# CLEARPATH MOTORS

# AC INPUT, INTEGRAL HORSEPOWER

MODELS MCVC, MCPV, SDSK, SDHP

NEMA 56, 143/145, AND IEC D100 FRAME SIZES

VERSION 3.26 / DECEMBER 9, 2025

TEKNIC, INC

PHONE (585) 784-7454

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# Top Tips For ClearPath MC/SD Users

The tips below apply to the integral horsepower ClearPath-MC and ClearPath-SD motors covered in this document.

TOP TIPS

- ✓ **Noise at Power Up?** The brief buzzing sound you hear from the motor upon first power up is the motor initializing itself. This is normal (and necessary).
- ✓ **Protect Your ClearPath I/O.** Brakes, solenoids, contactors (any coil-actuated device) that are wired in parallel with your ClearPath inputs can destroy them via inductive kickback. Diodes save motor lives. More…
- ✓ **USB Cables Matter.** Use only Hi-Speed USB data cables to communicate with your ClearPath motor.
- ✓ **Prevent USB Connector Damage.** Avoid yanking, twisting, or tripping on a USB cable that is connected to a ClearPath USB port. This can break the physical connector (and your ability to communicate with the motor).
- ✓ **Yellow Blink Code?** This indicates a shutdown of some type has occurred. 1) Look up motor blink codes in the user manual (see Appendix A). 2) Connect to your motor's USB port to view shutdown messages using the MSP software.
- ✓ **Auto-Tune *Fully Loaded*.** Auto-Tune with your motor connected to the mechanics exactly as it will run during normal operation. Note: The default motor tuning file that comes with your motor is designed for no-load operation.
- ✓ **Keep it Covered.** Install the motor's watertight junction box cover to prevent liquids and debris from falling into the motor's electronics compartment.
- ✓ **Step Timing Shutdowns?** (Applies to SD motors and MC motors in Pulse Burst mode.) Install resistors on the step and direction outputs of controllers with transistor outputs. More…

# 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 connect your ClearPath to a PC and establish communication
- How to spin your unloaded[1] ClearPath motor under MSP software control

## IMPORTANT SAFETY WARNING

Always use caution and common sense when handling motion control equipment. Even the smallest ClearPath motor is powerful enough to damage fingers, turn a tie into a noose, or tear out a patch of hair and/or scalp in just a few milliseconds.

**These devices are very powerful and can be extremely dangerous if used carelessly. Misuse can lead to severe injury or death.** We want all ClearPath users to be safe and *fully intact* at the end of the day, so please read and understand all safety warnings in the ClearPath User Manual before operating a ClearPath motor.

## 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

[1] Unloaded just 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

- AC ClearPath motor
- AC power cable and plug (not included with motor)
- Windows PC running Win 7, 8.1, 10
- USB cable (USB type-A to type-B)
- Clamps or a large vise

## WIRE AC POWER TO YOUR CLEARPATH MOTOR

Your ClearPath motor must be wired to an appropriate AC source. Please refer to the section ***Wiring AC Mains Power to ClearPath*** for instructions.

ClearPath supports the following AC line configurations:

- Single phase and 3 Phase, 100-240 VAC (common in North America)
- 5-wire (3 Phase with neutral and ground) 300-415 VAC (common in Europe)

Note: ClearPath **does not support** 3 Phase 277/480VAC mains power.

