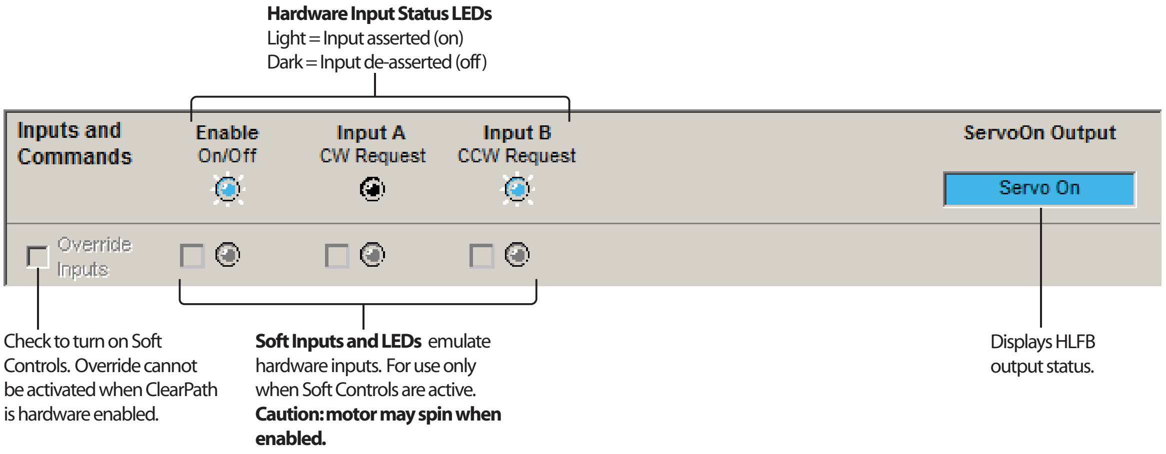
**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Enter desired motor acceleration rate.

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

Enter desired motor deceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.



**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.

## MOVE TO ABSOLUTE POSITION (2-POSITION, HOME TO SWITCH)

Available on
**MCVC + MCPV**

### MODE DESCRIPTION

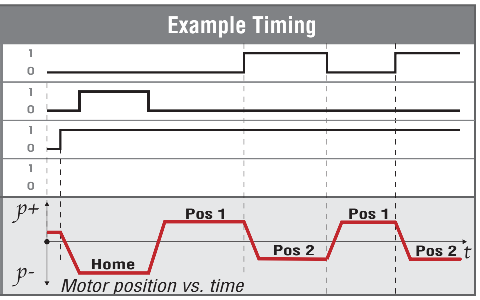
Trigger ClearPath to move to one of two preset locations. This mode was designed for replacing hydraulic or pneumatic cylinders that move between two positions.

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. | | | |

### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input selects one of two user-defined positions to which the motor should move.

**Input B -** This input is connected to the home switch. Its function is defined in the homing setup dialog.

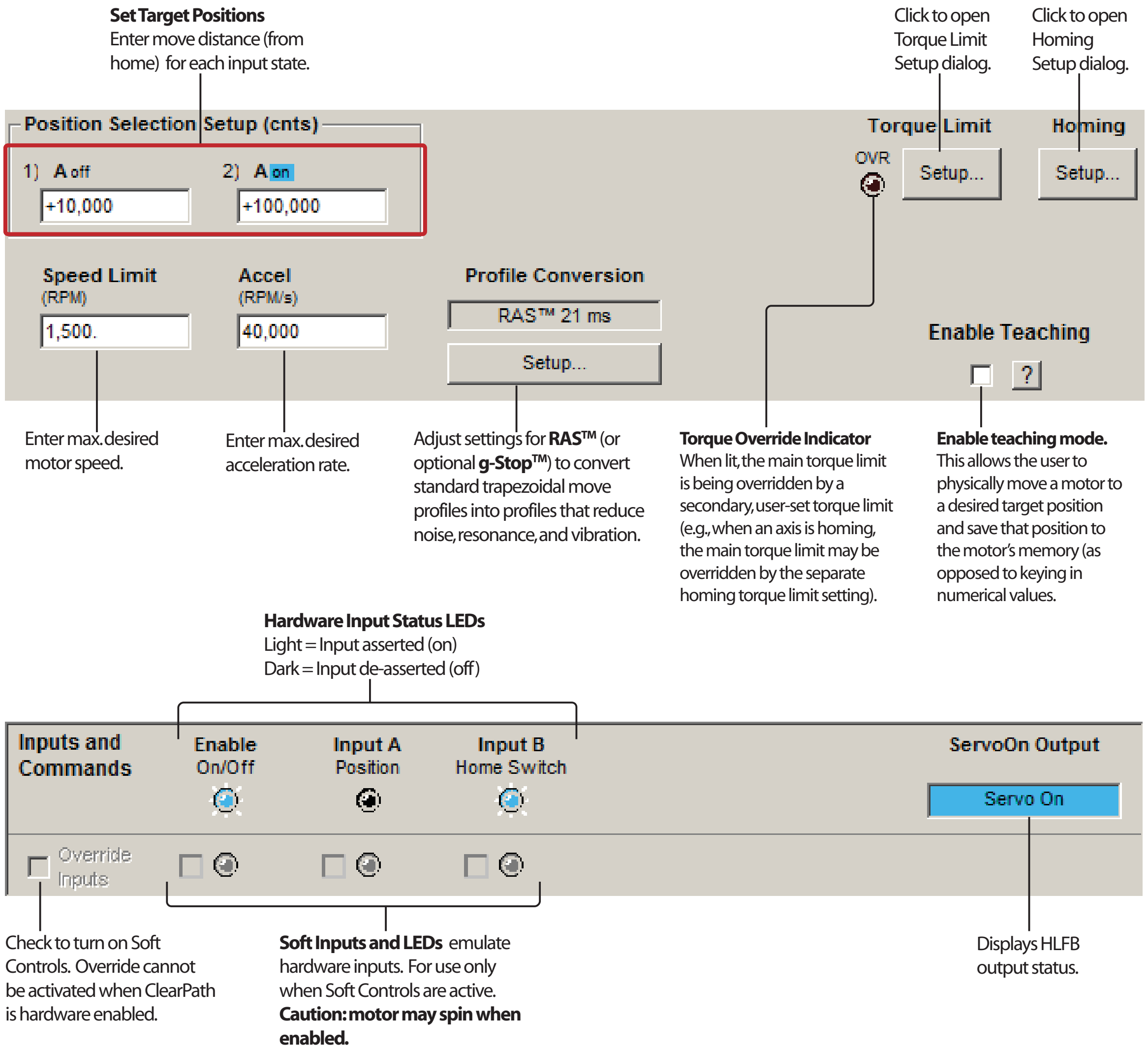
**Output (HLFB) -** See HLFB section for available modes.

**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.

- The user-defined positions can be 'taught' instead of entered numerically through MSP. To do this, the motor must be in a Logic Backup Power (LBP) state (using a ClearPath POWER4-HUB board). The main bus power must be off. **To teach a position**, deassert the Enable input with the motor in the position you want to teach (or deassert the Enable and then move the axis by hand to the desired spot). Set input A to the binary state you want to teach, and assert the Enable input. The current location will then be linked to the current input A state. Deassert Enable and repeat as desired with the other A state.
- 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



1) A off +10,000

2) A on +100,000

Speed Limit (RPM) 1,500.

Accel (RPM/s) 40,000

RAS™ 21 ms

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

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

Enter max. desired motor speed.

Enter max. desired acceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

**Enable teaching mode.**
This allows the user to physically move a motor to a desired target position and save that position to the motor's memory (as opposed to keying in numerical values.

**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.

## MOVE TO ABSOLUTE POSITION (4-POSITION, HOME TO HARD STOP)

Available on
MCPV

### MODE DESCRIPTION

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.

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.

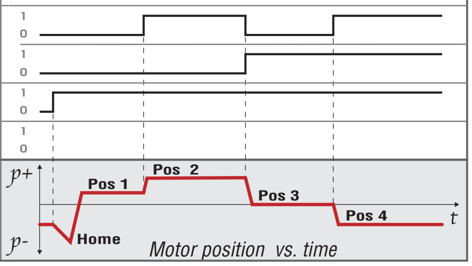
After homing, ClearPath can be commanded to move to any of four user-defined positions by changing the state of Input A and B. Changing these inputs has the dual effect of selecting target position, and triggering the move. See table below for timing and input details. All moves execute at the user-defined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

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

| Signal | Function | Position Settings | | | |
|---|---|---|---|---|---|
| | | 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.

Example Timing



### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input, along with Input B, selects one of four user-defined positions to which the motor should move.

**Input B -** This input, along with Input A, selects one of four user-defined positions to which the motor should move.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- If Input A or B changes while the ClearPath is moving, the behavior will depend on the new move target. If the new move target is in the same direction as the current motion, the move will continue until the new target location is reached. If the new move target is in the opposite direction of current motion, the move will decelerate to a stop and then immediately begin the move to the new target location.

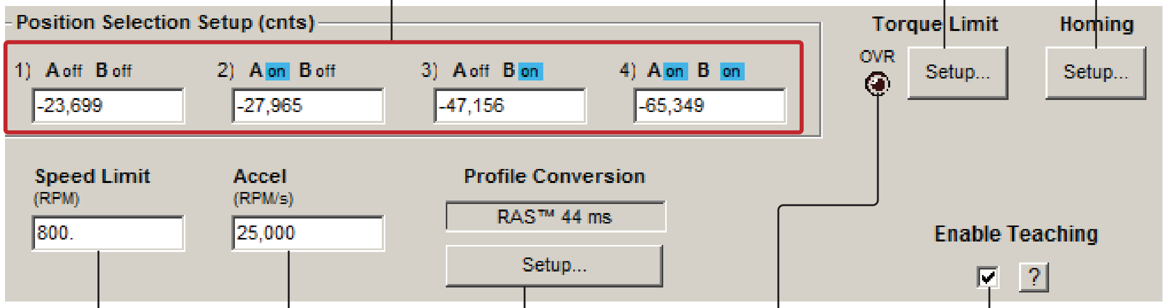
- The user-defined positions can be 'taught' instead of entered numerically through MSP. To do this, the motor must be in a Logic Power Backup (LPB) state (using a ClearPath POWER4-HUB board). The main bus power must be off.
- **To teach a position**, deassert the Enable input with the motor in the position you want to teach (or deassert the Enable and then move the axis by hand to the desired spot). Set inputs A and B to the binary state you want to teach, and assert the Enable input. The current location will then be linked to the current input A/B state. Deassert Enable and repeat as desired with other A/B states.
- 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.

Click to open Homing Setup dialog.



Position Selection Setup (cnts)

1) A off B off: -23,699
2) A on B off: -27,965
3) A off B on: -47,156
4) A on B on: -65,349

Speed Limit (RPM): 800.
Accel (RPM/s): 25,000
Profile Conversion: RAS™ 44 ms
Enable Teaching: ☑

Enter max. desired motor speed.

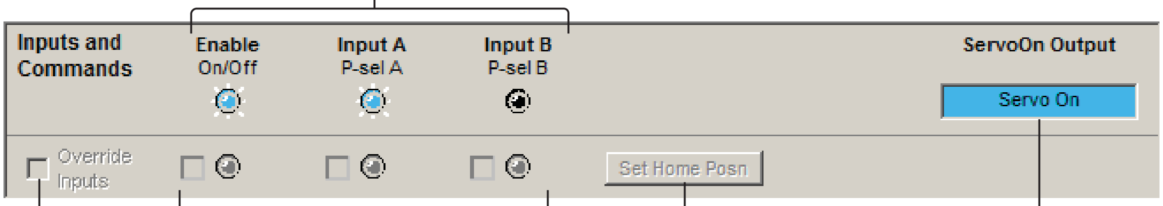
Enter max. desired acceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

**Enable teaching mode.**
This allows the user to physically move a motor to a desired target position and save that position to the motor's memory (as opposed to keying in numerical values by hand).

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



Override 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.**

Click during homing operation to manually set home position.

Displays HLFB output status.

# MOVE TO ABSOLUTE POSITION (16-POSITION, HOME TO HARD STOP)

Available on
MCPV

## MODE DESCRIPTION

Command ClearPath to move to one of 16 preset positions by toggling Input B (between 1 and 16 times) to specify a target position [position index]. then toggle input A to trigger the move.

**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 1000 encoder counts from home, while Position 2 might be defined as 2000 encoder counts from home, and so forth

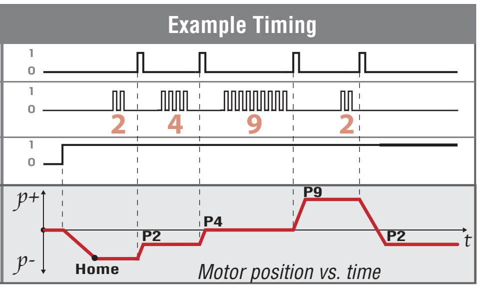
Assert the Enable Input to energize the motor. Once enabled, ClearPath must be homed to a known position.

To make a move, first send between 1 and 16 pulses to Input B (this tells ClearPath which target position to move to). Then toggle Input A to trigger the move. Example: to move to target position 9, you would send 12 pulses to input B. Then you would trigger the move by sending a single pulse to Input A. ClearPath would then move to position 9 at the user-defined speed and acceleration.

**Position Control** **Absolute Positioning (16 Positions, HS Home)**

| Signal | Function | Input Type |
|---|---|---|
| **Input A** | Trigger | Pulse to start move (on rising-edge) |
| **Input B** | Position Select | Pulse input to select target position |
| **Enable** | Enable | Logic: High=Enable Low=Disable |

Example Timing



**Notes:** ClearPath must be homed to use this mode (see text for details).

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input triggers the motor to move to one of sixteen user-selected positions.

**Input B -** Pulse (assert then deassert) this input 1-16 times to select which of sixteen user-defined positions the motor will move to when Input A is asserted.

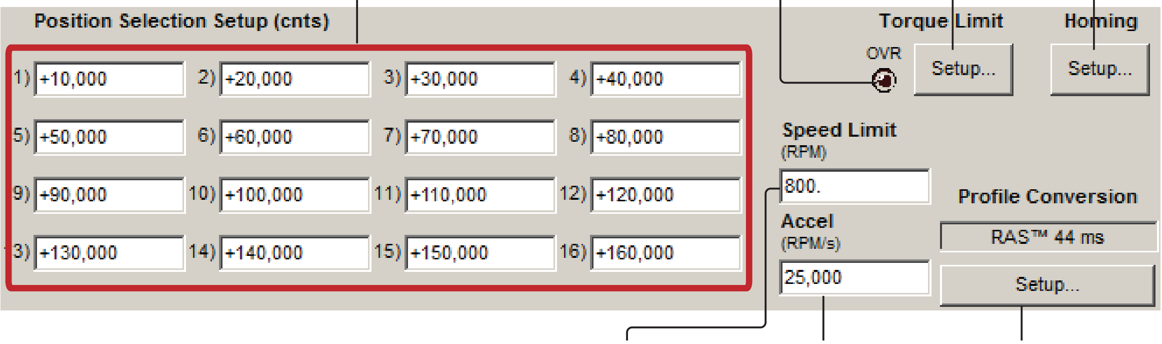
**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- While Input A is asserted pulses on Input B will be ignored and the motor will remain at its current position.

- Deasserting Input A resets the position selection index to 0.
- Asserting Input A (to move) after pulsing Input B more than 16 times generates a shutdown because an invalid index was selected. The shutdown can be cleared by toggling the Enable input.
- An executing move can be superseded by sending a new move index number command.
- Disable time = 10 mS

## Mode Controls



|  |  |  |  |
|---|---|---|---|
| 1) +10,000 | 2) +20,000 | 3) +30,000 | 4) +40,000 |
| 5) +50,000 | 6) +60,000 | 7) +70,000 | 8) +80,000 |
| 9) +90,000 | 10) +100,000 | 11) +110,000 | 12) +120,000 |
| 3) +130,000 | 14) +140,000 | 15) +150,000 | 16) +160,000 |

Speed Limit (RPM): 800.

Accel (RPM/s): 25,000

**Set Target Positions**
Enter move distance (from home) for each index position.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

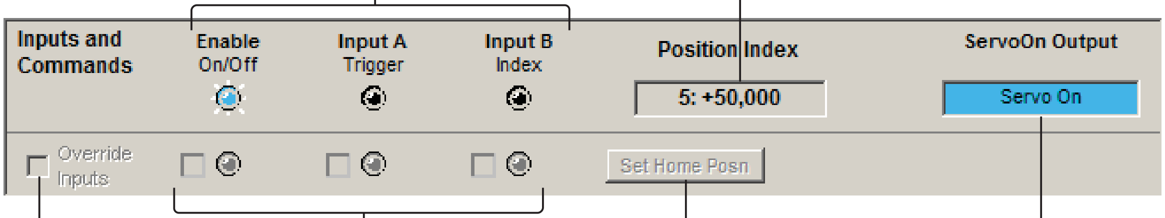
Enter max. desired motor speed.

Enter max. desired acceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

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

Displays the current Position Index number (5 in this example) and its associated encoder position. A trigger event on Input A will launch a move to this position (and reset the Index).



Position Index: 5: +50,000

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 simulate home position.

Displays HLFB output status.

# MOVE INCREMENTAL DISTANCE (4-DISTANCE, HOME TO HARD STOP)

Available on
MCPV

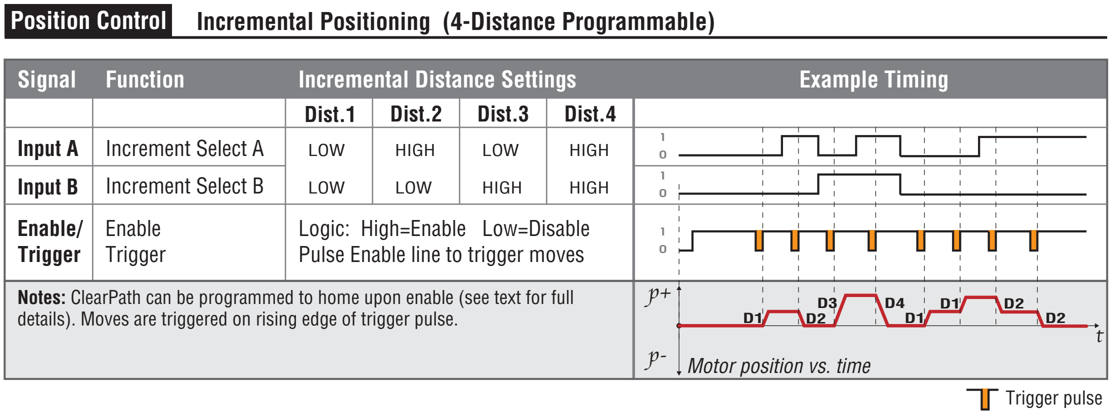
## MODE DESCRIPTION

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.

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<br>Trigger | Logic: High=Enable Low=Disable<br>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.

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input is the trigger that starts a move. (A "pulse" is a momentary interruption of current into the Enable input.)

**Input A -** This input, along with Input B, selects which of the four defined position increments to send upon a trigger pulse.

**Input B -** This input, along with Input A, selects which of the four defined position increments to send upon a trigger pulse.

**Output (HLFB) -** See HLFB section for available modes.

**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, 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.

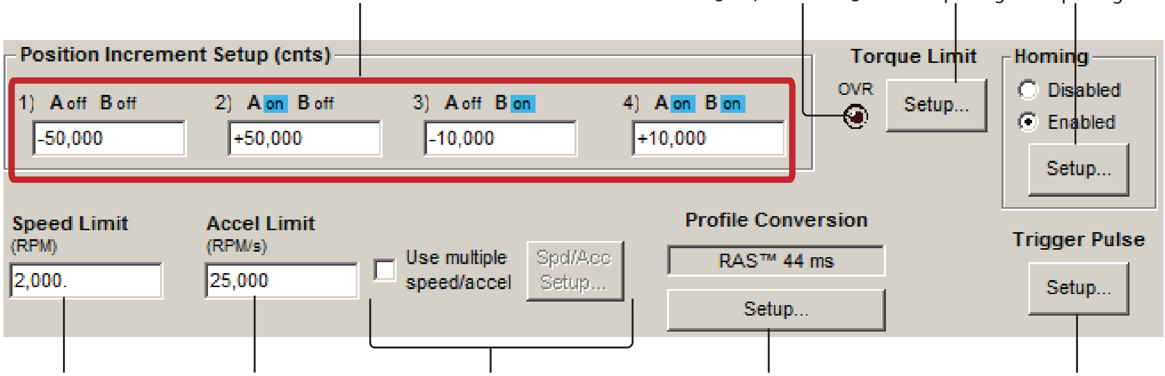
## MODE CONTROLS

**Set Move Increments**
Enter move distance for each input state.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.



Position Increment Setup (cnts)

1) A off B off: -50,000

2) A on B off: +50,000

3) A off B on: -10,000

4) A on B on: +10,000

Speed Limit (RPM): 2,000.

Accel Limit (RPM/s): 25,000

☐ Use multiple speed/accel

Homing: ○ Disabled ● Enabled

Profile Conversion: RAS™ 44 ms

Enter max. desired motor speed.

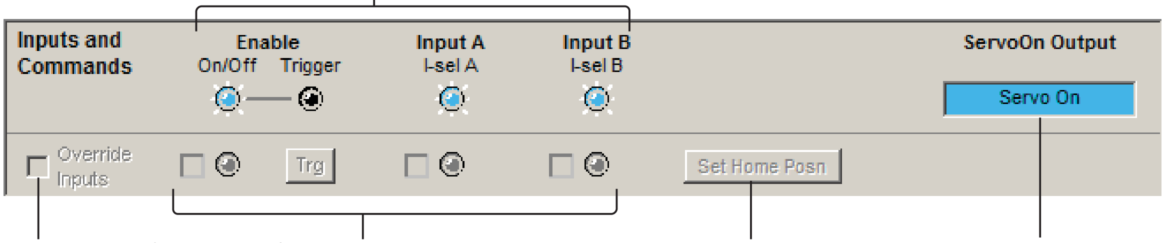
Enter max. desired acceleration rate.

Use these controls to set different speeds and accelerations for each position increment.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Click to adjust trigger pulse timing.

**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.

# MOVE INCREMENTAL DISTANCE (2-DISTANCE, HOME TO HARD STOP)

Available on

MCPV

## MODE DESCRIPTION

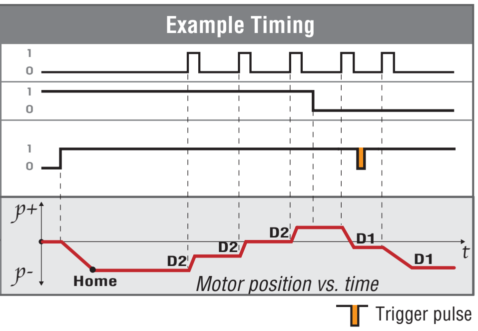
Change the state an input to tell ClearPath to move a user-defined, incremental distance from its current position. Send multiple, quick transitions to tell ClearPath to travel a multiple of any distance in one smooth, uninterrupted move.

**What is 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 move is launched.

Assert the Enable Input to energize the motor. (ClearPath can be set up to perform an optional home to hard stop upon enable.) Change the state of Input B to select which of the two move increments is currently active. Change the state of Input A to launch each move at the user-defined speed and acceleration. Briefly pulse the Enable input to execute the next move at the alternate speed limit.

**Position Control** **Incremental Positioning (2 Incremental Distances, HS Home)**

| Signal | Function | Input Type | Example Timing |
|---|---|---|---|
| **Input A** | Increment Position | Start move on rising (or falling) edge* |  |
| **Input B** | Increment Select | Logic: Low=Dist.1 High=Dist. 2 | |
| **Enable/ Trigger** | Enable<br>Trigger | Logic: High=Enable Low=Disable<br>Pulse Enable line for Alternate Speed | |

**Notes:** ClearPath can be programmed to home upon enable (see text for details).
*Moves can be triggered on rising *or* falling edge of Input A (based on user setting).

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input tells ClearPath to use the alternate speed limit setting for the next move.

**Input A -** Turning this input on (or off, if desired) sends the position increment.

**Input B -** This input selects which of the two defined position increments to send.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- Send incremental move commands by turning Input A either on or off (user settable).

- Multiple position increments can be smoothly chained together (i.e., with no stops in between) by toggling Input A before ClearPath starts decelerating. For example, three quick cycles of Input A will create one smooth move of three times the length of the selected position increment.
- If you need to move in both directions, make sure you define both a positive and a negative position increment.

## MODE CONTROLS

**Set Move Increments**
Enter move distance for each state of Input B.

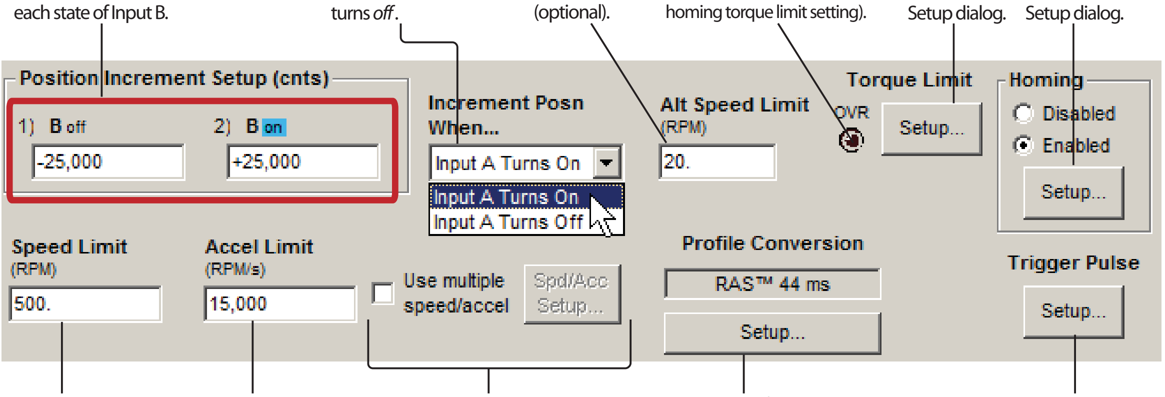
Select how you want to launch incremental moves; when Input A turns *on*, or when it turns *off*.

Enter alternate motor speed (optional).

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.



Position Increment Setup (cnts)
1) B off: -25,000
2) B on: +25,000
Increment Posn When...: Input A Turns On
Alt Speed Limit (RPM): 20.
Speed Limit (RPM): 500.
Accel Limit (RPM/s): 15,000
Profile Conversion: RAS™ 44 ms
Homing: ○ Disabled ● Enabled

Enter max. desired motor speed.

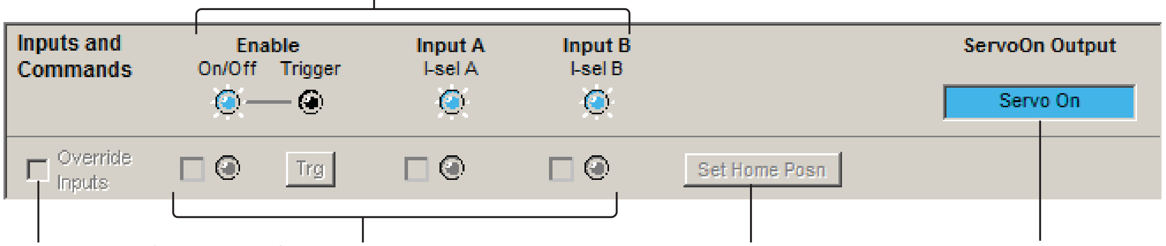
Enter max. desired acceleration rate.

Use these controls to set different speeds and accelerations for each position increment.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Click to adjust trigger pulse timing.

**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.

## MOVE INCREMENTAL DISTANCE (2-DISTANCE, HOME-TO-SWITCH)

Available on

**MCPV**

### MODE DESCRIPTION

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.

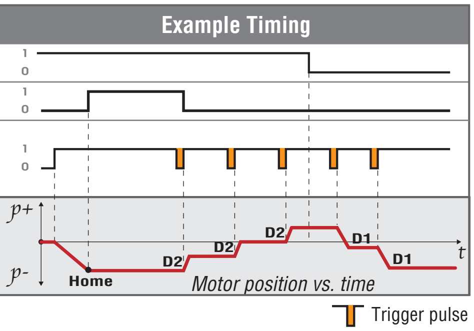
**Incremental Positioning**

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.

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<br>Trigger | Logic: High=Enable Low=Disable<br>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. | | | |



### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** This input selects which of the two defined position increments to send upon a trigger pulse.

**Input B -** This input is connected to the home switch/sensor. Its function is defined in the homing setup dialog. Home switch polarity can be inverted if desired.

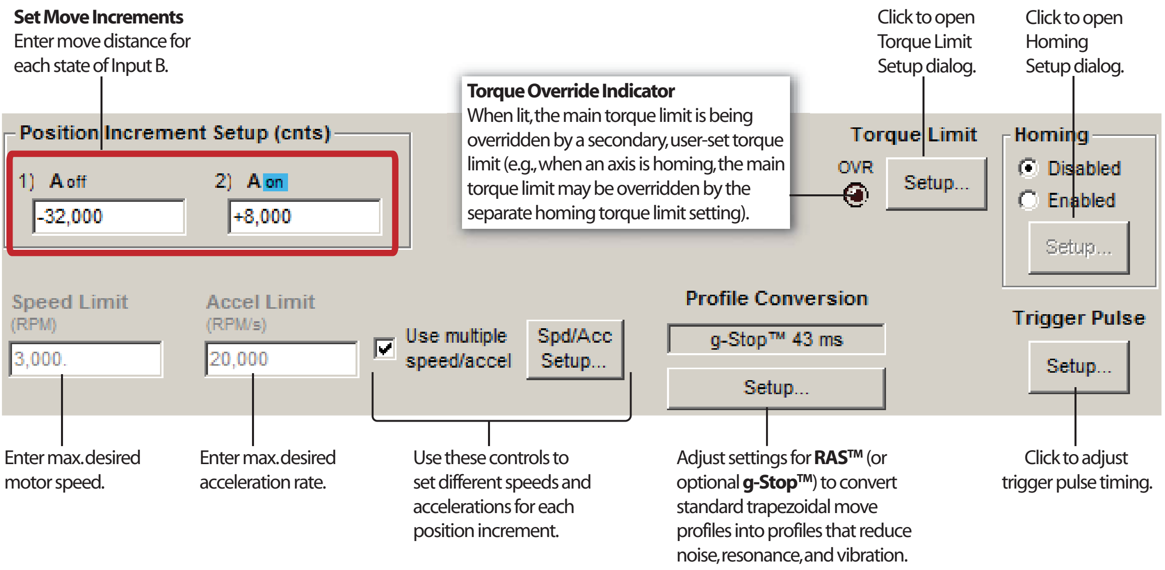
**Output (HLFB) -** See HLFB section for available modes.

**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



1) A off: -32,000
2) A on: +8,000
Speed Limit (RPM): 3,000
Accel Limit (RPM/s): 20,000
☑ Use multiple speed/accel
Homing: ● Disabled ○ Enabled
Profile Conversion: g-Stop™ 43 ms

**Set Move Increments**
Enter move distance for each state of Input B.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

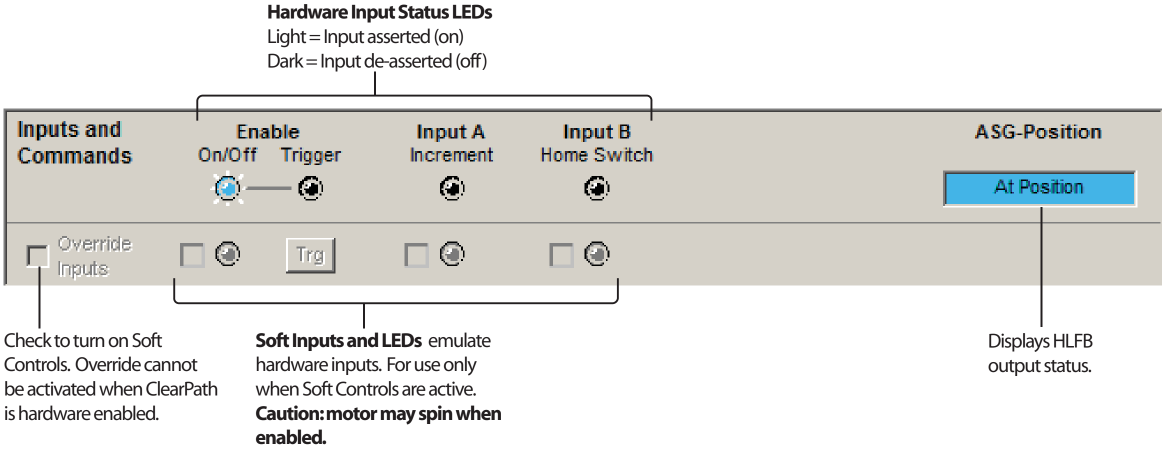
Enter max. desired motor speed.

Enter max. desired acceleration rate.

Use these controls to set different speeds and accelerations for each position increment.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Click to adjust trigger pulse timing.



**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.

# MOVE INCREMENTAL DISTANCE (1-DISTANCE, HOME-TO-SWITCH)

Available on
MCPV

## MODE DESCRIPTION

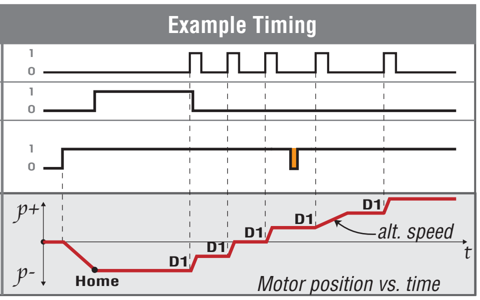
ClearPath will make an incremental move when the state of Input A changes. If automatic homing is on, ClearPath will seek for the home switch connected to Input B the first time it is enabled after power up, or, if desired, each time it is enabled.

**What is 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 move is launched.

Assert the Enable Input to energize the motor. ClearPath can be set up to perform an optional homing routine upon enable (home-to-switch only in this mode). Change the state of Input A to launch each move at the user-defined speed and acceleration. Briefly pulse the Enable input to execute the next move at the alternate speed limit.

**Position Control** **Incremental Positioning (1 Incremental Distance, Home-To-Switch)**

| Signal | Function | Input Type | Example Timing |
|---|---|---|---|
| **Input A** | Start Move | Start move on rising (or falling) edge* |  |
| **Input B** | Home Switch | Logic: High=Home Low=Not Home | |
| **Enable/ Trigger** | Enable<br>Trigger ⊤ | Logic: High=Enable Low=Disable<br>Pulse Enable line for Alternate Speed | |
| **Notes:** ClearPath can be programmed to home upon enable (see text for details). *Moves can be triggered on either rising *or* falling edge of Input A ( this is user settable). | | | |

⊤ Trigger pulse

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input tells ClearPath to use the alternate speed limit setting for the next move. (A "pulse" is a momentary interruption of current into the Enable input.)

**Input A -** Turning this input on (or off, if desired) sends the position increment.

**Input B -** This input is connected to the home switch/sensor. Its function is defined in the homing setup dialog.

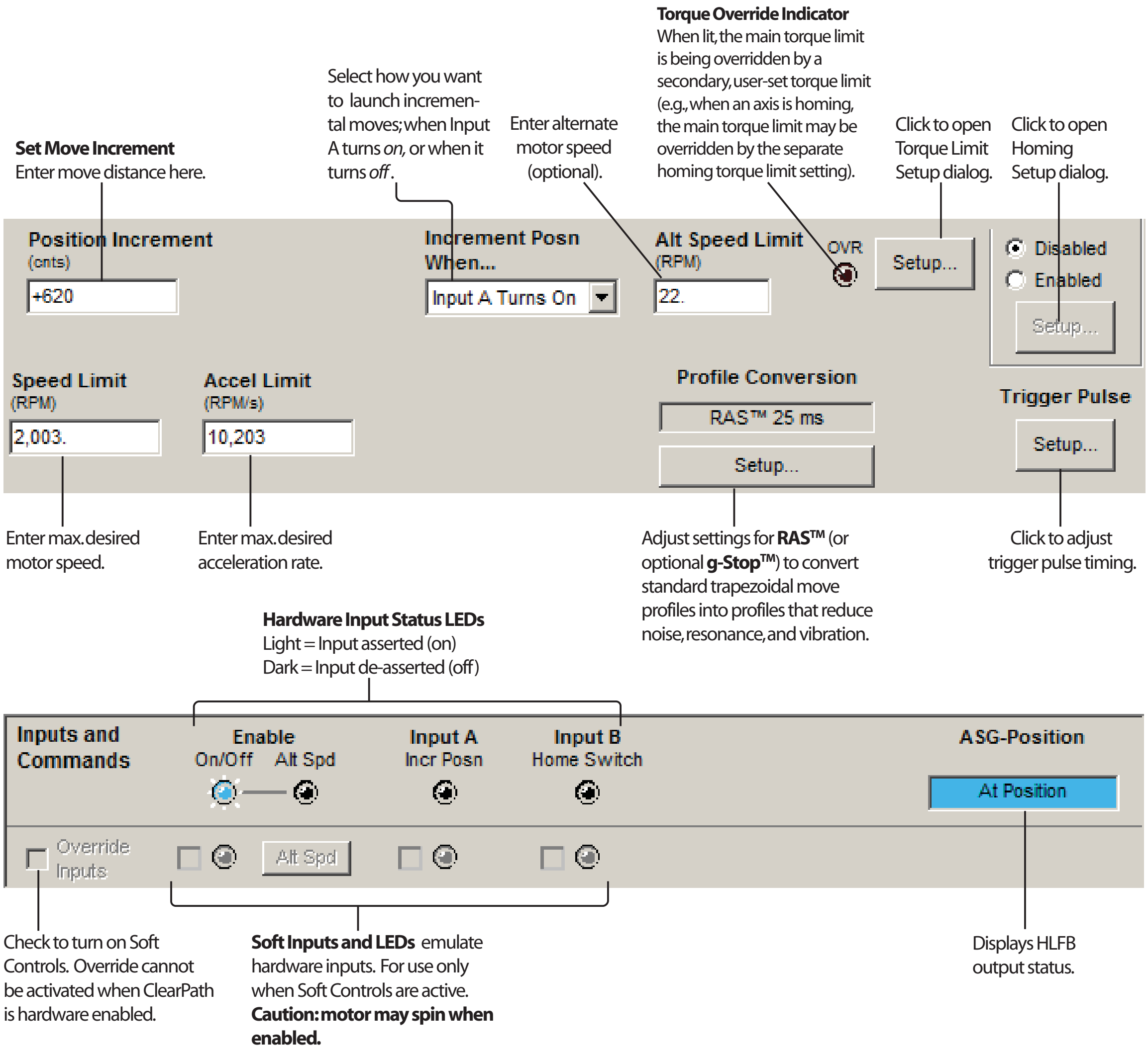
**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- Send incremental moves by turning Input A either on or off (this is user settable).

- Multiple position increments can be smoothly chained together (i.e., with no stops in between) by toggling Input A before ClearPath starts decelerating. For example, three quick cycles of Input A will create one smooth move of three times the length of the position increment.
- The direction of the move is specified by the sign of the position increment (i.e., a positive position increment will move the shaft in a counter-clockwise direction, while a negative increment will cause a move in the clockwise direction).
- Note that this 1 increment mode only allows for movement in one direction."

## MODE CONTROLS



Position Increment (cnts): +620

Increment Posn When...: Input A Turns On

Alt Speed Limit (RPM): 22.

Speed Limit (RPM): 2,003.

Accel Limit (RPM/s): 10,203

Profile Conversion: RAS™ 25 ms

● Disabled
○ Enabled

**Set Move Increment** Enter move distance here.

Select how you want to launch incremental moves; when Input A turns *on,* or when it turns *off*.

Enter alternate motor speed (optional).

**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

Enter max. desired motor speed.

Enter max. desired acceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Click to adjust trigger pulse timing.

**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.

## PULSE BURST POSITIONING

Available on

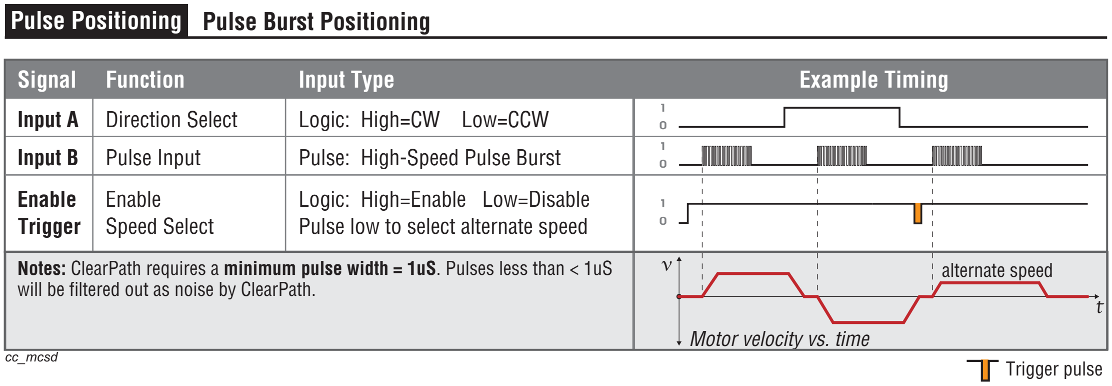
**MCPV**

### MODE DESCRIPTION

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.