## 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.

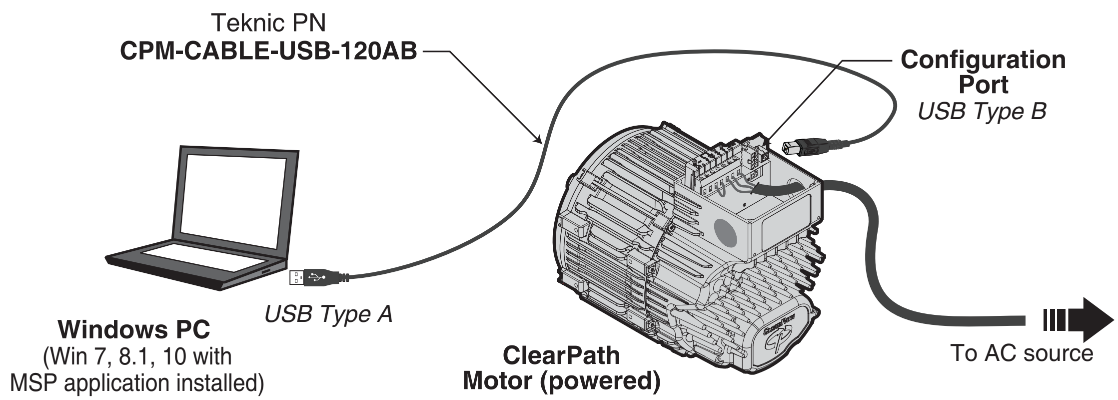
**Note:** MSP is free to download and can be installed on multiple computers with no serial number or activation codes.

## SECURE YOUR MOTOR TO A SOLID WORK SURFACE

**Before operating your ClearPath motor,** secure it to a stable, flat, level work surface using clamps, a vise, or similar. An unrestrained motor will buck and jump during operation.

## CONNECT CLEARPATH MOTOR TO YOUR PC

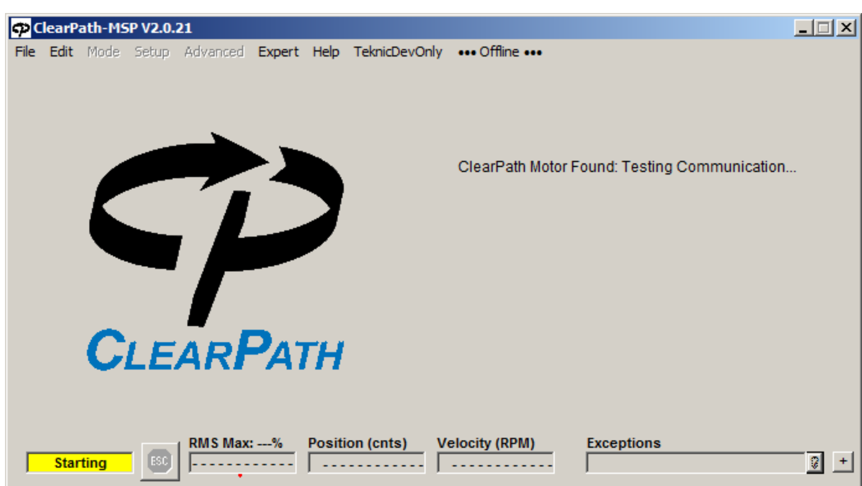
With your motor securely clamped down and powered up, connect the motor's USB configuration port to a USB port on your PC with a high quality USB type-A to B cable (Teknic PN: **CPM-CABLE-USB-120AB**). If this is a first-time connection, wait for ClearPath to automatically install its driver software before proceeding. This should take less than a minute.




***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 shown below.




***Open MSP (Motor Setup Program)***

# SPIN YOUR MOTOR UNDER MSP SOFTWARE CONTROL

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

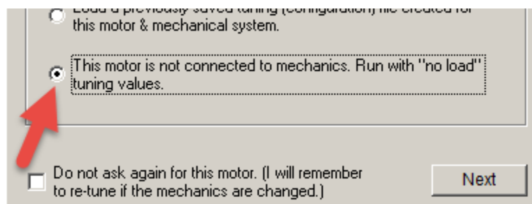
**Note:** ClearPath Soft Controls are great for test, development and training, but are not meant to be used as the control system for your machine.

## SPINNING A MODEL MCPV OR MCVC

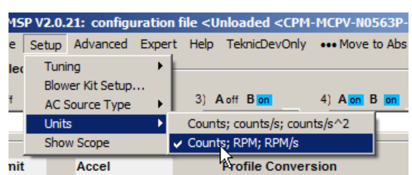
***Note:*** *Spinning models SDSK and SDHP is covered in the next section.*

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

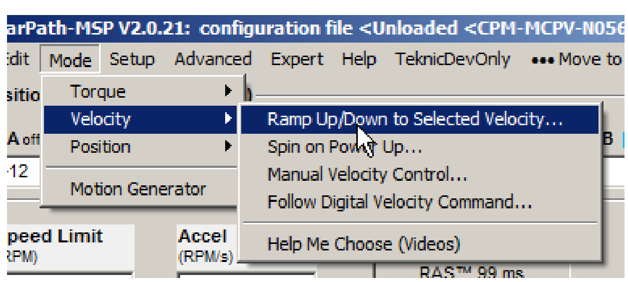
1. Open MSP software.
2. Select the bottom option to run with no load.



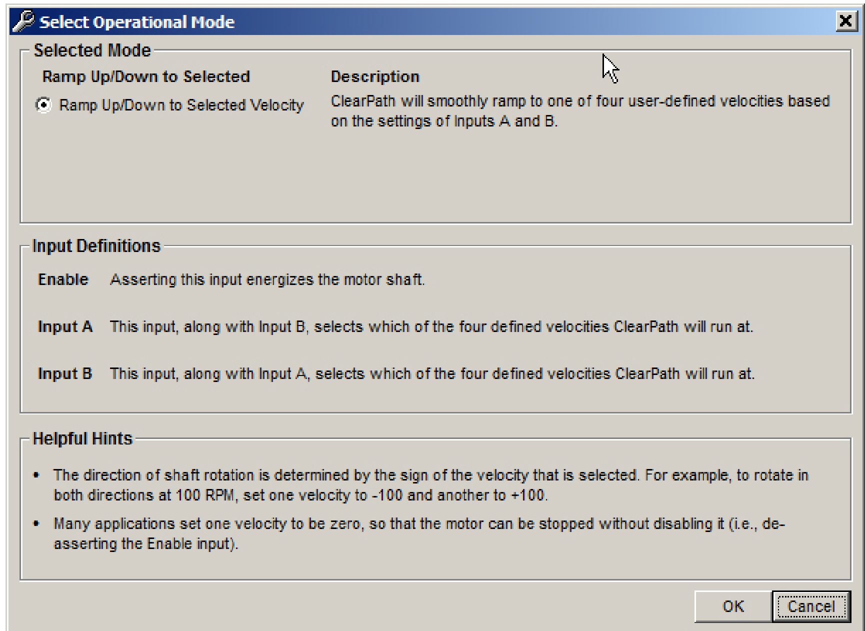

3. From the MSP menu, select Setup>Units>Counts; RPM; RPM/s. This just tells MSP how to display distance, velocity, and acceleration.




4. Select Mode>Velocity>Ramp Up/Down to Selected Velocity.

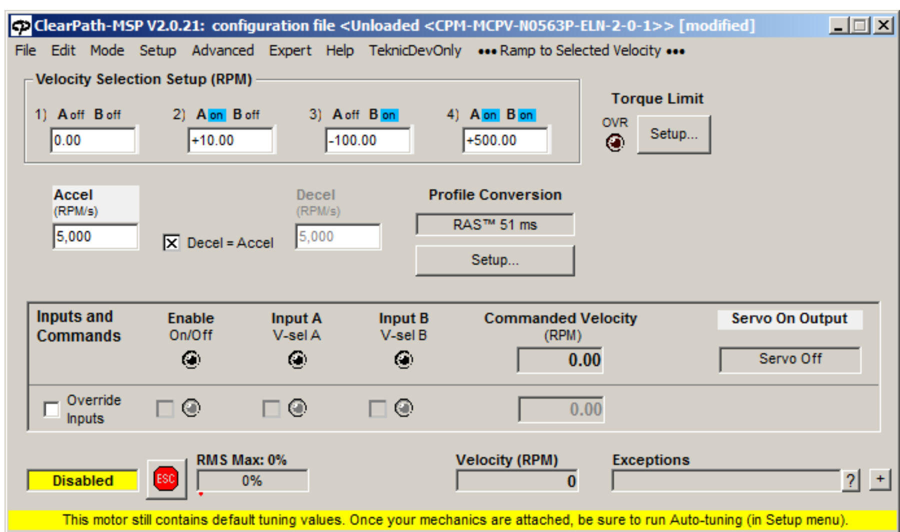


5. A dialog window will open (see below). Read all of the text presented, especially if you're unfamiliar with how the mode works. Click OK to proceed.