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.



**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**<br>**Trigger** | Enable<br>Speed Select | Logic: High=Enable Low=Disable<br>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.

### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input tells ClearPath to use the alternate speed limit setting for the next move.

**Input A -** This input selects the direction of rotation.

**Input B -** This input is connected to the pulse source.

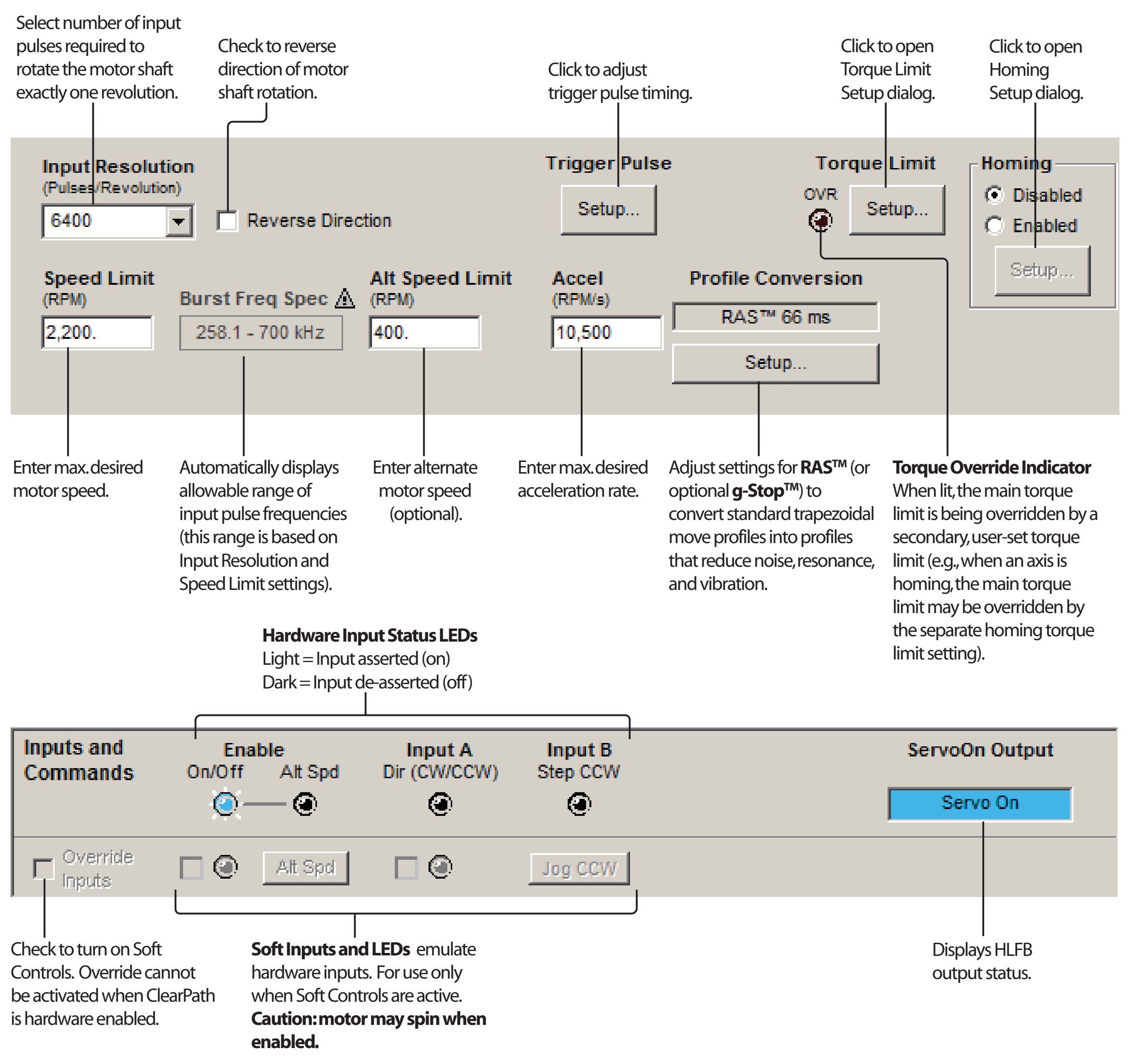
**Output (HLFB) -** See HLFB section for available modes.

**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, this is one of the reasons why this mode was developed. Just send a burst of

pulses and ClearPath creates a smooth motion profile for you automatically.

## MODE CONTROLS



Select number of input pulses required to rotate the motor shaft exactly one revolution.

Check to reverse direction of motor shaft rotation.

Click to adjust trigger pulse timing.

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

Input Resolution (Pulses/Revolution): 6400

☐ Reverse Direction

Homing: ● Disabled ○ Enabled

Speed Limit (RPM): 2,200.

Burst Freq Spec: 258.1 - 700 kHz

Alt Speed Limit (RPM): 400.

Accel (RPM/s): 10,500

Profile Conversion: RAS™ 66 ms

Enter max. desired motor speed.

Automatically displays allowable range of input pulse frequencies (this range is based on Input Resolution and Speed Limit settings).

Enter alternate motor speed (optional).

Enter max. desired acceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

**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.

**Note: Input Resolution** (see upper left of mode controls screen capture above) 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. Please see the Resolution appendix for a detailed discussion of this topic.

## MULTI-SENSOR POSITIONING: BI-DIRECTIONAL (HOME TO HARD STOP)

Available on

**MCPV**

### MODE DESCRIPTION

Move to a maximum of 16 different positions using simple I/O from your PLC, microcontroller or similar to control ClearPath's direction and position.

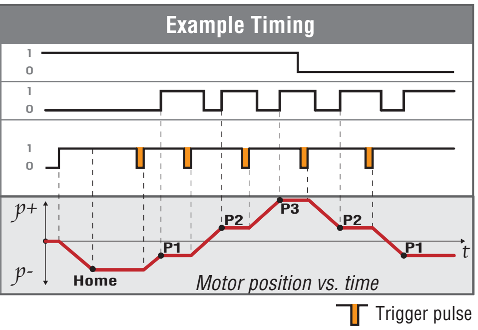
Wire up to 16 switches or sensors in series with Input B. Assert the Enable Input to energize the motor windings. Once homing is complete, a trigger pulse starts ClearPath moving in the direction indicated by Input A. When Input B sees a count of transitions equal to the count of trigger pulses, ClearPath will ramp to a stop at the user-defined rate. (These transitions are typically switch closures or sensor interruptions.)

**Position Control** **Multi-Sensor Position: Bi-directional (Home to Hard Stop)**

| Signal | Function | Input Type |
|---|---|---|
| **Input A** | Direction Select | Logic: High=CW Low=CCW |
| **Input B** | Sensors | Logic: High=On Low=Off |
| **Enable/ Trigger** | Enable<br>Trigger | Logic: High=Enable Low=Disable<br>Pulse Enable line low to trigger moves |

**Notes:** ClearPath must be homed before use.
Moves are triggered on rising edge of trigger pulse.

**Example Timing**



### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input is the trigger that starts a move. (A "pulse" is a momentary interruption of current into the Enable input.)

**Input A -** This input selects the direction of rotation.

**Input B -** Transitions on this input count up until they equal the count of transitions seen on Input A, at which time ClearPath will ramp to a stop.

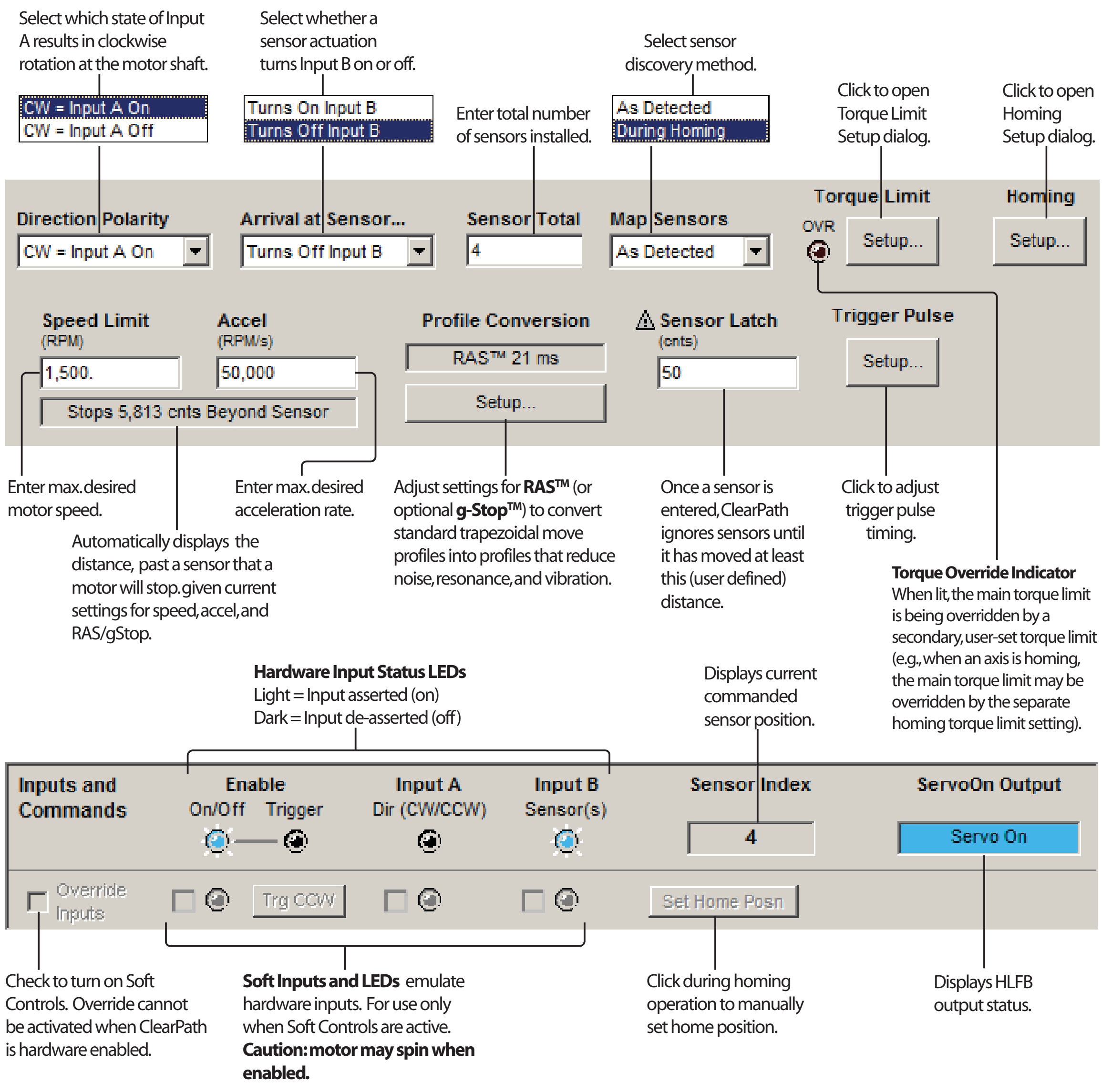
**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- Up to 16 sensors/switches can be placed along an axis and their outputs wired-ORed for multiple stops.
- Multiple trigger pulses issued in the same direction before a sensor is detected will cause the motor to continue through the number of sensors matching the number of pulses seen. Example: If you send 3 trigger pulses, ClearPath moves to the third sensor position.
- ClearPath will always finish moves in one direction before executing moves commanded in the other direction.

- Homing is required in this mode; it can be performed upon first enable after power up, or upon every enable.
- Time to disable depends on trigger pulse setting. i.e. a longer trigger pulse setting will result in a longer time to disable.
- Once all sensors are mapped, the motor will stop at the same position each time, regardless of the direction of approach.

## MODE CONTROLS



Direction Polarity: CW = Input A On

Arrival at Sensor...: Turns Off Input B

Sensor Total: 4

Map Sensors: As Detected

Speed Limit (RPM): 1,500.

Accel (RPM/s): 50,000

Stops 5,813 cnts Beyond Sensor

Profile Conversion: RAS™ 21 ms

Sensor Latch (cnts): 50

Sensor Index: 4

ServoOn Output: Servo On

Select which state of Input A results in clockwise rotation at the motor shaft.

Select whether a sensor actuation turns Input B on or off.

Enter total number of sensors installed.

Select sensor discovery method.

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

Enter max. desired motor speed.

Automatically displays the distance, past a sensor that a motor will stop.given current settings for speed, accel, and RAS/gStop.

Enter max. desired acceleration rate.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Once a sensor is entered, ClearPath ignores sensors until it has moved at least this (user defined) distance.

Click to adjust trigger pulse timing.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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

Displays current commanded sensor position.

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.

# MULTI-SENSOR POSITIONING: UNIDIRECTIONAL (SENSORLESS HOMING)

Available on
MCPV

## MODE DESCRIPTION

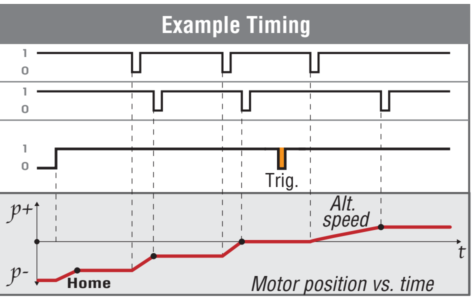
Use simple I/O from your PLC, microcontroller etc. to command ClearPath to move to the sensor or switch of your choosing. Direction, speed, and acceleration are all user-defined in MSP.

This mode starts by finding a user-defined, shaft angle home position. Then, upon seeing a transition on Input A, ClearPath will start to move in one, fixed, user-defined direction, at one of two velocities. ClearPath will ramp to a stop at the user-defined rate when Input B has seen a count of transitions equal to the count of transitions on Input A. (These transitions are typically switch closures or sensor interruptions.)

**Position Control** **Multi-Sensor Position: Unidirectional (Sensorless Homing)**

| Signal | Function | Input Type | Example Timing |
|---|---|---|---|
| **Input A** | Start Move | Start on rising or falling edge* | |
| **Input B** | Stop Move (Sensor) | Stop on rising or falling edge* | |
| **Enable/ Trigger** | Enable<br>Trigger ┳ | Logic: High=Enable Low=Disable<br>Pulse Enable line for Alternate Speed | |

**Notes:** ClearPath can be programmed to home upon enable (see text for details). *User may select rising or falling edge for input action (via MSP setup software). This diagram shows moves starting on the falling edge of Input A and stopping on the falling edge of Input B. Pulse Enable to execute next move at alternate speed.



┳ Trigger pulse

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input tells ClearPath to use the alternate speed limit setting for the next move. (A "pulse" is a momentary interruption of current into the Enable input.

**Input A -** A transition on this input starts a move. You can define whether the move starts on a rising or falling transition.

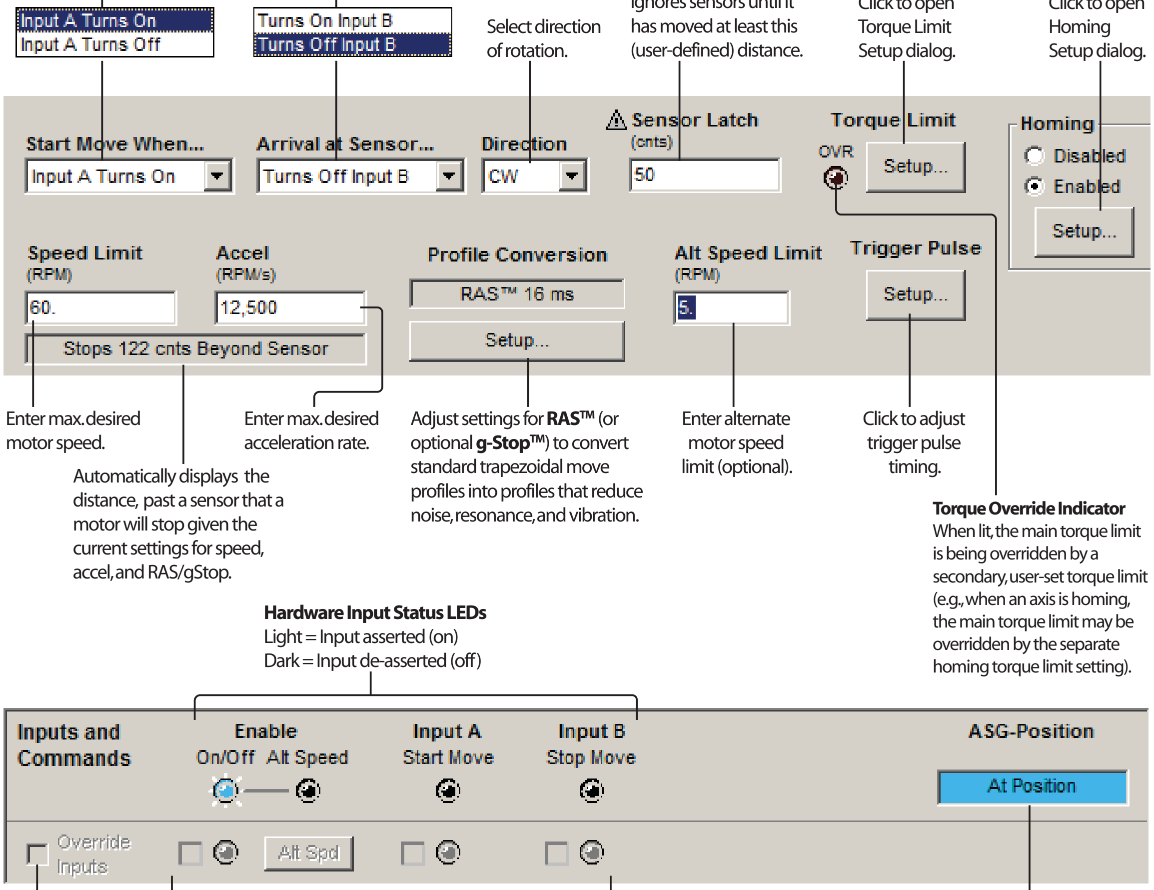
**Input B -** Transitions on this input count up until they equal the count of transitions seen on Input A, at which time ClearPath will ramp to a stop.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- This mode can also be used without homing if all the desired stopping locations are equivalent (e.g., an indexing table with four positions spaced an even 90 degrees apart).

## Mode Controls



Start Move When...: Input A Turns On

Arrival at Sensor...: Turns Off Input B

Direction: CW

Sensor Latch (cnts): 50

Homing: ○ Disabled ● Enabled

Speed Limit (RPM): 60.

Accel (RPM/s): 12,500

Stops 122 cnts Beyond Sensor

Profile Conversion: RAS™ 16 ms

Alt Speed Limit (RPM): 5.

ASG-Position: At Position

Select which edge transition at Input A will start a move.

Select whether a sensor actuation turns Input B on or off.

Select direction of rotation.

Once a sensor is entered, ClearPath ignores sensors until it has moved at least this (user-defined) distance.

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

Enter max. desired motor speed.

Enter max. desired acceleration rate.

Automatically displays the distance, past a sensor that a motor will stop given the current settings for speed, accel, and RAS/gStop.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Enter alternate motor speed limit (optional).

Click to adjust trigger pulse timing.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

**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.

# MULTI-SENSOR POSITIONING: UNIDIRECTIONAL (HOME TO SENSOR)

Available on

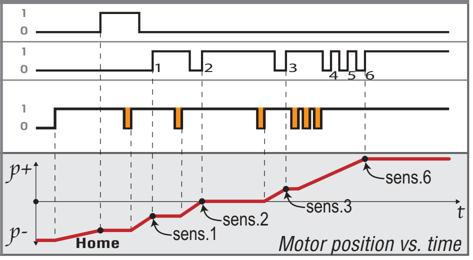
MCPV

## MODE DESCRIPTION

Use simple I/O from your PLC, microcontroller etc. to command ClearPath to move to the sensor or switch of your choosing. Direction, speed, and acceleration are all user-defined in MSP. Optional homing (home-to-sensor) is available.

This mode starts by finding a home sensor wired to Input A. Then, a “trigger” pulse on the Enable input starts ClearPath moving in one, fixed, user-specified direction. When Input B sees a count of transitions equal to the count of trigger pulses, ClearPath will ramp to a stop at the user-defined rate. (These transitions are typically switch closures or sensor interruptions.)

**Position Control** **Multi-Sensor Position: Unidirectional (Home to Sensor)**

| Signal | Function | Input Type | Example Timing |
|---|---|---|---|
| **Input A** | Home Sensor | Logic: High=in Home* \| Low=not in Home |  |
| **Input B** | Sensors | Edge: Stop move on edge transition** | |
| **Enable/ Trigger** | Enable<br>Trigger | Logic: High=Enable Low=Disable<br>Pulse Enable Input to trigger moves | |

**Notes:**
* User can invert Home switch operating polarity in MSP.
**Diagram shows moves stop on rising edge (transition) of Input B. User may specify either rising or falling edge in MSP.

= Trigger pulse

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short pulse (user-definable) on this input is the trigger that starts a move. (A "pulse" is a momentary interruption of current into the Enable input.)

**Input A -** This input is connected to the home switch. Homing options are set in the Homing Setup dialog.

**Input B -** Transitions on this input count up until they equal the count of trigger pulses seen on the Enable input, at which time ClearPath will ramp to a stop.

**Notes:**

- ClearPath can be programmed to home upon enable. If homing is not needed because all the desired stopping locations are equivalent (e.g., an indexing table with four positions spaced an even 90 degrees apart), consider using the Rotary with Sensorless Homing mode. This will allow the use of a second, alternate move velocity if desired.
- Moves are triggered by quickly pulsing the Enable input. Moves stop when sensor count at Input B matches trigger pulse count.
- Trigger pulses made in rapid succession result in longer, continuous moves.

## Mode Controls

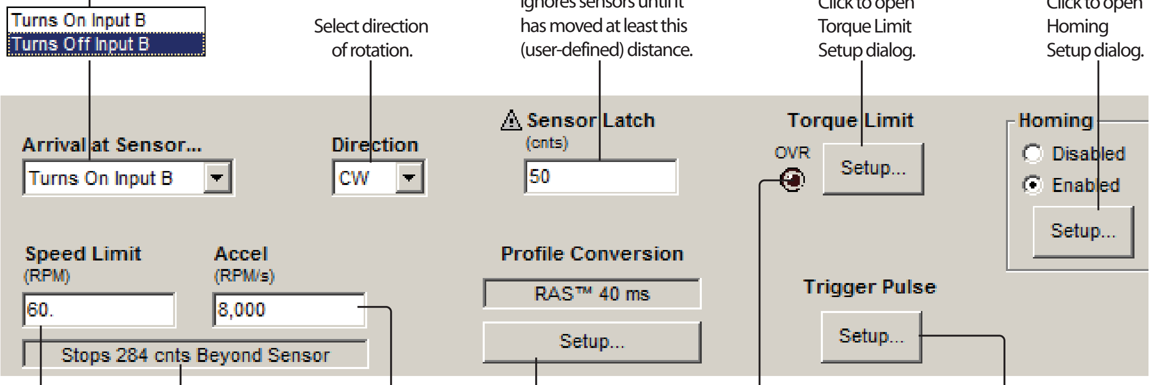
Select whether a sensor actuation turns Input B on or off.

Select direction of rotation.

Once a sensor is entered, ClearPath ignores sensors until it has moved at least this (user-defined) distance.

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.



Arrival at Sensor...: Turns On Input B

Direction: CW

Sensor Latch (cnts): 50

Speed Limit (RPM): 60.

Accel (RPM/s): 8,000

Stops 284 cnts Beyond Sensor

Profile Conversion: RAS™ 40 ms

Enter max. desired motor speed.

Enter max. desired acceleration rate.

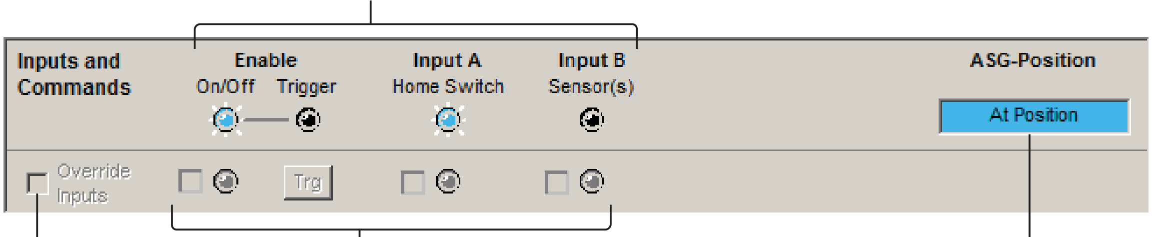
Automatically displays the distance, past a sensor that a motor will stop given the current settings for speed, accel, and RAS/gStop.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Click to adjust trigger pulse timing.

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



ASG-Position: At Position

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.**

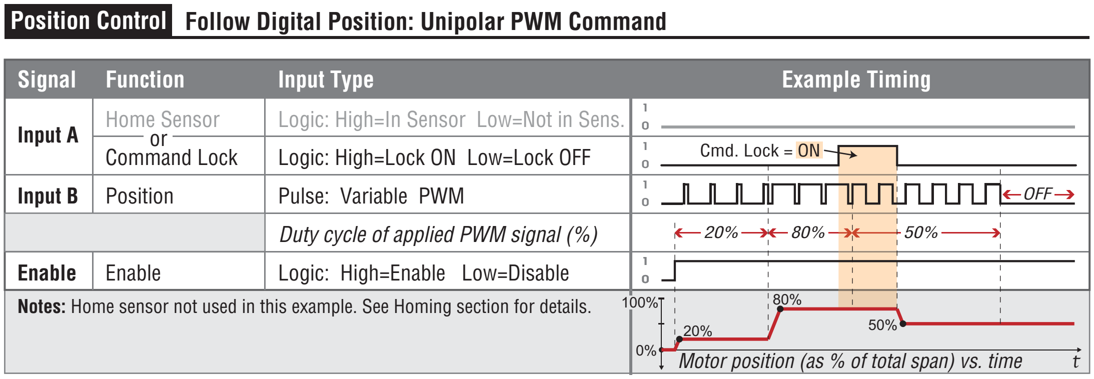
Displays HLFB output status.

# FOLLOW DIGITAL POSITION COMMAND: UNIPOLAR PWM COMMAND

## MODE DESCRIPTION

Available on
MCPV

ClearPath will servo to a position between two user-defined limits proportional to the PWM duty cycle of the signal on input B.



**Position Control** Follow Digital Position: Unipolar PWM Command

| Signal | Function | Input Type |
|---|---|---|
| **Input A** | Home Sensor<br>or<br>Command Lock | Logic: High=In Sensor Low=Not in Sens.<br>Logic: High=Lock ON Low=Lock OFF |
| **Input B** | Position | Pulse: Variable PWM |
| | | *Duty cycle of applied PWM signal (%)* |
| **Enable** | Enable | Logic: High=Enable Low=Disable |

**Notes:** Home sensor not used in this example. See Homing section for details.

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** Asserting this input will make ClearPath continue to servo to its current position regardless of any changes to the duty cycle on Input B. Alternatively, this signal can be used as a home sensor input.

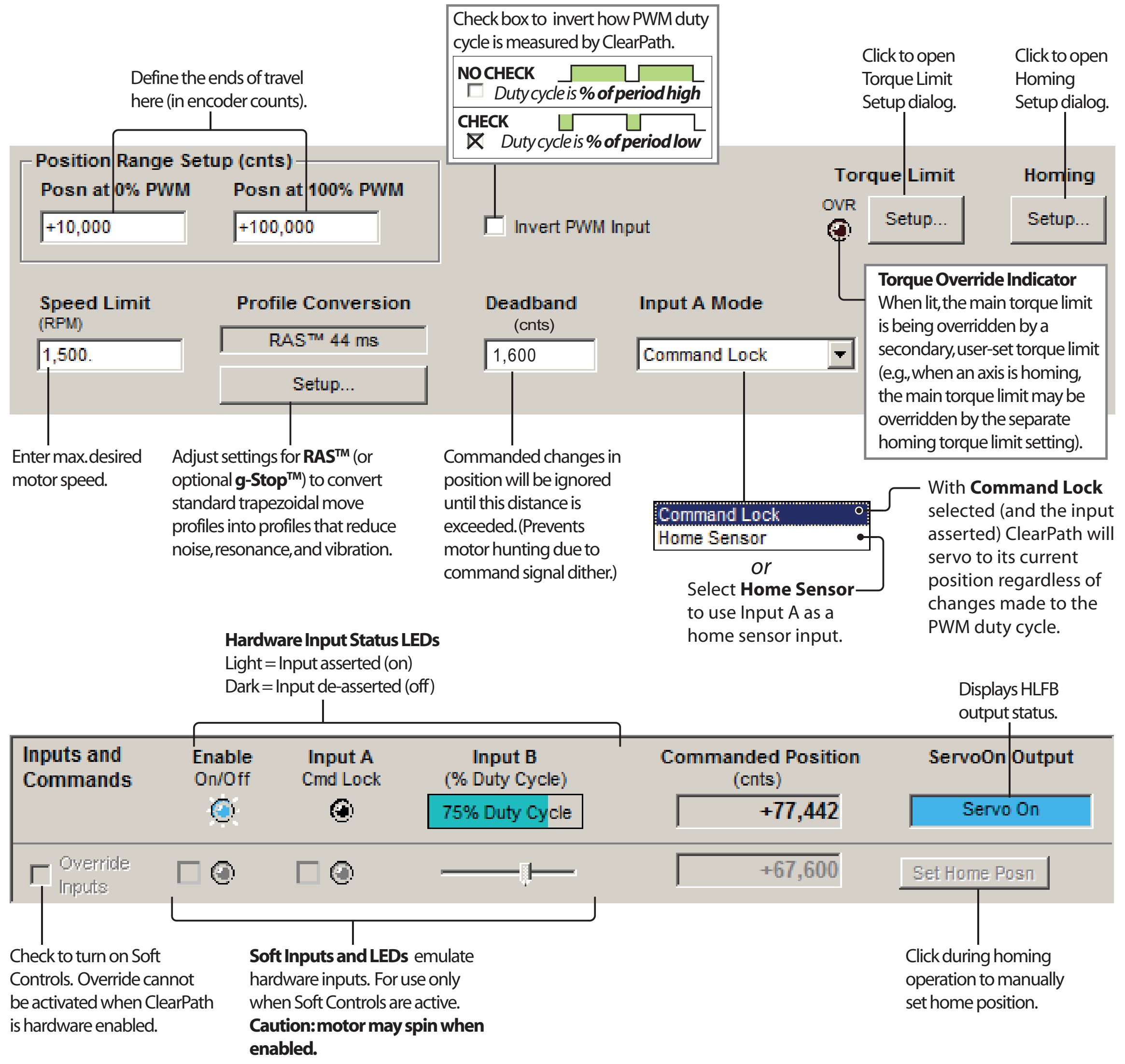
**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired position.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- A loss of modulation (meaning Input B has no transitions for more than 50 ms) is considered an error condition, and ClearPath will maintain its current position.
- A duty cycle of nearly 0% or 100% (with a state transition at least every 50 ms) will command ClearPath to move to position 0 or position 1, respectively.
- A duty cycle between 0% and 100% will command a position proportionally between position 0 and 1.

## MODE CONTROLS



Define the ends of travel here (in encoder counts).

Check box to invert how PWM duty cycle is measured by ClearPath.

**NO CHECK** ☐ *Duty cycle is **% of period high***

**CHECK** ☒ *Duty cycle is **% of period low***

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Enter max. desired motor speed.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Commanded changes in position will be ignored until this distance is exceeded. (Prevents motor hunting due to command signal dither.)

With **Command Lock** selected (and the input asserted) ClearPath will servo to its current position regardless of changes made to the PWM duty cycle.

*or*

Select **Home Sensor** to use Input A as a home sensor input.

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

Displays HLFB output status.

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.

Posn at 0% PWM: +10,000
Posn at 100% PWM: +100,000
Speed Limit (RPM): 1,500.
Profile Conversion: RAS™ 44 ms
Deadband (cnts): 1,600
Input A Mode: Command Lock
Input B (% Duty Cycle): 75% Duty Cycle
Commanded Position (cnts): +77,442
ServoOn Output: Servo On

***caption***

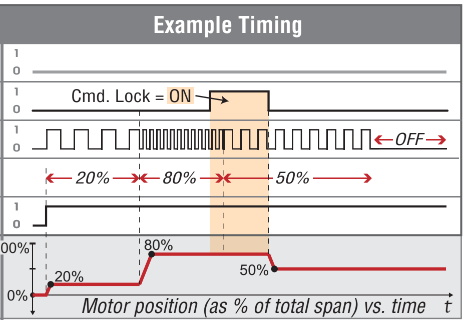
# FOLLOW DIGITAL POSITION COMMAND: FREQUENCY COMMAND

Available on
MCPV

## MODE SUMMARY

ClearPath will servo to a position between two user-defined limits based on the frequency of the signal on Input B.

**Position Control** Follow Digital Position: Frequency Command

| Signal | Function | Input Type | Example Timing |
|---|---|---|---|
| **Input A** | Home Sensor | Logic: High=In Sensor Low=Not in Sens. |  |
| | or<br>Command Lock | Logic: High=Lock ON Low=Lock OFF | |
| **Input B** | Position | Pulse: Variable Frequency | |
| | *Frequency of signal (as % of user-defined freqency range)* | | |
| **Enable** | Enable | Logic: High=Enable Low=Disable | |

**Notes:** Home sensor not used in this example. See Homing section for details.

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** Asserting this input will make ClearPath continue to servo to its current position regardless of any changes to the frequency on Input B. Alternatively, this signal can be used as a home sensor input.

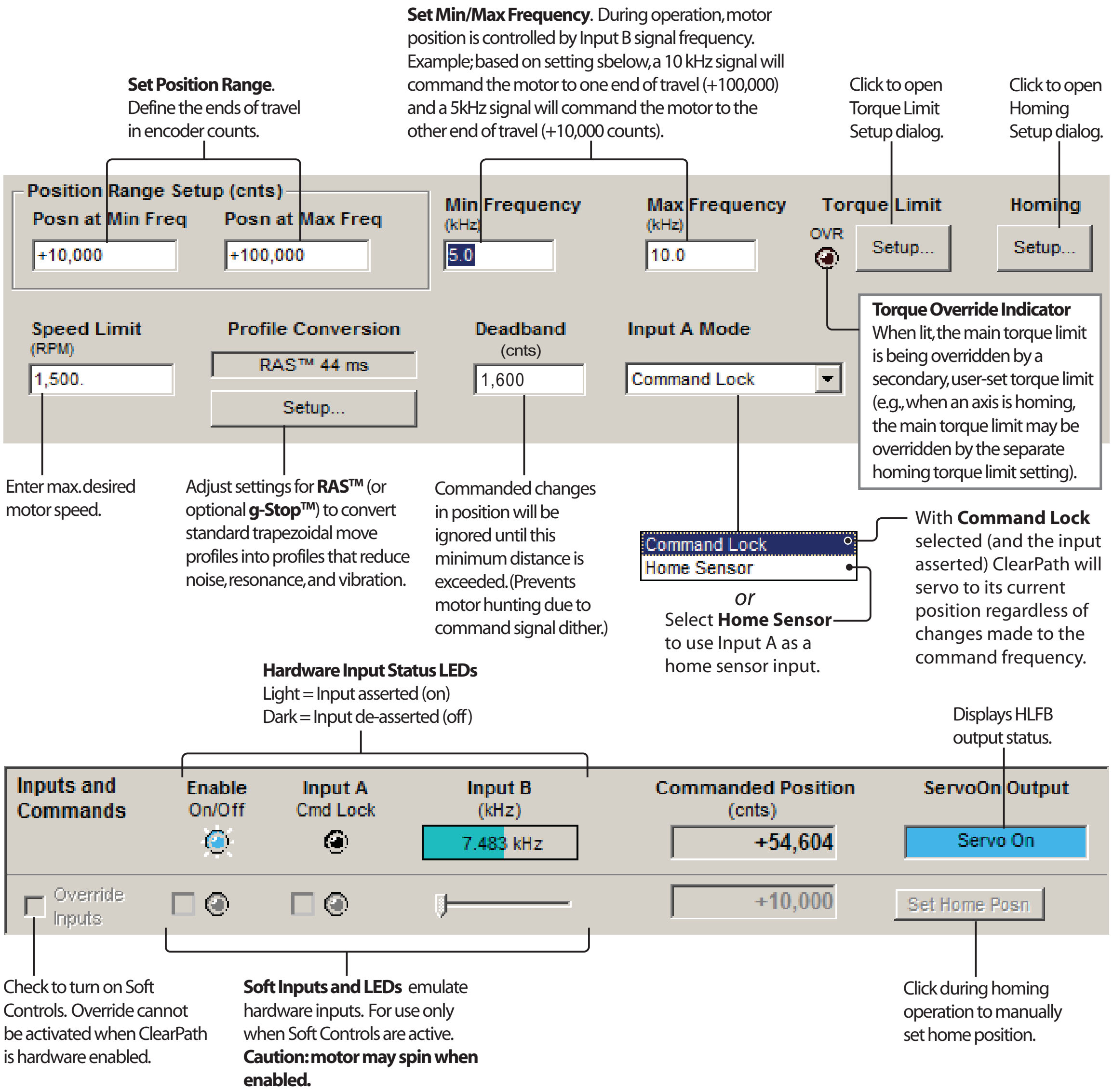
**Input B -** This input is connected to a digital signal whose frequency represents the desired position.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- A signal frequency on Input B equal to the user-defined minimum will move the motor to position 0. A frequency equal to the user-defined maximum will move the motor to position 1.
- Frequencies between the minimum and maximum will command a position proportionally between position 0 and 1.
- If there are no transitions on Input B for 50 ms or more, this will be considered an error condition, and the motor will hold its current position.

## MODE CONTROLS



**Set Position Range**. Define the ends of travel in encoder counts.

**Set Min/Max Frequency**. During operation, motor position is controlled by Input B signal frequency. Example; based on setting sbelow, a 10 kHz signal will command the motor to one end of travel (+100,000) and a 5kHz signal will command the motor to the other end of travel (+10,000 counts).

Click to open Torque Limit Setup dialog.

Click to open Homing Setup dialog.

**Torque Override Indicator** When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

Enter max. desired motor speed.

Adjust settings for **RAS™** (or optional **g-Stop™**) to convert standard trapezoidal move profiles into profiles that reduce noise, resonance, and vibration.

Commanded changes in position will be ignored until this minimum distance is exceeded. (Prevents motor hunting due to command signal dither.)

With **Command Lock** selected (and the input asserted) ClearPath will servo to its current position regardless of changes made to the command frequency.

*or*

Select **Home Sensor** to use Input A as a home sensor input.

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

Displays HLFB output status.

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.

# OPERATIONAL MODES: SDSK AND SDHP

The ClearPath SD (Step & 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 & direction** signals.

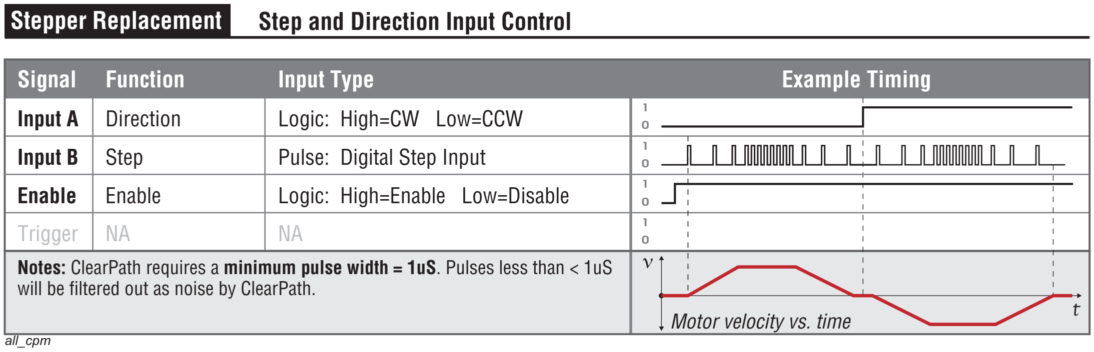
## STEP & DIRECTION

Available on
**SDSK + SDHP**

### MODE DESCRIPTION

Enable your ClearPath and send industry standard step & direction signals to Inputs A and B, and ClearPath faithfully follows them. Use the included RAS (Regressive Auto Spline) feature to reduce vibration and noise. This mode is great for replacing stepper motor and drive systems with a single, compact device that costs less and does more.

ClearPath SD models require step and direction signals generated from an external device such as an indexer, microcontroller, 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.

*Step and Direction Inputs and Timing*

### I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** Direction input.

**Input B -** Step input.

**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

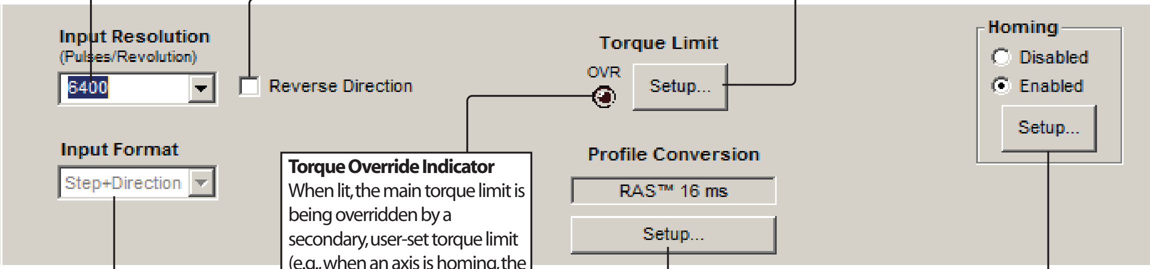
- Minimum pulse on/off time = 1uS. See diagram next page for step and direction timing information.
- Motion occurs on the rising edge of each step input pulse.
- Time before Disable = 10 mS

## MODE CONTROLS

Select number of input pulses required to rotate the motor shaft exactly one revolution.