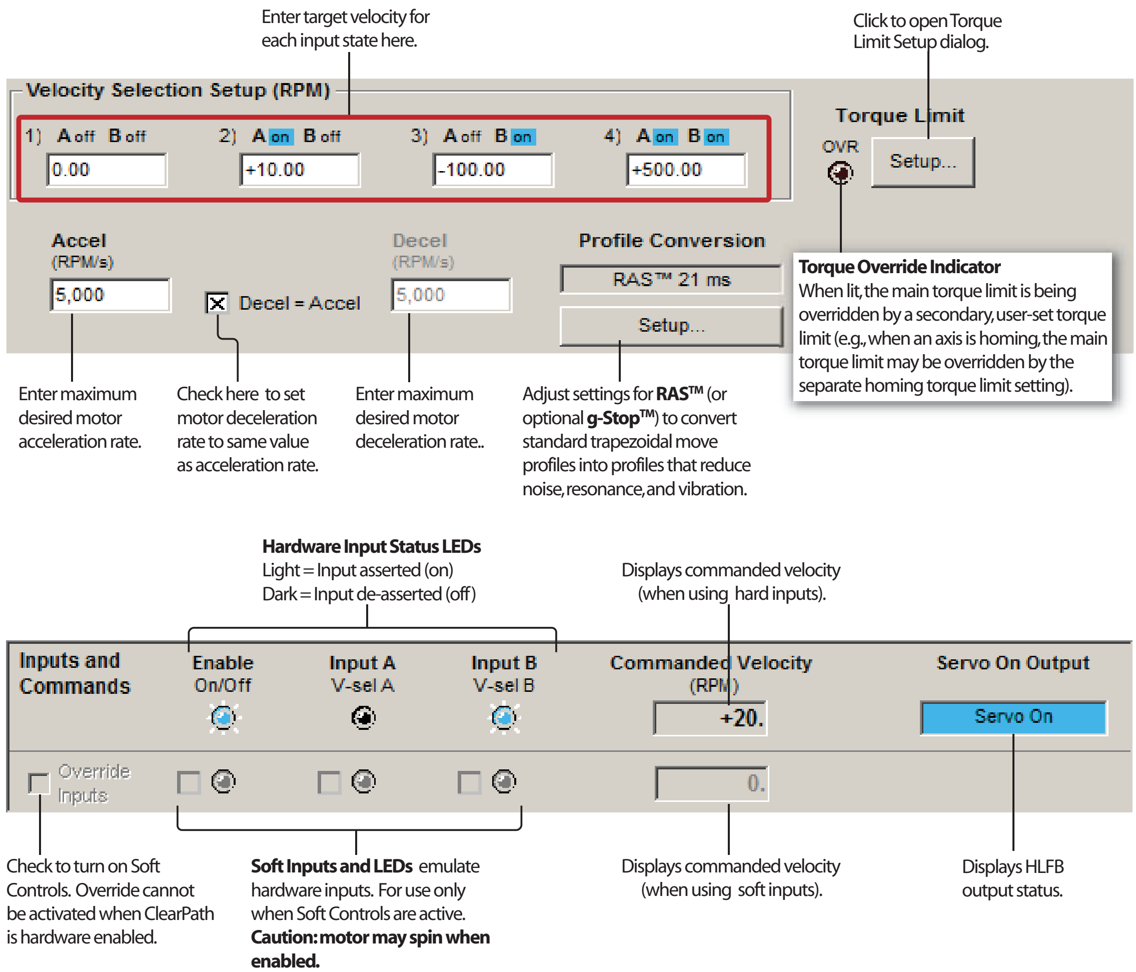

***Select a mode of operation***

6. The MSP UI should look similar to this.



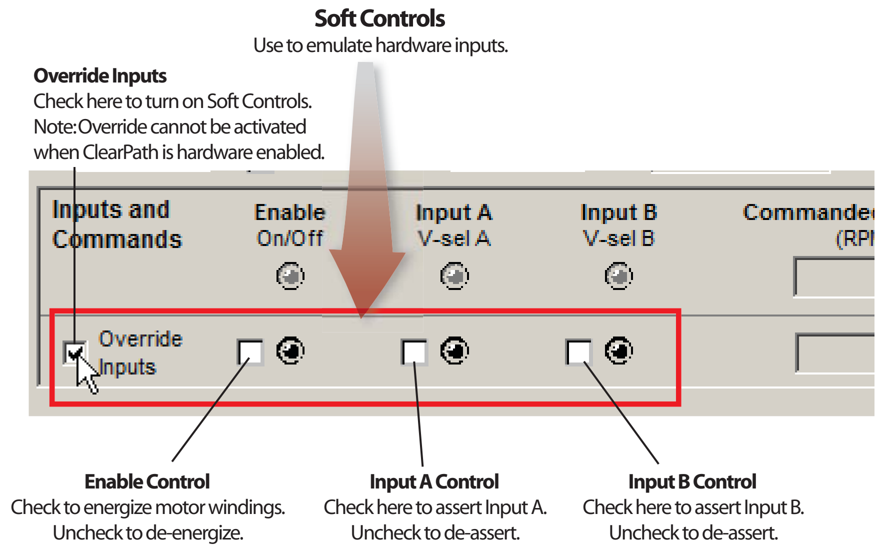

***MSP UI in "Ramp Up/Down to Selected Velocity" mode***

7. The mode controls are explained below. To follow along, enter the settings as they appear below.