Check to reverse direction of motor shaft rotation.

Click to open Torque Limit Setup dialog.



Input Resolution (Pulses/Revolution): 6400

Input Format: Step+Direction

☐ Reverse Direction

Homing: ○ Disabled ● Enabled

Profile Conversion: RAS™ 16 ms

Choose pulse input format.
Step & Direction
or
Quadrature

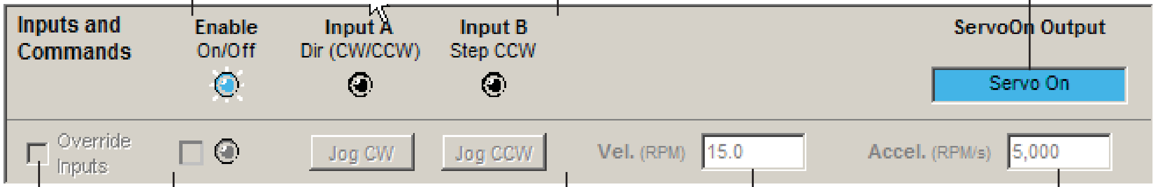
**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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 (when homing is enabled).

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

Displays HLFB output status.



☐ Override Inputs

Vel. (RPM): 15.0

Accel. (RPM/s): 5,000

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.**

Enter motor velocity. For use with Soft Controls.

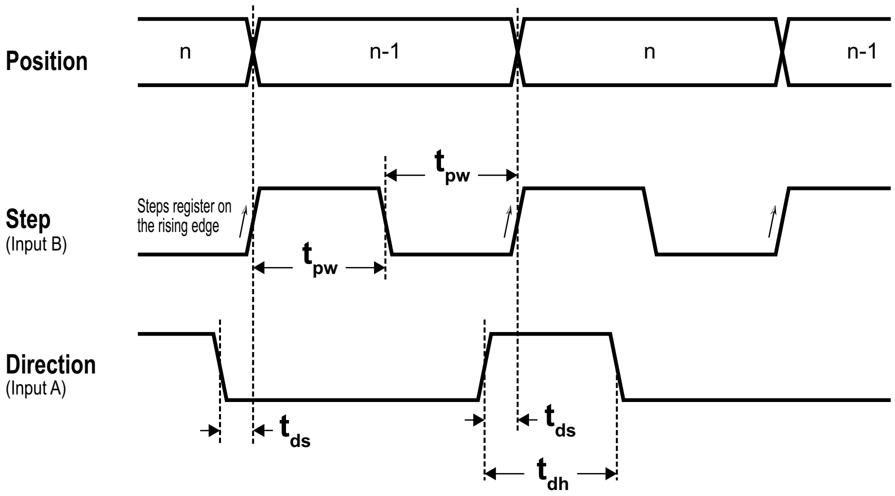
Enter motor acceleration. For use with Soft Controls.

## 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.

**Note:** In this example, 1 step received at Input B = 1 count of rotation.



$t_{pw}$ *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 & direction timing***

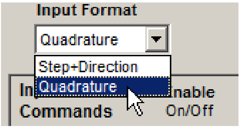
# QUADRATURE INPUT

Available on
**SDSK + SDHP**

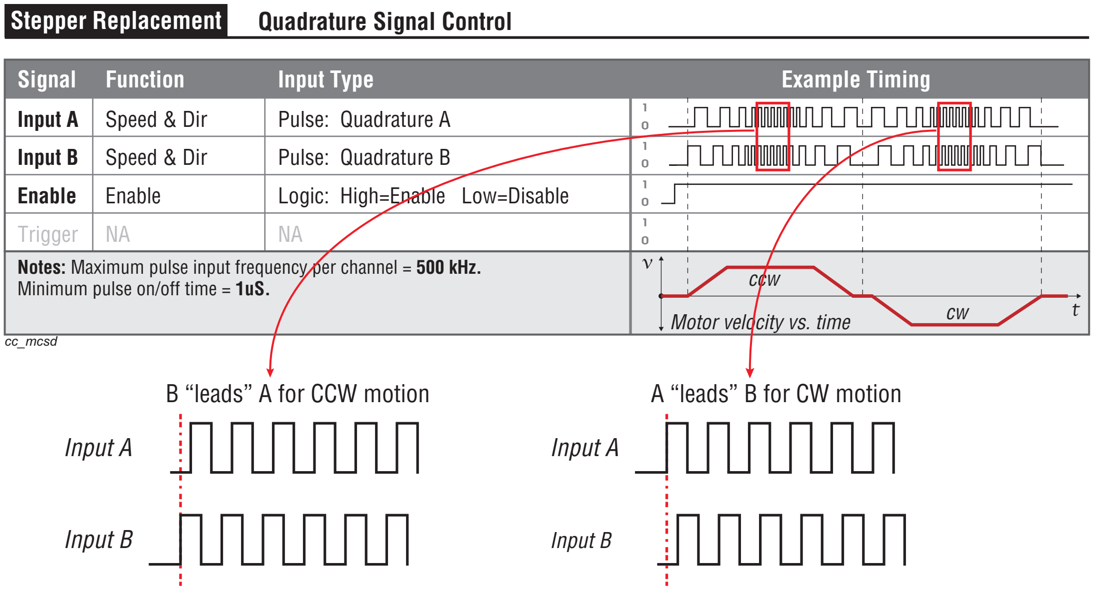
## MODE DESCRIPTION

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.

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 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***

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft.

**Input A -** Quadrature A input.

**Input B -** Quadrature B input.

**Output (HLFB) -** See HLFB section for available modes.

**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.

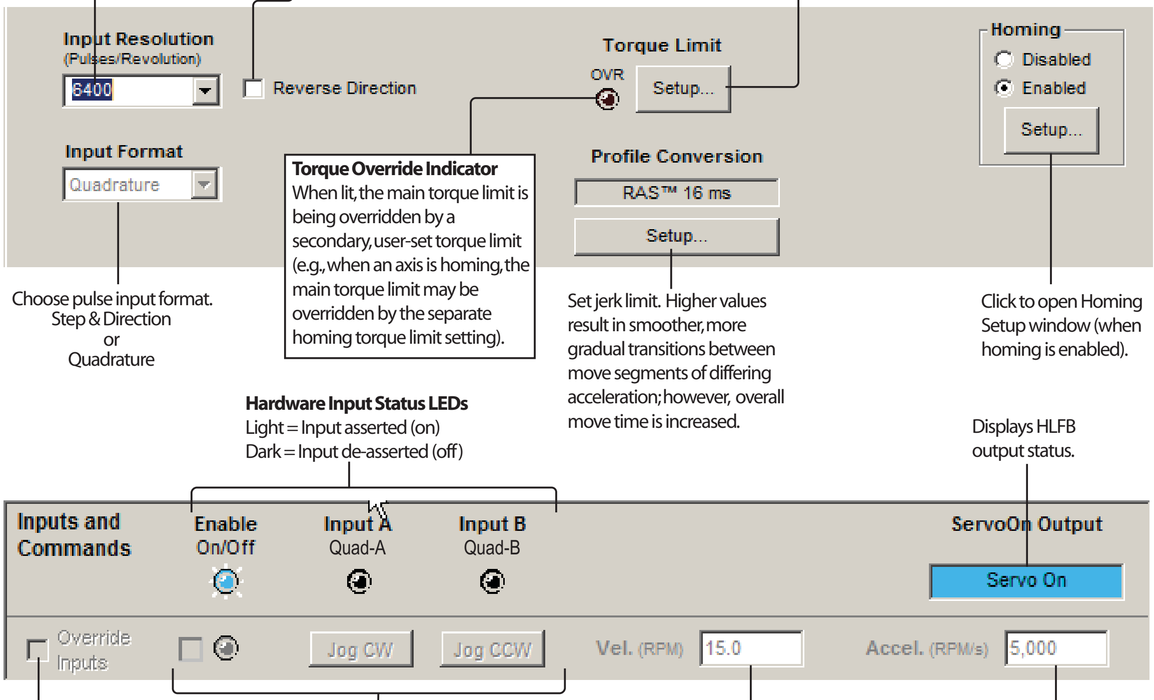
- Time before Disable = 10 mS.

## MODE CONTROLS

Select number of input pulses required to rotate the motor shaft exactly one revolution.

Check to reverse direction of motor shaft rotation.

Click to open Torque Limit Setup dialog.



Input Resolution (Pulses/Revolution): 6400

Input Format: Quadrature

☐ Reverse Direction

Profile Conversion: RAS™ 16 ms

Homing: ○ Disabled ● Enabled

Vel. (RPM): 15.0

Accel. (RPM/s): 5,000

Choose pulse input format.
Step & Direction
or
Quadrature

**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

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 (when homing is enabled).

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

Displays HLFB output status.

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.**

Enter motor velocity. For use with Soft Controls.

Enter motor acceleration. For use with Soft 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.

# 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**<br>Verify power is correctly wired and within specified voltage range. |
| Yellow – on solid | N/A | N/A | Servo off | N/A | **Status: Disabled**<br>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**<br>Motor power is on. ClearPath will respond to motion commands. |
| Yellow - 2 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **User Stop**<br>ESC key or button was pressed by the user. |
| Yellow - 2 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Motor Enable Conflict**<br>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**<br>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**<br>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**<br>Probable cause: commanded speed/velocity is beyond motor spec. |
| Yellow - 4 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Tracking Error Limit Exceeded**<br>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**<br>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**<br>Probable cause: bad tuning, low bus voltage. |
| Yellow - 5 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Excessive Motor Temp**<br>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**<br>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**<br>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**<br>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**<br>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**<br>Probable cause: bad tuning, low bus voltage. |
| Yellow - 7 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Commutation Startup Error**<br>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**<br>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**<br>Velocity/speed limit exceeds motor's factory-set maximum speed. |
| Yellow - strobe | Shutdown | Disallows motion | Servo off | Toggle Enable input | **RAS Change Rejected**<br>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**<br>Unexpected error. Contact Teknic for work-around or new firmware. |
| Yellow - strobe | Shutdown | Disallows motion | Servo off | Toggle Enable input | **MagAlign Distance Error**<br>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**<br>Direction traveled is incorrect. Probable cause: external forces during MagAlign procedure. |
| Yellow - strobe | Shutdown | Disallows motion | Servo off | Toggle Enable input | **DSP Watchdog Restart**<br>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)**<br>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)**<br>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**<br>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)**<br>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)**<br>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**<br>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**<br>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**<br>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)**<br>Probable cause: Dropped AC phase; Bus volts under operating voltage. |
| Red Toggle | Motor Failure | Disallows Motion | Servo off | Not clearable (typically) | **Motor Has Failed**<br>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.

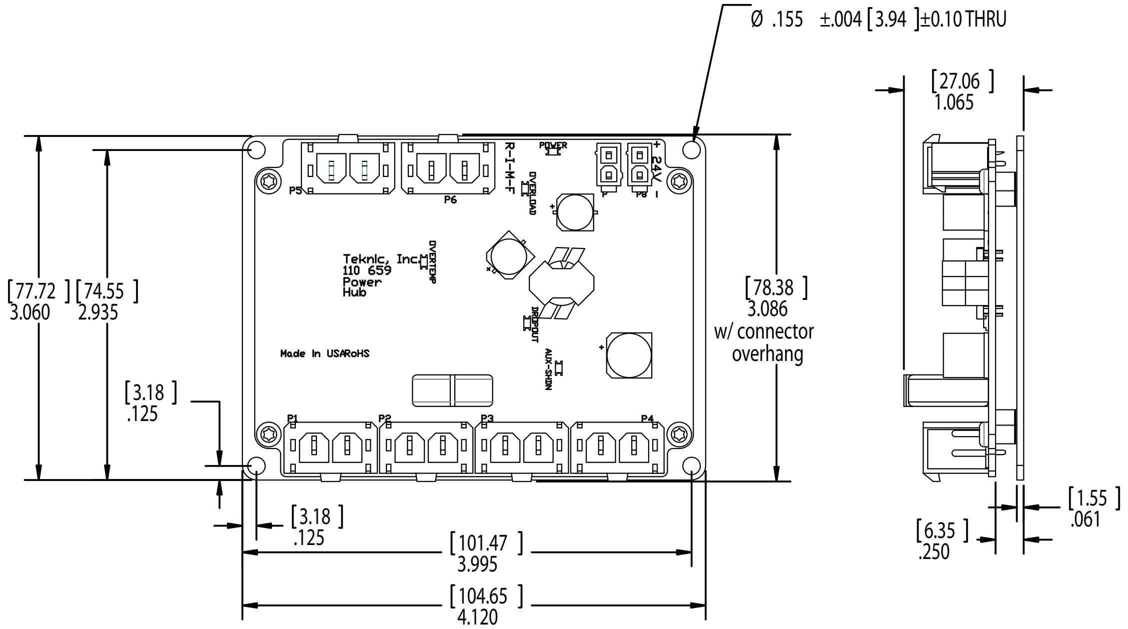
- The LED will remain off. Toggling the Enable *will not* clear this shutdown.

**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

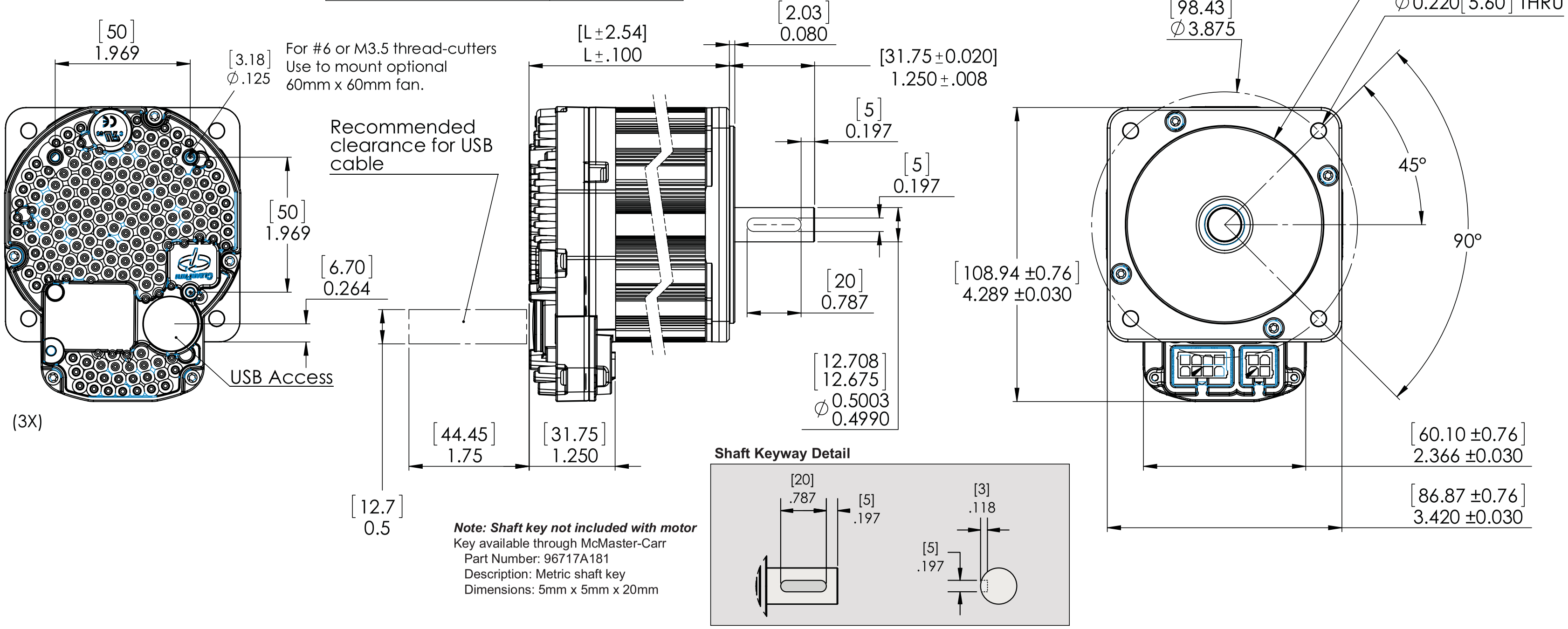
## MOUNTING DIMENSIONS: POWER HUB



*Power Hub Mounting Dimensions*

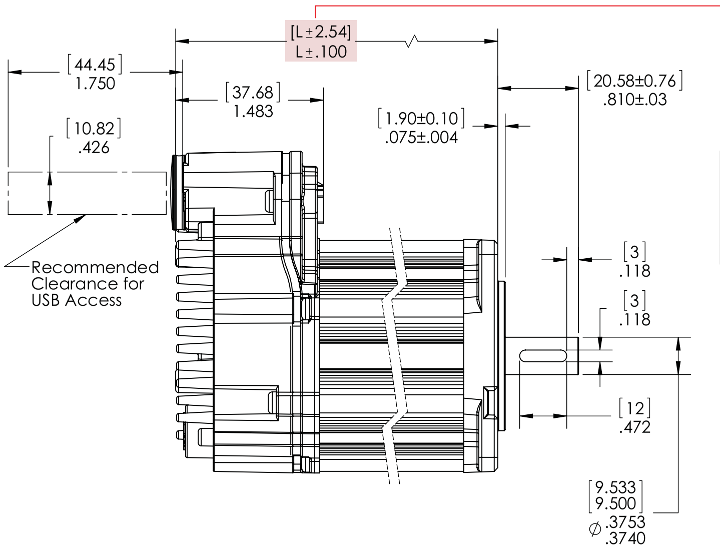
# MOUNTING DIMENSIONS: CLEARPATH NEMA 34

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



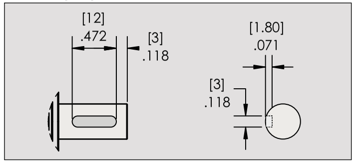
***Note: Shaft key not included with motor***
Key available through McMaster-Carr
Part Number: 96717A181
Description: Metric shaft key
Dimensions: 5mm x 5mm x 20mm

# MOUNTING DIMENSIONS: CLEARPATH NEMA 23



| Model Number | "L" Dimension |
|---|---|
| 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] |

**Shaft Keyway Detail**



***Note: Shaft key not included with motor***

Key available through McMaster-Carr

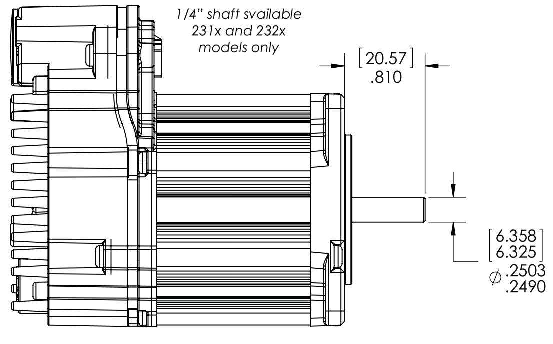
Part Number: 96717A086

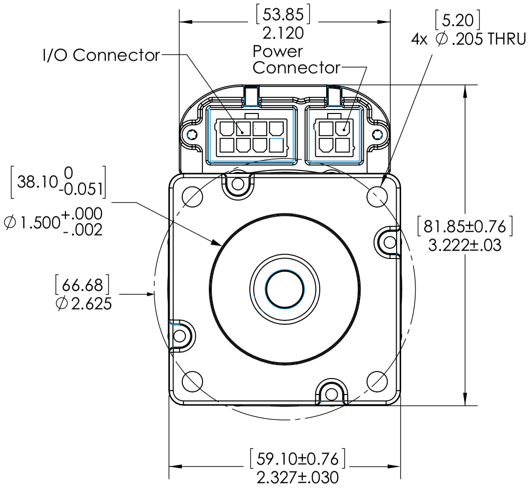
Description: Metric shaft key

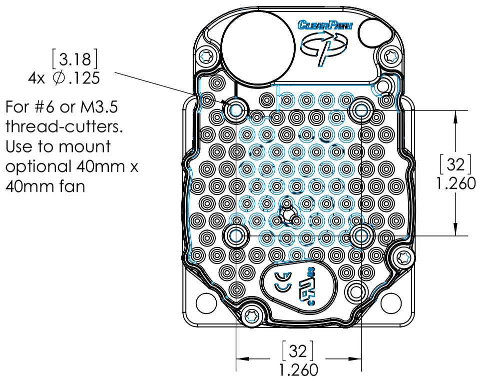
Dimensions: 3mm x 3mm x 10mm

**Optional 1/4" Full Round Shaft**

*1/4" shaft svailable 231x and 232x models only*







### 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

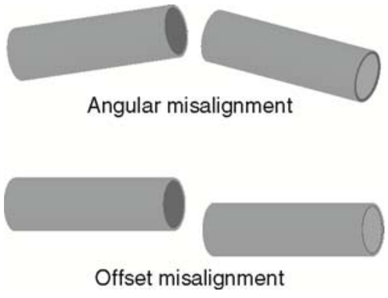
While it’s obvious that ClearPath must be connected to a mechanical system to do useful work, it’s not always clear just how to connect the motor to the mechanics.