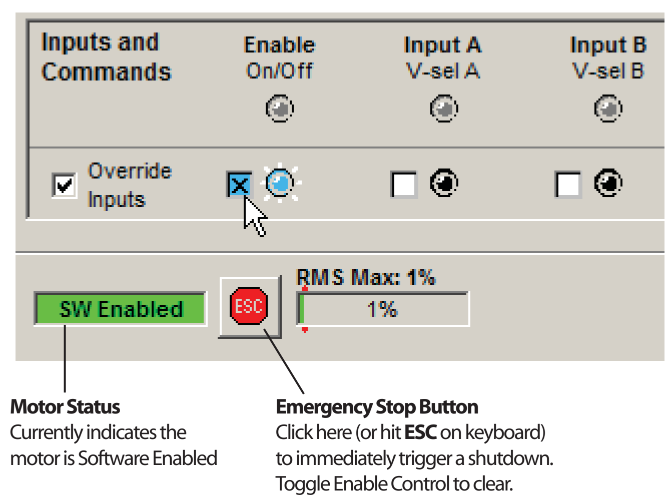

***Mode Controls for "Ramp Up/Down to Selected Velocity" mode***

8. Click the Override Inputs checkbox (lower left of figure below). This turns on the software controls. You may notice that the other Soft Controls are no longer grayed out.