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.

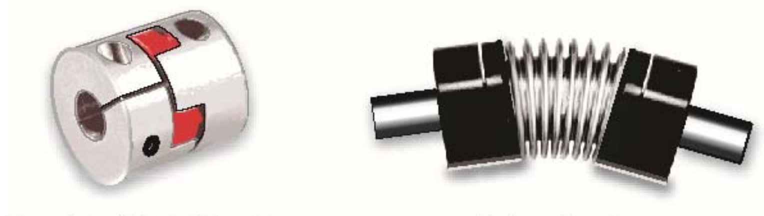
### General Guidelines for Coupling Selection

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.



Curved Jaw (Spider) Coupling

Bellows Coupling

***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.

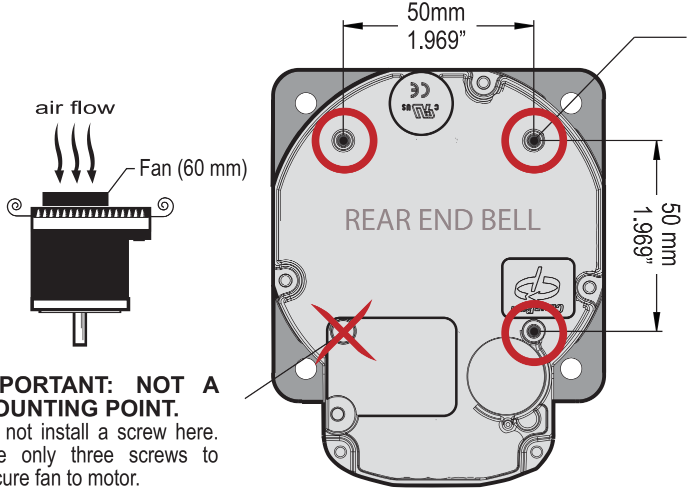
## FAN MOUNTING AND COOLING

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.

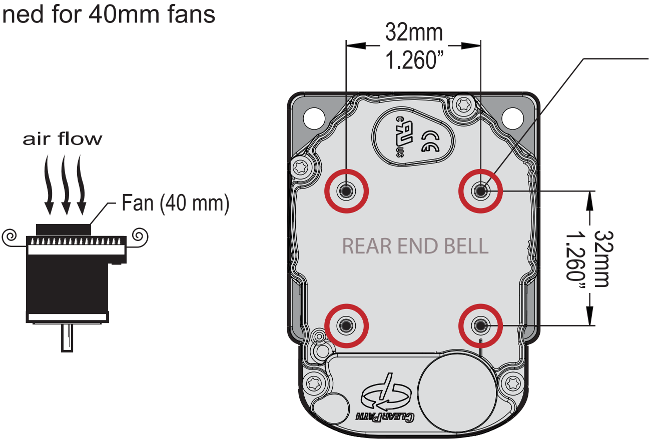
**ClearPath NEMA 34**
Designed for 60mm fans



Mounting Boss (3 places)
Inner dia: 0.125” (3.17mm)
Use #6 or M3 thread cutters.
Max penetration into boss: 0.28”

**IMPORTANT: NOT A MOUNTING POINT.**
Do not install a screw here. Use only three screws to secure fan to motor.

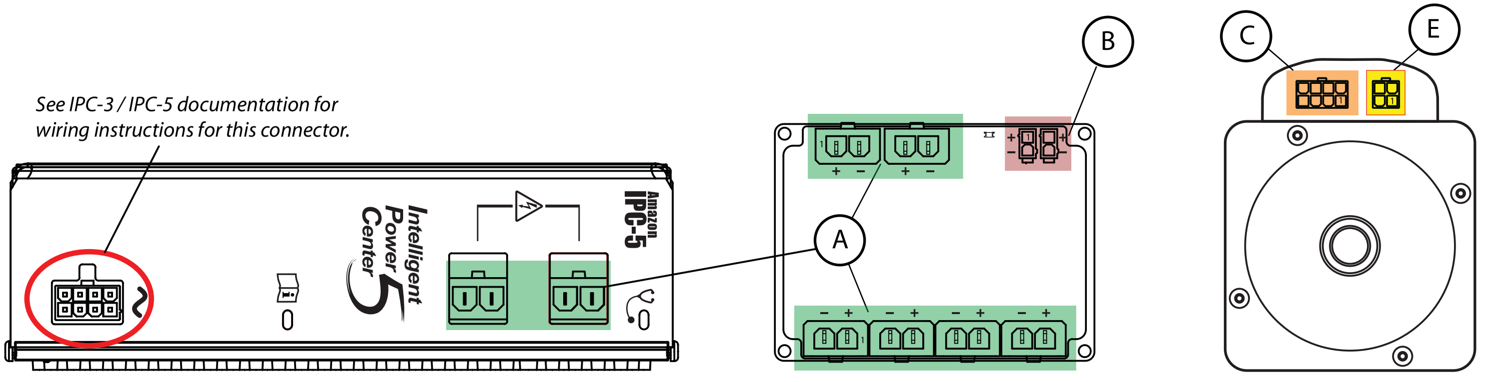
**ClearPath NEMA 23**
Designed for 40mm fans



Mounting Boss (4 places)
Inner dia: 0.125” (3.17mm)
Use #6 or M3 thread cutters.
Max penetration into boss: 0.28”

# APPENDIX C: MATING CONNECTORS AND CABLE PINOUTS

## MATING CONNECTOR INFORMATION



IPC-5 or IPC-3 Power Supply

POWER4- HUB

ClearPath Motor

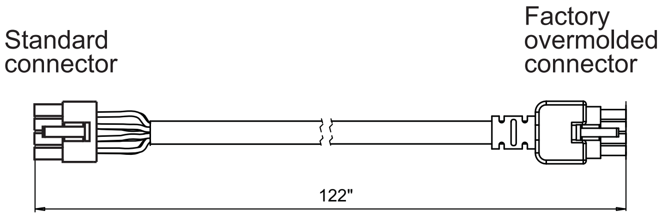
*Parts listed in table manufactured by Molex Inc. Visit www.molex.com for complete specifications and application information.*

| 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)<br>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)<br>39-01-3025 (black, UL 94V-2)<br>39-01-3028 (natural, UL 94V-0)<br>39-03-9022 (black, UL 94V-0) | 39-00-0059 (reel)<br>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)<br>39-01-3085 (black, UL 94V-2)<br>39-01-2085 (natural, UL 94V-0)<br>39-03-9082 (black, UL 94V-0) | 39-00-0046 (reel)<br>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)<br>39-01-3045 (black, UL 94V-2)<br>39-01-2045 (natural, UL 94V-0)<br>39-03-9042 (black, UL 94V-0) | 39-00-0077 (reel)<br>39-00-0078 (loose) | Female crimp terminal, tin plate, 16 AWG | 63819-0900 (16-24 AWG) | 11-03-0044 | 16 AWG |

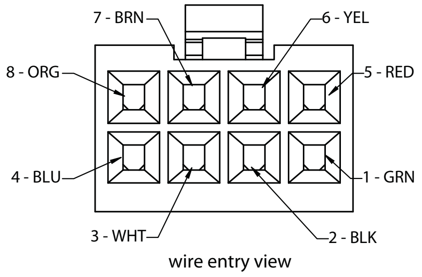
[1] AWG values listed are the actual wire gauges used in Teknic-manufactured cables.

## 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).

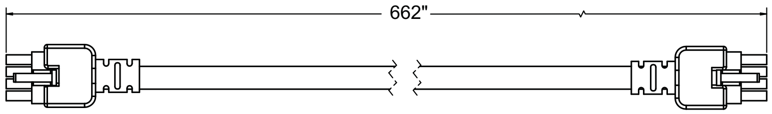


| Pin Assignments | | |
|---|---|---|
| **Pin** | **Color** | **Name** |
| 1 | GRN | HLFB + |
| 2 | BLK | Input B + |
| 3 | WHT | Input A + |
| 4 | BLU | Enable + |
| 5 | RED | HLFB - |
| 6 | YEL | Input B - |
| 7 | BRN | Input A - |
| 8 | ORN | Enable - |

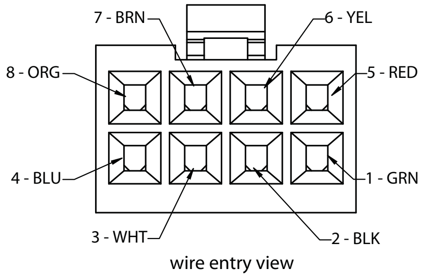


## CABLE PINOUT: CPM-CABLE-CTRL-MM660

**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.

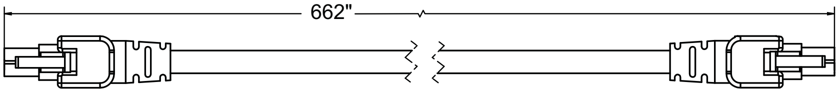


| Pin Assignments | | |
|---|---|---|
| **Pin** | **Color** | **Name** |
| 1 | GRN | HLFB + |
| 2 | BLK | Input B + |
| 3 | WHT | Input A + |
| 4 | BLU | Enable + |
| 5 | RED | HLFB - |
| 6 | YEL | Input B - |
| 7 | BRN | Input A - |
| 8 | ORN | Enable - |

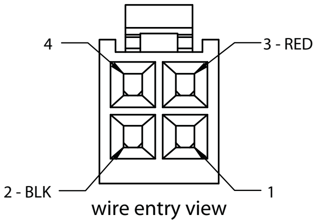


## CABLE PINOUT: CPM-CABLE-PWR-MM660

**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.

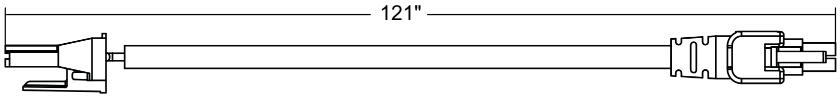


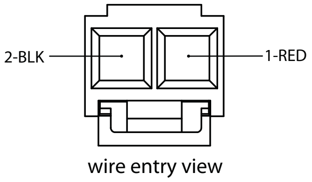
| Pin Assignments | | |
|---|---|---|
| **Pin** | **Color** | **Name** |
| 2 | BLK | GND |
| 3 | RED | V+ |

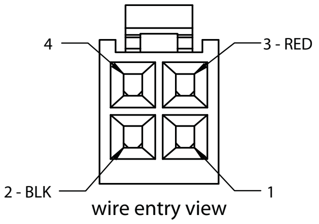


## CABLE PINOUT: CPM-CABLE-PWR-MS120

**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)<br>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 x$10^9$ to 5.3 x$10^9$ 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 x$10^9$ to 5.0 x$10^9$ 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)<br>For continuous long-term use: 55°C/122°F (RMS torque output de-rated)<br>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 #6-32, thread forming screw, 5/16" length** (McMaster-Carr PN 93878A145). 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.

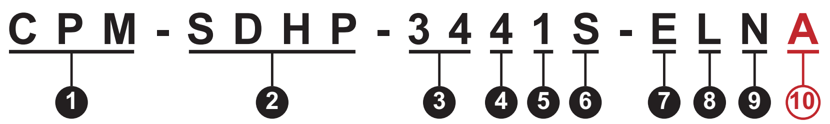
**Note:** All ClearPath I/O signals are electrically isolated from ClearPath's DC power input and motor output circuits, as well as from the motor case. This design feature helps to ensure that control signals aren't compromised by induced currents from the motor, power supply, or internal PWM.

## 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

*Example Part Number*



| | | | |
|---|---|---|---|
| 1 | **Product ID** | **CPM** | ClearPath® Motor |
| 2 | **Family/Model** | **SDSK** | Step & Direction / "Stepper Killer" *(2-3x the power of a similarly sized stepper)* |
| | | **SDHP** | Step & Direction / High Power model *(8-15x the power of a similarly sized stepper)* |
| | | **MCVC** | Motion Controller / Velocity, Torque, 2 Position Modes |
| | | **MCPV** | Motion Controller / Position, Velocity, Torque Modes |
| | | **SCSK** | Software Control / "Stepper Killer" *(3x the power of similarly sized steppers)* |
| | | **SCHP** | Software Control / High Power model *(8-15x the power of similarly sized steppers)* |
| 3 | **Motor Frame Size** | **23** | NEMA 23 frame |
| | | **34** | NEMA 34 frame |
| 4 | **Body Length**<br>*Approximate, excludes shaft length* | **1** | 82mm |
| | | **2** | 100mm |
| | | **3** | 120mm |
| | | **4** | 140mm |
| 5 | **Winding/Magnetic Structure** | **0** | Indicates specific winding design. See your motor's torque-speed curve for more information. |
| | | **1** | |
| | | **2** | |
| | | **5** | |
| | | **6** | |
| 6 | **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) |
| 7 | **Enhanced Options** | **R** | Positioning Resolution = 800 counts per revolution |
| | | **E** | Positioning Resolution = 6400 counts per revolution |
| 8 | **Shaft Diameter** | **L** | Standard (NEMA 34 = 1/2", NEMA 23 = 3/8") |
| | | **Q** | 1/4" shaft diameter *(available only on NEMA 23 models with body length 1 or 2)* |
| 9 | **Shaft Seal** | **N** | Standard dust sealing |
| | | **S** | Extra PTFE infused polyimide seal. ***Not available on 1/4" shaft models.*** |
| 10 | **Feature Set**<br>***SC Models Only*** | **B** | Basic features; see list below. |
| | | **A** | Advanced features; see list below. |

**Basic Features-SC models only**

Velocity moves
Global torque limit
HardStop foldback (homing)
Trapezoidal moves
Node stops / e-stops
Reading and modifying positions
RAS™ (jerk limiting)
Status register
Warning and alert system
Parameter memory
Safety shutdowns
Soft limits
User defined data
Automatic brake coil control
Group shutdowns

**Advanced Features-SC models only (Includes all Basic Features)**

RAS™ & g-Stop™ (jerk limiting & vibration suppression)
Positive and Negative torque limiting
Triggered moves (on input or command, including move groups)
Head-tail moves
Asymmetric moves
A-after-start event generation
B-before-end event generation
Conditional torque limiting
Attention generation
Position capture

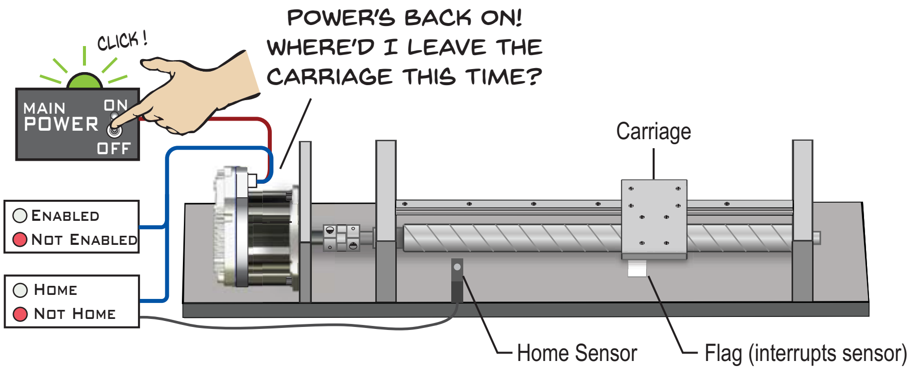
# APPENDIX G: MISCELLANEOUS TOPICS

## HOMING

### INTRODUCTION

**Why Home?** In many servo positioning applications, the moving element of the stage (i.e., the load) must be precisely positioned at a known location along the stroke of the axis before accurate positioning can begin. This is where homing comes in.

When a ClearPath motor is powered up the motor does not know exactly where its load is positioned along the stroke. Thus, if an application requires the load to be in a specific location before operations begin, the motor must be homed.



### HOMING (OVERVIEW)

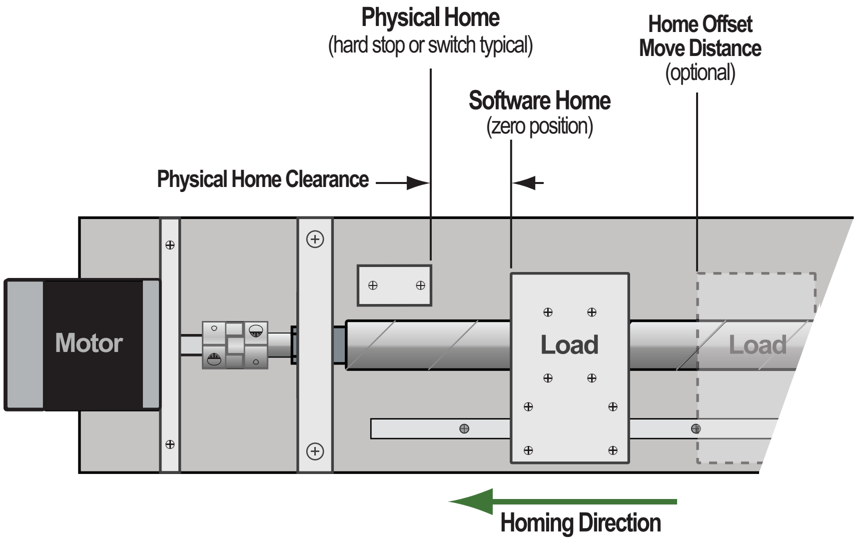
The homing process typically involves moving the motor in a predetermined direction towards a physical home location (typically a sensor or hardstop at the end of travel).

When the motor arrives at this location, the position is recorded, and the motor moves to a predefined offset location. Once at the offset position, the motor will begin to operate normally as defined by the currently selected operating mode.

This process ensures that an application will always begin in the same physical location regardless of the motor's position upon power-up.

## TERMS USED IN THIS SECTION

Please read the below definitions to familiarize yourself with a few frequently used ClearPath homing terms.



**Physical Home -** Physical Home is the position of a mechanical hardstop or home sensor. When the Physical Home is encountered, e.g. a homing switch is actuated, the position is recorded, and the ClearPath motor stops and moves away towards the final offset position.

**Software Home (zero position) -** During homing, once the Physical Home (sensor or hard stop) is detected, ClearPath's position counter is adjusted such that the Software Home (zero position) is a user defined distance from the Physical Home

**Physical Home Clearance (setting) -** This is the user-defined distance between Physical Home and Software Home (in encoder counts). Physical Home Clearance provides safety spacing between the load and Physical Home. The default setting is 1 motor revolution.

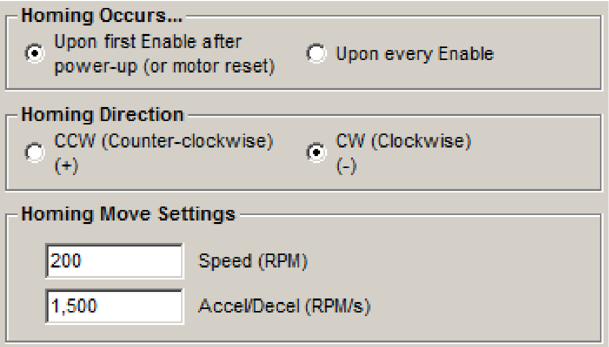
**Home Offset Move Distance (setting) -** This is an additional, user-defined parameter which determines the final offset location when homing is completed. At the end of homing the load will be the specified distance away from the Software Home.

## Homing Settings

Homing dialog settings are explained below.

### Homing Settings: Common to All Modes

These homing settings are common to all ClearPath Automatic Homing setups. They tell ClearPath the basics of when, where, and how to home.



Homing Occurs...

● Upon first Enable after power-up (or motor reset)
○ Upon every Enable

Homing Direction

○ CCW (Counter-clockwise) (+)
● CW (Clockwise) (-)

Homing Move Settings

200 Speed (RPM)
1,500 Accel/Decel (RPM/s)

#### Homing Occurs...

Lets you specify when to home your axis, either 1) the first time ClearPath is enabled after power up (typical), or 2) every time ClearPath is enabled.

**Application Note:** If your ClearPath has Logic Power Back-up, *and* you select "Homing Upon first Enable after power-up", you must cycle both power sources (main DC and Logic Power) before homing will be allowed.

#### Homing Direction

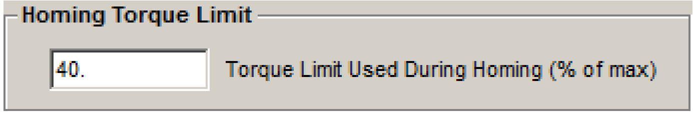
Lets you choose clockwise or counter-clockwise shaft rotation during homing. Select the direction of motor shaft rotation that will move the load toward the Physical Home (hard stop, switch, sensor).

#### Homing Move Settings

Lets you specify homing speed and acceleration. **Caution:** always test homing operation at low speed and acceleration.

## HOMING SETTINGS: OTHER

### Homing Torque Limit (Hard Stop Homing only)



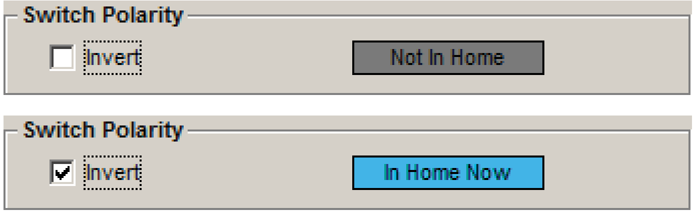
Homing Torque Limit

40. Torque Limit Used During Homing (% of max)

When homing is initiated, ClearPath lowers the torque limit to this value. The Main Torque Limit is automatically restored after homing is complete.

### Switch Polarity (Home To Switch only)

The Switch Polarity checkbox gives you the option of inverting how ClearPath interprets the home switch input state. This is helpful, for example, if you have a normally closed home switch and you really needed a normally open switch.



Switch Polarity

☐ Invert — Not In Home

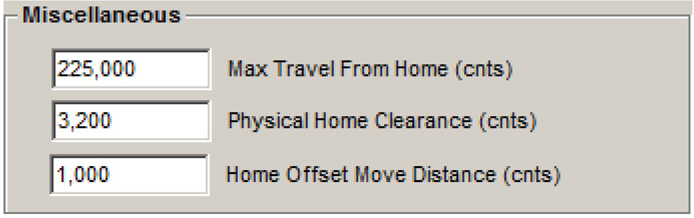
Switch Polarity

☑ Invert — In Home Now

### To test or change the Home Switch Polarity:

1. Actuate the home switch manually, i.e. close the switch or interrupt the sensor.
2. Read the status indicator from the homing dialog in MSP as shown above. If it reads "Not in Home" when the switch is actuated then click the Invert checkbox. "In Home Now" should display.
3. Release the home switch and verify that "Not in Home" is now displayed in the status indicator.

### "Miscellaneous" Settings



Miscellaneous

225,000 Max Travel From Home (cnts)

3,200 Physical Home Clearance (cnts)

1,000 Home Offset Move Distance (cnts)

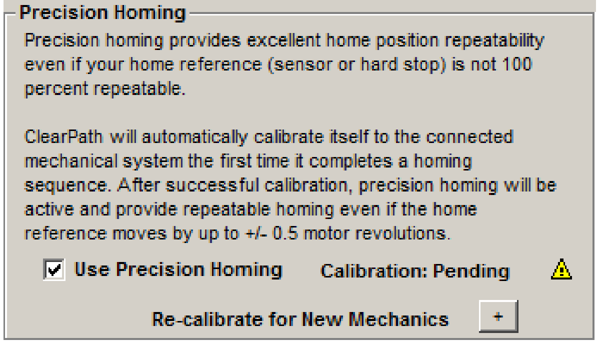
**Max Travel From Home (cnts)** - (Optional. Set to "0" to turn off.) This is a software enforced travel limit. It is the maximum distance that the motor is allowed to travel away from the Software Home position (i.e., the zero position). ClearPath will not execute any move that would violate this travel limit.

**Physical Home Clearance (cnts) -** This is the user-defined distance between Physical Home and Software Home (in encoder counts). It is intended to provide safety spacing between the load and Physical Home. Default setting is 1 motor revolution.

**Home Offset Move Distance (cnts) -** (Optional. Set to "0" to ignore.) This parameter determines the final position of the axis relative to the Software Home. If this parameter is set to zero, the motor will remain at the Software Home (zero) position when homing is complete.

### Precision Homing

The Precision Homing feature was created to help ensure that ClearPath always finds the exact same Software Home (zero) position, even in cases where the hard stop or home switch has slipped, bent, or otherwise drifted in position. See the "Precision Homing" section later in this document for more information.



**Precision Homing**

Precision homing provides excellent home position repeatability even if your home reference (sensor or hard stop) is not 100 percent repeatable.

ClearPath will automatically calibrate itself to the connected mechanical system the first time it completes a homing sequence. After successful calibration, precision homing will be active and provide repeatable homing even if the home reference moves by up to +/- 0.5 motor revolutions.

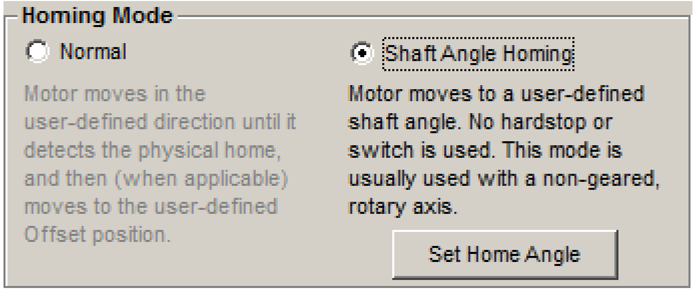
☑ Use Precision Homing

Calibration: Pending ⚠

*Precision Homing section of Homing Dialog*

### Shaft Angle Homing

This homing method was designed with a rotary axis in mind– a rotary tool changer for example. This method requires no additional sensor or end of travel hard stop to use.



**Homing Mode**

○ Normal

Motor moves in the user-defined direction until it detects the physical home, and then (when applicable) moves to the user-defined Offset position.

● Shaft Angle Homing

Motor moves to a user-defined shaft angle. No hardstop or switch is used. This mode is usually used with a non-geared, rotary axis.

### To use Shaft Angle Homing:

1. Select "Shaft Angle Homing" from the homing dialog (see image above).
2. Manually move the motor shaft to the desired position.
3. Click "Set Home Angle" button to store the shaft angle in the motor's memory. This setting will be retained in motor memory, even if main power to ClearPath is cycled.

**Note:** on first power-up, the motor may move more than 1 revolution before reaching the desired shaft angle.

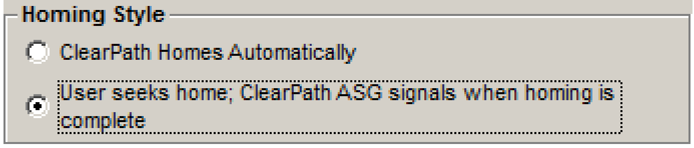
### Manual Homing aka "User Seeks Home"

*Manual Homing is available in Step & Direction and Pulse Burst Positioning modes only.*

When using Manual Homing, the user is responsible for sending homing moves to ClearPath via step and direction or pulse burst signals.

To use this feature, select the **"User Seeks Home"** setting in the homing dialog of Step and Direction or Pulse Burst Positioning mode.

See typical homing sequences section for more information on manual hard stop homing.

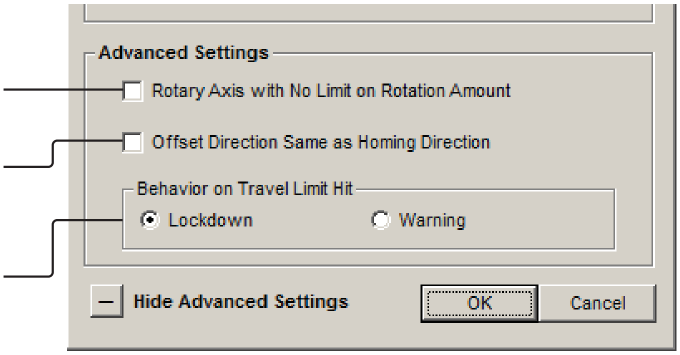


**Homing Style**

○ ClearPath Homes Automatically

● User seeks home; ClearPath ASG signals when homing is complete

### Advanced Settings



Check here if the axis can spin "forever" in both directions.

Check here if you need the Homing Offset to be in the same direction as the homing move (not typical).

Select whether ClearPath issues a Lockdown or a Warning when the "Max Travel From Home" value is exceeded.

Advanced Settings

☐ Rotary Axis with No Limit on Rotation Amount

☐ Offset Direction Same as Homing Direction

Behavior on Travel Limit Hit

● Lockdown ○ Warning

*Homing: Advanced Settings*

#### Rotary Axis 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 *(not commonly used)*

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 until you toggle Enable to clear it. 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 condition that caused it is no longer present. The indicator LED on ClearPath flashes a green 2-blink code when a Warning occurs.

## TYPICAL HOMING SEQUENCES

This section enumerates the main steps involved in the most common ClearPath homing scenarios.

For the sake of discussion, we will assume that the ClearPath motor described in this section is set to **home every time it is enabled** (as opposed to homing only the first time it is enabled after power up).

### AUTOMATIC SWITCH HOMING SEQUENCE

1. The user Enables ClearPath. (Enabling energizes the motor coils and puts ClearPath in Automatic Homing mode.)
2. ClearPath automatically moves the load toward Physical Home (a sensor) at the user-specified acceleration, speed, and direction.
3. The sensor is actuated. The point of actuation is defined as Physical Home. The Software Home (zero position) is defined to be the Physical Home Clearance away from the Physical Home.
4. The motor begins to decelerate.
5. The motor stops at some point past the sensor location (determine by homing velocity and deceleration).
6. ClearPath moves towards the offset location as defined by the [Home Offset Move Distance] parameter. If this value is zero, ClearPath moves to the Software Home (zero position).
7. Homing is complete. ClearPath can now act on motion commands.

### AUTOMATIC HARD STOP HOMING SEQUENCE

1. The user Enables ClearPath. (Enabling energizes the motor coils and puts ClearPath in Automatic Homing mode.)
2. ClearPath automatically moves the load toward Physical Home (a hard stop in this case) at the user-specified acceleration, speed, and direction.
3. The load hits the hard stop, triggering the Hard Stop Detection algorithm. Holding torque against the hard stop is automatically rolled back.
4. Physical Home is established. This then defines the Software Home(zero position) to be the Physical Home Clearance away from the Physical Home.
5. ClearPath moves away from the Physical Home to the offset location specified in the [Home Offset Move Distance] parameter. If this value is zero, ClearPath moves to the Software Home(zero position).
6. Homing is complete. ClearPath can now act on motion commands.

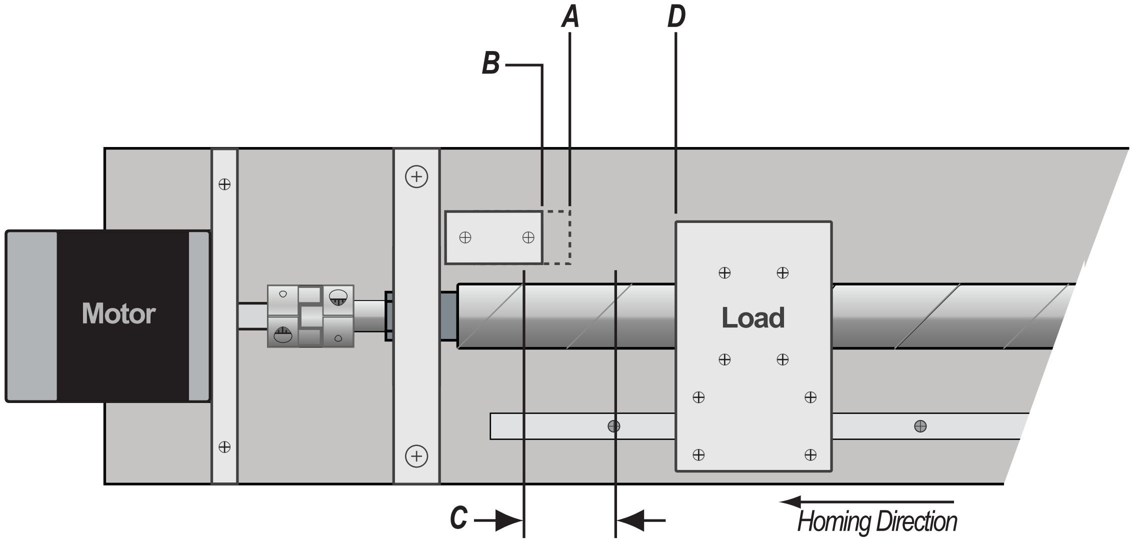
### MANUAL HARD STOP HOMING SEQUENCE

1. The user Enables ClearPath. (Enabling energizes the motor coils and puts ClearPath in Manual Homing mode.)
2. The motor remains stationary until the user's control system issues a move toward the Physical Home (hard stop) using Step & Direction or Pulse Burst signals. *Note: This initial move must be long enough to guarantee the load will hit the hard stop from the farthest point away from the stop.*
3. The load hits the hard stop, triggering the Hard Stop Detection algorithm. Holding torque against the hard stop is automatically rolled back.
4. If the motor's HLFB output is set to "ASG", the output asserts.
5. ClearPath waits for the user's controller to send pulses to command motion *away* from the hard stop. Any further commands into the hardstop are disregarded while the motor is folding back torque.
6. Upon seeing the first step or pulse away from the hard stop ClearPath's position counter is automatically zeroed. ClearPath exits homing mode and is ready for further move commands.

## PRECISION HOMING

Precision Homing helps assure home position repeatability *even if the Physical Home (sensor or hard stop) is not perfect, such as when a hard stop wears out, shifts position, or becomes deformed.*

When set up for Precision Homing, ClearPath automatically calibrates itself to the connected mechanical system *only the very first time* it completes a homing operation. After successful calibration, Precision Homing remains active, ensuring highly repeatable homing *even if the physical home moves by up to ± 1/2 of a motor revolution.*



***Precision Homing Nomenclature***

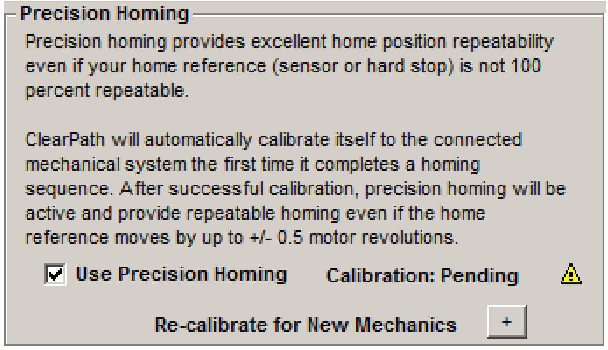
(a) **Original Physical Home -** This is the Physical Home reference *point found during the initial homing/calibration* operation. Note: This reference position is stored in the motor's NV memory. It is not reset if power is cycled.

(b) **Current Physical Home -** This is the most recent Physical Home found. This position will only be different from Original Physical Home if the associated sensor or hard stop has moved or drifted.

(c) **Max. Error Between Original (Calibrated) Physical Home and Current Physical Home.** Precision Homing will successfully complete as long as the Current Physical Home position does not exceed +/- 1/2 rev from Original Physical Home.

(d) **Final Position** after homing is complete (defined by the Physical Home Clearance, and Offset Move Distance parameters).

### PRECISION HOMING SETUP



Precision Homing

Precision homing provides excellent home position repeatability even if your home reference (sensor or hard stop) is not 100 percent repeatable.

ClearPath will automatically calibrate itself to the connected mechanical system the first time it completes a homing sequence. After successful calibration, precision homing will be active and provide repeatable homing even if the home reference moves by up to +/- 0.5 motor revolutions.

☑ Use Precision Homing Calibration: Pending ⚠

*Precision Homing dialog in Homing Setup window*

**To calibrate ClearPath to your mechanics**, you only need to complete one initial homing operation. Whenever you need to clear and reset calibration, click the (+) button as shown in the above screenshot and follow the prompts to clear the calibration.

**Important:** Any time a motor is connected to new or different mechanics, or is disassembled from its associated mechanics and reassembled, **you must clear the Precision Homing calibration data** to allow a new calibration to occur.

**Manually clear the Precision Homing calibration data** by doing one of the following:

- Press the “Clear Calibration…” button.
- Load a motor configuration file.
- Run Auto-tune.
- Reset the configuration to factory default settings. Once cleared, re-calibration will occur on the very next homing operation.

## HOMING METHODS LISTED BY OPERATIONAL MODE

**Sensor Homing is available in the following modes:**

- Move to Absolute Position: 2 Positions (Home to Switch)
- Move Incremental Distance: 2 Increments (Home to Switch)
- Move Incremental Distance: 1 Increments (Home to Switch)
- Multiple Sensor Positioning: Rotary with Sensor Homing
- Follow Digital Position Command: Unipolar PWM Command
- Follow Digital Position Command: Frequency Command

**Automatic Hard Stop Homing is available in the following modes:**

- Move to Absolute Position: 4 Positions (Home to Hard Stop)
- Move to Absolute Position: 16 Positions (Home to Hard Stop)
- Move Incremental Distance: 4 Increments (Home to Hard Stop)
- Move Incremental Distance: 2 Increments (Home to Hard Stop)
- Pulse Burst Positioning
- Multiple Sensor Positioning: Linear
- Follow Digital Position Command: Unipolar PWM Command
- Follow Digital Position Command: Frequency Command
- Step and Direction

**Manual Hard Stop Homing aka "User Seeks Home" is available in these modes:**

- Pulse Burst Positioning
- Step and Direction

**Shaft Angle Homing is available in the following modes:**

- Move to Absolute Position: 4 Positions (Home to Hard Stop)
- Move to Absolute Position: 16 Positions (Home to Hard Stop)
- Move Incremental Distance: 4 Increments (Home to Hard Stop)
- Move Incremental Distance: 2 Increments (Home to Hard Stop)
- Pulse Burst Positioning
- Multiple Sensor Positioning: Linear
- Multiple Sensor Positioning: Rotary with Sensorless Homing
- Follow Digital Position Command: Unipolar PWM Command
- Follow Digital Position Command: Frequency Command
- Step and Direction

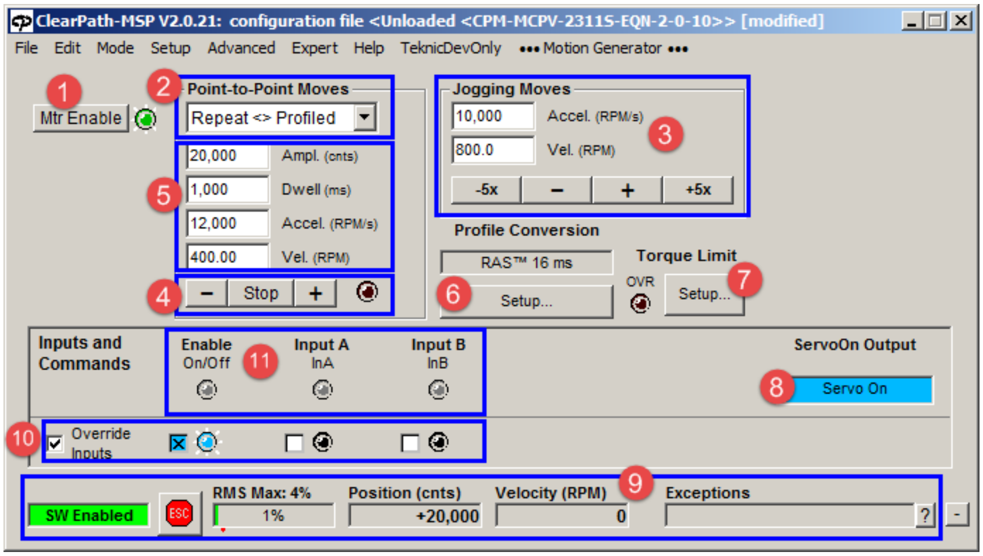
# MOTION GENERATOR

The Motion Generator allows you to quickly and easily jog and test your ClearPath motors (and any connected mechanics) with **no external switches or sensors required.**

**With the Motion Generator you can:**

- Manually enable your ClearPath motor
- Run point-to-point profiled moves at the velocity, acceleration, and distance of your choosing
- Jog your motor at different velocities and accelerations
- Manually toggle all of your motor's digital inputs
- Visually monitor the status of the motor inputs and HLFB output

**To open the Motion Generator mode** from the MSP main menu, select *Mode>Motion Generator*.


ClearPath-MSP V2.0.21: configuration file <Unloaded <CPM-MCPV-2311S-EQN-2-0-10>> [modified]

Point-to-Point Moves: Repeat <> Profiled

20,000 Ampl. (cnts)

1,000 Dwell (ms)

12,000 Accel. (RPM/s)

400.00 Vel. (RPM)

Jogging Moves

10,000 Accel. (RPM/s)

800.0 Vel. (RPM)

Profile Conversion: RAS™ 16 ms

RMS Max: 4% 1%

Position (cnts) +20,000

Velocity (RPM) 0

*Motion Generator window*

## MOTION GENERATOR CONTROLS

### 1. Mtr Enable (Enable/Disable Button)

Use this button to enable and disable the motor. When ClearPath is enabled, the motor windings are energized and the motor is capable of responding to move commands.