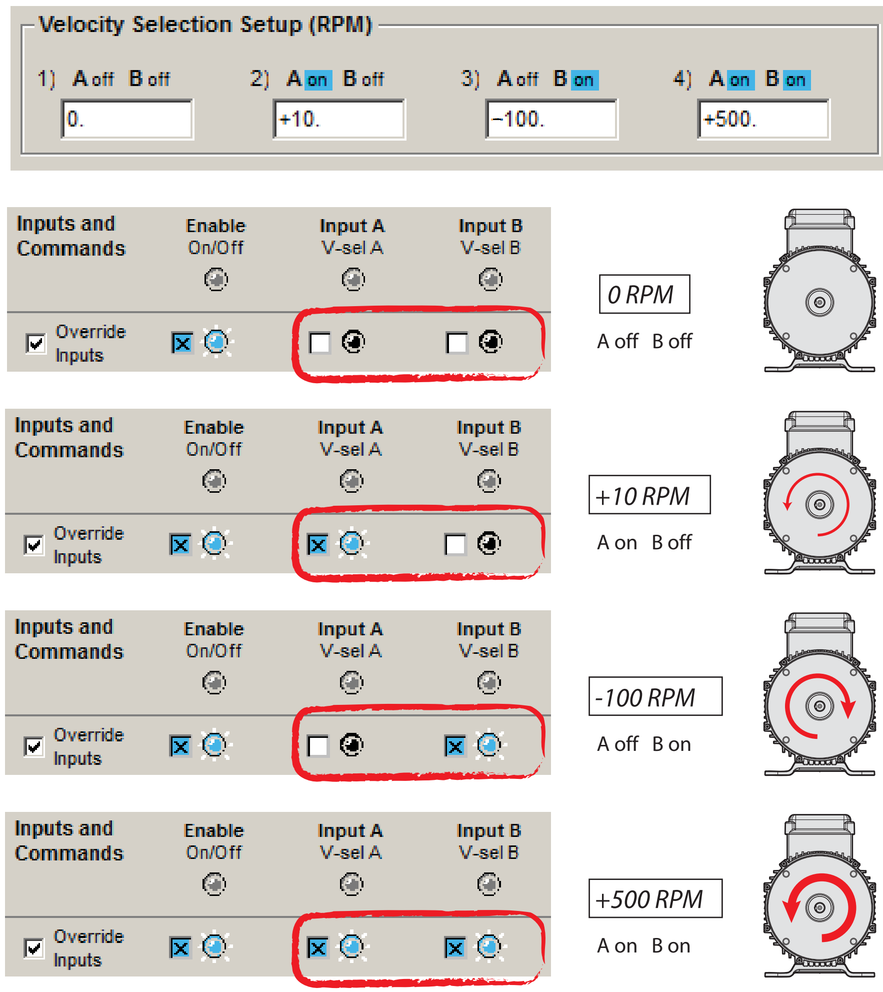

***Check "Override Inputs" box to turn on Soft Controls***

9. **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.
10. Click the Enable Control. **Caution: the motor is now energized and capable of motion.**




***Enable ClearPath using Soft Controls***

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




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

## Additional Notes

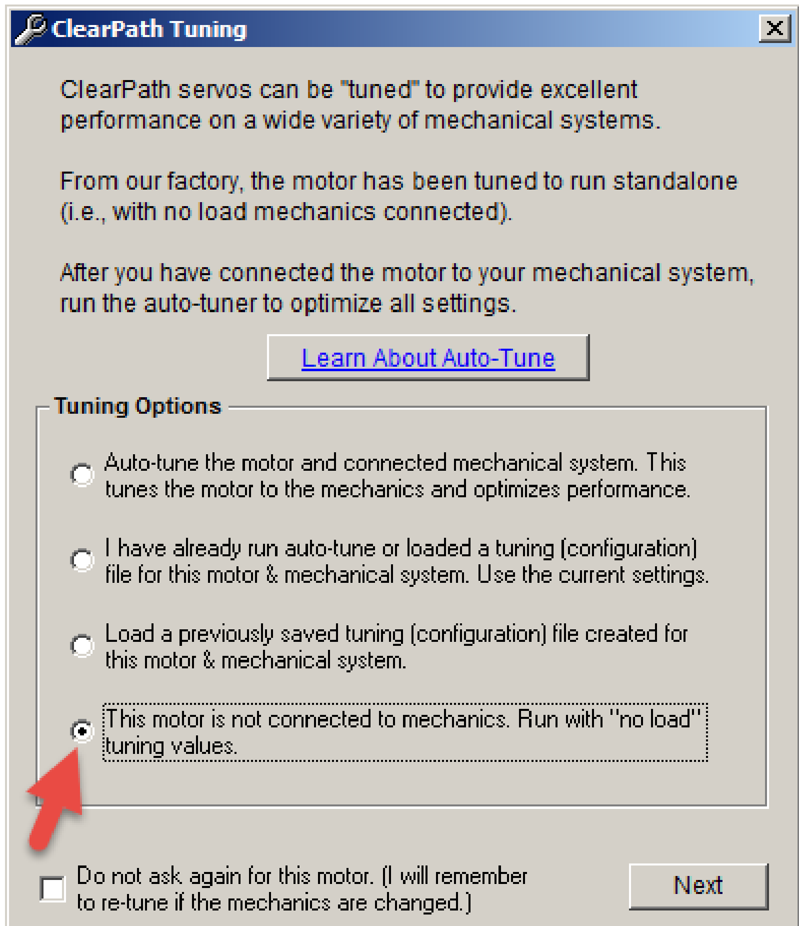
- Direction of shaft rotation is set by entering a "+" or "-" sign in front of the velocity settings (see top of figure above). "+" will cause CCW rotation, "-" will cause CW rotation.