### 2. Point-to-Point Move Type *(drop down menu)*

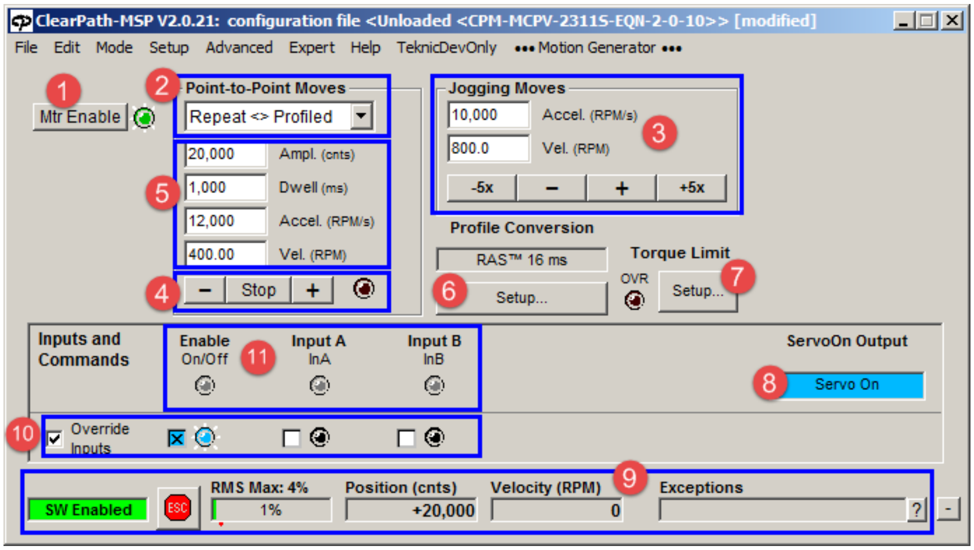
- **Single Profiled** - Move once and stop. Click + or - button to launch a single move in the specified direction.
- **Repeat <> Profiled** - Move back and forth repeatedly. Click + or - button to launch reciprocating (back and forth) moves. Moves will repeat indefinitely until the Stop button is clicked or an exception occurs.

- **Repeat >> Profiled** - Move repeatedly in the same direction. Click + or - button to launch repeating moves in the same direction. Moves will repeat indefinitely until the Stop button is clicked or an exception occurs.

**3. Jog Controls -** Jog your motor with a single click. Set acceleration and velocity as desired. Then, hold down (+) or (-) button to jog ClearPath; release to stop motion. Hold down the (+5x) or (-5x) button to jog ClearPath at 5 times the speed setting.

**4. Move Start and Stop:** Use these controls to start and stop a point-to-point move. The (+) button commands a move in the counterclockwise direction; the (-) button commands a move in the clockwise direction. Click the Stop button to end a move cycle. ***Double-click the Stop button to stop motion immediately.***

**5. Move Parameters:** Define move parameters for Point-to-Point Moves here. These include move distance (Ampl.), Velocity (Vel.) Acceleration (Accel.), and pause time between repeating moves in milliseconds (Dwell).



ClearPath-MSP V2.0.21: configuration file <Unloaded <CPM-MCPV-2311S-EQN-2-0-10>> [modified]

Point-to-Point Moves: Repeat <> Profiled

20,000 Ampl. (cnts)

1,000 Dwell (ms)

12,000 Accel. (RPM/s)

400.00 Vel. (RPM)

Jogging Moves

10,000 Accel. (RPM/s)

800.0 Vel. (RPM)

Profile Conversion: RAS™ 16 ms

RMS Max: 4% 1%

Position (cnts) +20,000

Velocity (RPM) 0

*Motion Generator window (duplicate figure for reference)*

**6. g-Stop and RAS Setup:** Opens the Profile Conversion dialog. Use this to set and test the effect of different g-Stop and RAS settings on your Motion Generator moves. Not all op modes support all RAS and g-Stop options.

**7. Torque Limit Setup:** Opens Torque Limit dialog.

**8. High Level Feedback Readout:** Displays status of ClearPath's digital output, HLFB (High Level Feedback).

**9. Dashboard:** Displays real-time motor information including enable state, RMS torque level, motor position, motor velocity, and exception information.

**10. Software Control Override:** Check the "Override Inputs" button to activate Soft Controls. Manually toggle the motor's inputs without an external hardware controller.

**11. Input Status:** Software LEDs that visually indicate the logic states of the Enable Input, Input A, and Input B.

# ENCODER AND INPUT RESOLUTION

## INTRODUCTION

This section includes a discussion of 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 Positioning* 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** for motor part numbers ending in **-Rxx.**
- **6400 counts per revolution** for motor part numbers ending with **-Exx**.

## INPUT RESOLUTION SETTING IN MSP

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

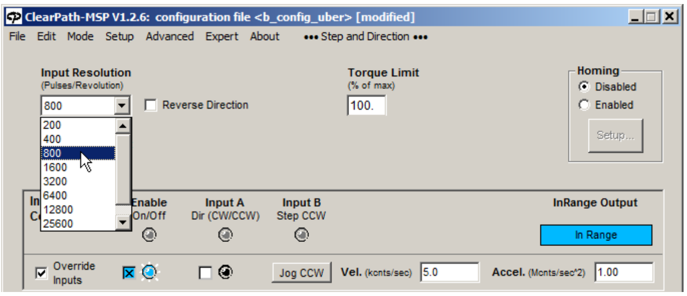
The **Input Resolution** setting lets you vary the ratio of step pulses received by the motor to encoder counts moved. It is set via a drop down menu in the mode settings of *Pulse Burst Positioning* and *Step and Direction* modes.

**Feature Note:** Enhanced ClearPath motors (part# ends in -Exx) allow the user to set the Input Resolution (steps per revolution) to **any whole number value greater than or equal to 200**.

### 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.



ClearPath-MSP V1.2.6: configuration file <b_config_uber> [modified]

Input Resolution (Pulses/Revolution): 800

☐ Reverse Direction

Torque Limit (% of max): 100.

Homing: ● Disabled ○ Enabled

☑ Override Inputs

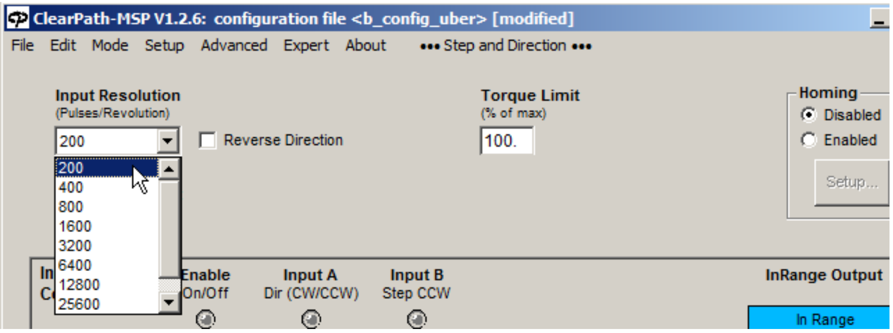
Vel. (kcnts/sec): 5.0

Accel. (Mcnts/sec^2): 1.00

***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.



Input Resolution (Pulses/Revolution): 200

☐ Reverse Direction

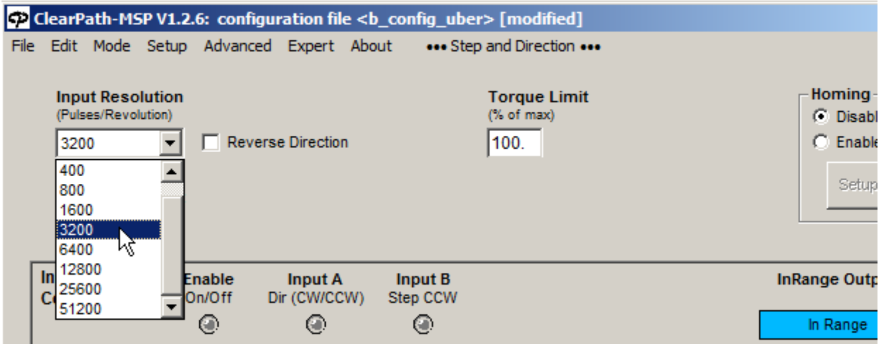
Torque Limit (% of max): 100.

Homing: ● Disabled ○ Enabled

*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.



Input Resolution (Pulses/Revolution): 3200

☐ Reverse Direction

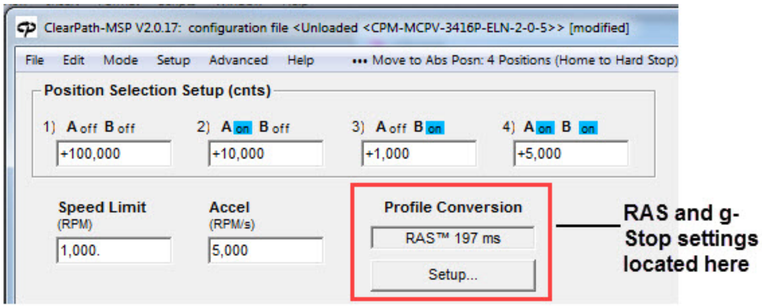
Torque Limit (% of max): 100.

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

# RAS AND G-STOP (VIBRATION AND RESONANCE SUPPRESSION)

RAS (**R**egressive **A**uto-**S**pline) and g-Stop are Teknic's proprietary, vibration and resonance suppression features. Although these features work somewhat differently, both were designed to help produce smooth motion, reduce machine vibration, improve settling time, and decrease audible noise.

*Note: RAS and g-Stop cannot be used simultaneously.*



Position Selection Setup (cnts)

1) A off B off: +100,000
2) A on B off: +10,000
3) A off B on: +1,000
4) A on B on: +5,000

Speed Limit (RPM): 1,000.
Accel (RPM/s): 5,000
Profile Conversion: RAS™ 197 ms

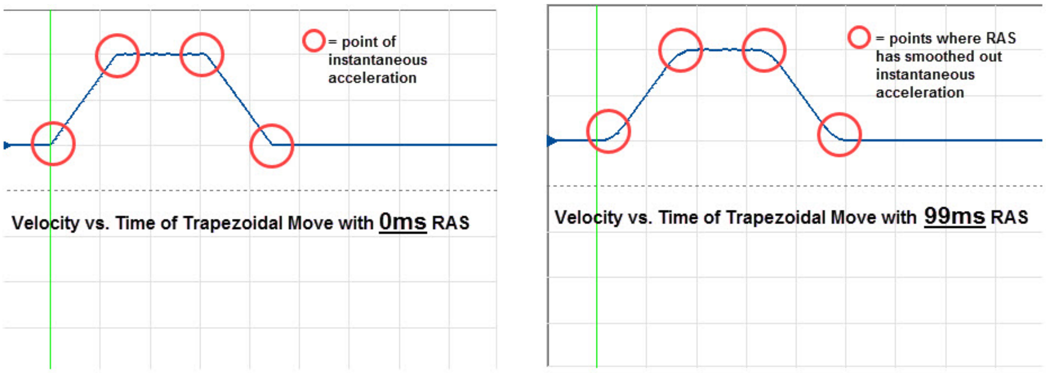
***Location of RAS and g-Stop settings***

## RAS (REGRESSIVE AUTO-SPLINE)

RAS is a jerk limiting, and jerk-derivative limiting feature based on proprietary technology developed by Teknic.

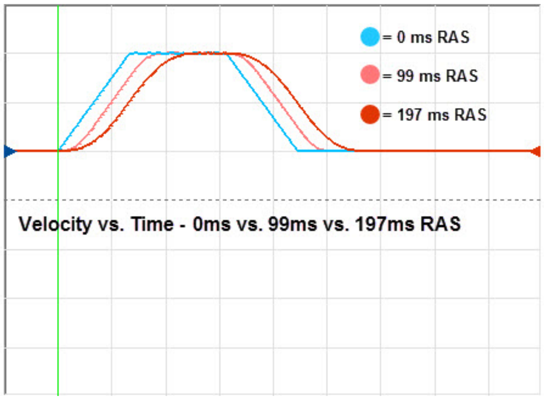
The RAS software uses advanced algorithms to analyze each commanded move and rapidly calculate and "fit" a forth-order polynomial spline to it. This converts the sharp transitions between constant velocity and acceleration with more gradual, rounded corners.

Controlling the rate of change of acceleration in this manner results in moves that are lower in vibration, quieter, and easier on the machine's mechanical parts.



***RAS Settings Comparison***

Although RAS adds some time to the move (in the millisecond range), it can actually reduce overall move time by reducing settling time and/or allowing for the use of higher acceleration limits.

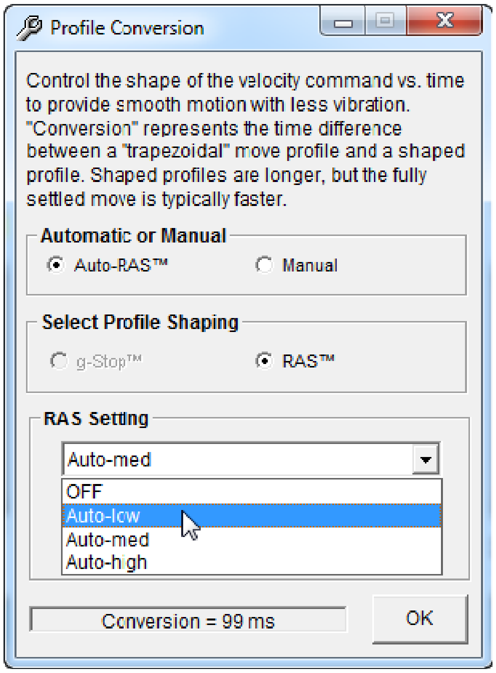


*RAS Motion Profile Comparisons*

### AUTO-RAS (MC SERIES MOTORS)

Auto-RAS simplifies RAS selection by offering three settings, "Auto-High", "Auto-Med", or "Auto-Low". "Auto-High" applies the most jerk/jerk-derivative limiting, but also adds the most conversion time.

Each Auto-RAS setting you choose, automatically adjusts to the motor's velocity and acceleration settings.



Control the shape of the velocity command vs. time to provide smooth motion with less vibration. "Conversion" represents the time difference between a "trapezoidal" move profile and a shaped profile. Shaped profiles are longer, but the fully settled move is typically faster.

Automatic or Manual: ● Auto-RAS™ ○ Manual

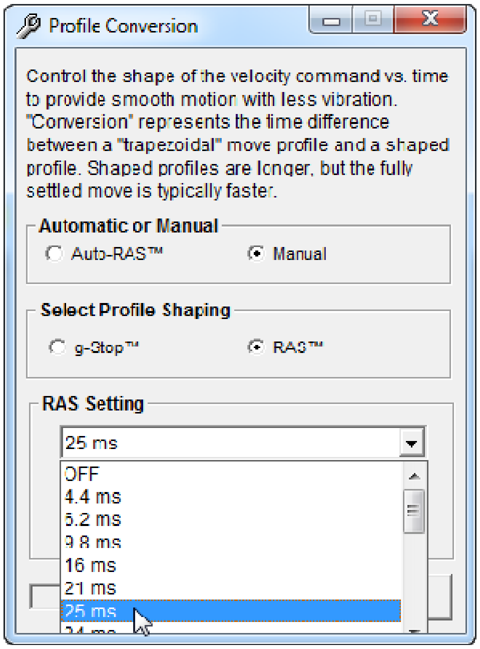
Select Profile Shaping: ○ g-Stop™ ● RAS™

RAS Setting: Auto-med

Conversion = 99 ms

### MANUAL RAS SETTINGS (MC AND SD MOTORS)

In MC and SD ClearPath op modes, you can manually select a single numerical RAS setting from the drop down list as shown below.



Control the shape of the velocity command vs. time to provide smooth motion with less vibration. "Conversion" represents the time difference between a "trapezoidal" move profile and a shaped profile. Shaped profiles are longer, but the fully settled move is typically faster.

**Automatic or Manual**
○ Auto-RAS™ ● Manual

**Select Profile Shaping**
○ g-Stop™ ● RAS™

**RAS Setting**
25 ms

### Additional Notes

- Manual RAS settings add a fixed conversion time to all moves. For example, a RAS setting of 25ms will add 25ms of conversion time to all moves issued while Manual RAS is in effect.
- ClearPath SD motors with part numbers ending in -Rxx have limited Manual RAS selections.
- ClearPath MC motors offer Manual RAS settings in increments from 0-779ms.
- Auto-RAS is only available for ClearPath MC series motors.

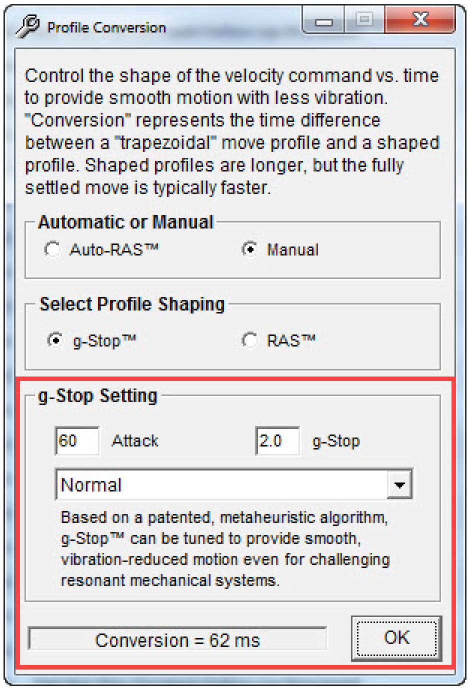
## G-Stop Tuning

g-Stop was designed to help address machine resonances, reduce machine shake and vibration, allow for the use of higher acceleration limits, and reduce audible noise. This feature builds on patented technology developed by Teknic.

**Teknic Video: g-Stop**

To understand how g-Stop works, watch the Teknic video on this topic here. Note: This video was created for the *ClearPath-SC* family of motors, so the UI shown in the video is slightly different from that of MSP.

g-Stop works by analyzing and identifying problematic machine resonances, and then converting the commanded move profile such that energy is intelligently added or removed from the system to cancel the vibrations.



Profile Conversion

Control the shape of the velocity command vs. time to provide smooth motion with less vibration. "Conversion" represents the time difference between a "trapezoidal" move profile and a shaped profile. Shaped profiles are longer, but the fully settled move is typically faster.

Automatic or Manual

○ Auto-RAS™ ● Manual

Select Profile Shaping

● g-Stop™ ○ RAS™

g-Stop Setting

60 Attack 2.0 g-Stop

Normal

Based on a patented, metaheuristic algorithm, g-Stop™ can be tuned to provide smooth, vibration-reduced motion even for challenging resonant mechanical systems.

Conversion = 62 ms

***g-Stop Settings***

To implement g-Stop, start with a tuned motor that is attached to the mechanical system on which it will be running. Create a test move that is aggressive but realistic. Use the highest acceleration and velocity that the axis or machine is expected to run at. The load must be moving back and forth during the g-Stop tuning process, so always use a repeating (back and forth) type move. MSP's Move Generator can do this type of move.

With the repeating test move running, slowly increase the Attack setting–one increment at a time–while observing axis performance, preferably on an accelerometer, but by observation if necessary. *Tip: Use your keyboard's Page Up and Page Down keys to increment and decrement Attack and g-Stop settings.)*

Increase Attack until the machine vibration has improved to the desired level of performance. Then, slowly increment the g-Stop value to fine tune performance. The objective is to find a solution that results in minimal machine shake and vibration and optimal move and settle time.

**Notes:**

- ClearPath-SD motors do not have g-Stop.

# APPENDIX H: LOGIC POWER SUPPLY SIZING

This section was designed to help users estimate how much power (wattage) to specify when selecting a logic power supply for a ClearPath system. The logic supply is typically 24VDC (nominal).

The worksheet below lists the power rating of ClearPath "logic power" system components. Space is provided for calculation of total estimated power usage for any combination of these components.

**Additional Notes**

- Your ClearPath system may not include all of the components listed below.
- The topic of main DC bus power is not discussed in this section.

| **Part** | **Power Req'd (ea)** | x | **Qty** | = | **Line Total (Watts)** |
|---|---|---|---|---|---|
| Logic power backup: *integral* hp ClearPath motors (optional) | 5W | x | | = | |
| Logic power backup: *fractional* hp ClearPath motors (optional, and requires POWER4-HUB accessory) | 3W | x | | = | |
| POWER4-HUB (for fractional hp motors only, optional) | 2W | x | | = | |
| Brake/GPO (optional) | ____W | x | | = | |
| Input Sensors (optional) | ____W | x | | = | |
| Other | ____W | x | | = | |
| | | | | **Grand Total (W)** | |

# INDEX

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