## Spinning a Model SDHP or SDSK

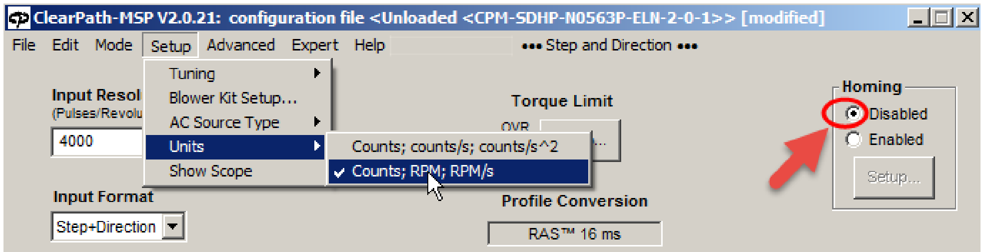
*Note: Spinning ClearPath models MCVC and MCPV is covered in the previous section.*

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

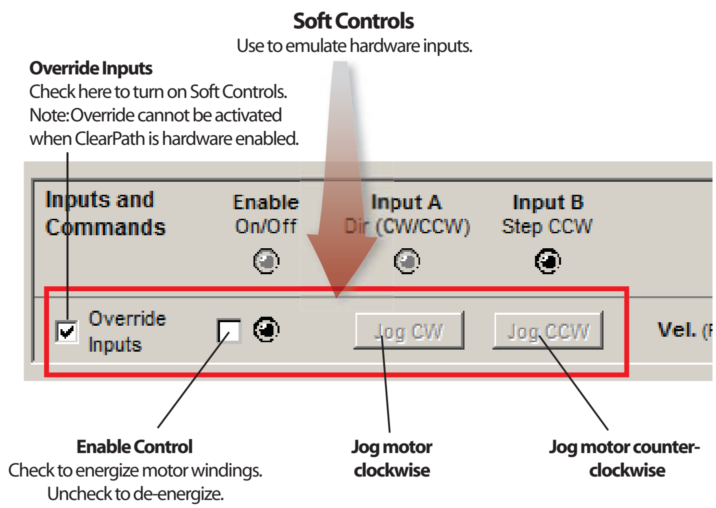
1. Open MSP software.
2. Establish USB communication to your motor.
3. The "Tuning" dialog will appear. For now select the bottom option (run with no load) and hit "Next".



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).



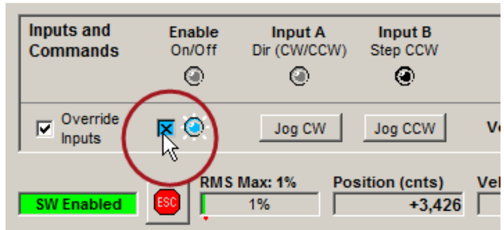

7. **Click the Override Inputs checkbox.** This turns on the software controls. You may notice that the other Soft Controls are no longer grayed out.




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

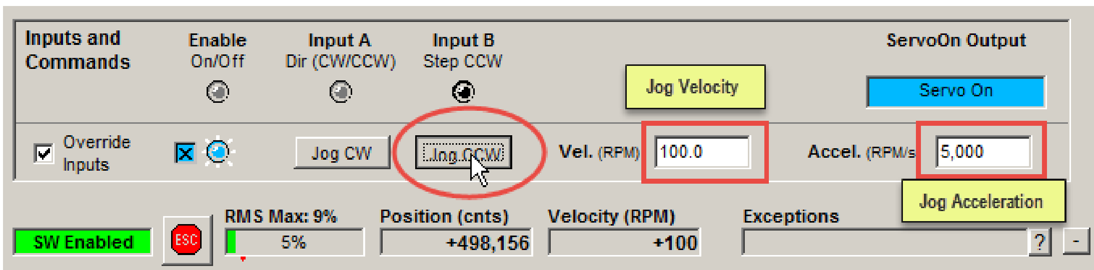
8. **Safety check!** Before proceeding, make sure that the motor is securely clamped down and the shaft is safely positioned away from fingers, clothing, hair, cables, etc.

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 CW/CCW (clockwise/counterclockwise) buttons. Change motor velocity and acceleration using the fields shown in the figure below.




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

# DAMAGE WARNING: CLEARPATH INPUTS/OUTPUTS

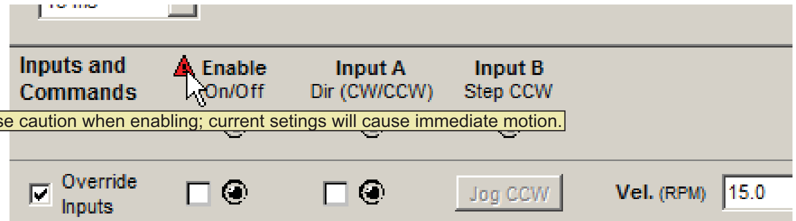
Never connect “unprotected” inductive loads across your ClearPath motor’s input or output circuits. If you have inductive devices such as relay coils, solenoids, contactor coils, power-off brakes, (any device that works by intermittently powering and unpowering a large inductor/coil) connected across your ClearPath inputs or outputs, you will damage or destroy the ClearPath I/O circuits. Damage of this nature manifests as inputs or outputs not working, and can happen immediately or over time.

**Always install a protection diode across any coils wired across your ClearPath inputs and output to prevent high voltage discharge spikes from permanently damaging the motor.**

Please read the section *How Inductive Loads Can Damage ClearPath I/O* for more information on how to protect your ClearPath motor from this type of damage.

## 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).




***Hover cursor over "warning triangle" to read its message***

- If you exceed your power supply's capability, ClearPath will tell you. You'll see warnings or shutdowns in the Exceptions field at lower right of the UI. (This does not mean that the motor is broken!) Try lowering the acceleration and/or velocity until the warning goes away.
- The majority of shutdowns are caused by 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

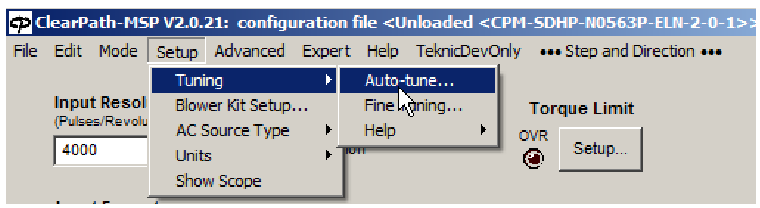
***Tuning is required** whenever you bolt your ClearPath motor to a new or different mechanical system*. The Auto-Tune feature simplifies this formerly complicated and time consuming process.

## Before you begin the Auto-Tune process:

- Disable your motor.
- **IMPORTANT:** Securely bolt or clamp your motor to a machine frame or solid work surface. Don't try to tune a system on wheels or a flimsy table.
- Tighten all couplings, fasteners, pinions, and belts to the manufacturer's specifications.
- Make sure the axis or machine frame is fully intact.
- Recommended: Turn off your PC's sleep mode. If your PC goes into standby, sleep, or hibernation mode during Auto-Tune, the process will fail.

## 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 ASSISTANCE

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

- Connect power to ClearPath.
- Verify wall outlet is powered, circuit breakers and contactors are all closed (conducting).

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

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

**Issue: Auto-Tune failed to complete.**

- Check to see if more than one version of MSP is installed on your computer. Always uninstall older versions of MSP before upgrading.

**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

- There are circuits within the junction box area that are shock hazards. **Some circuits within the junction box will continue to be a shock hazard for up to ten (10) minutes after power is removed.**
- 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 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.
- When wiring to the motor, keep all debris e.g., wire clippings, insulation fragments, etc. from falling into the motor. Damage can occur.
- Before applying 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 except for access to the junction box for wiring,. There are no user serviceable parts inside this product.
- Do not remove the clear PWB support or the white polyester bib from the junction box area; these help reduce shock hazards and also reduce the opportunity for debris to fall into motor internals.
- 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.
- 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.

## 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.

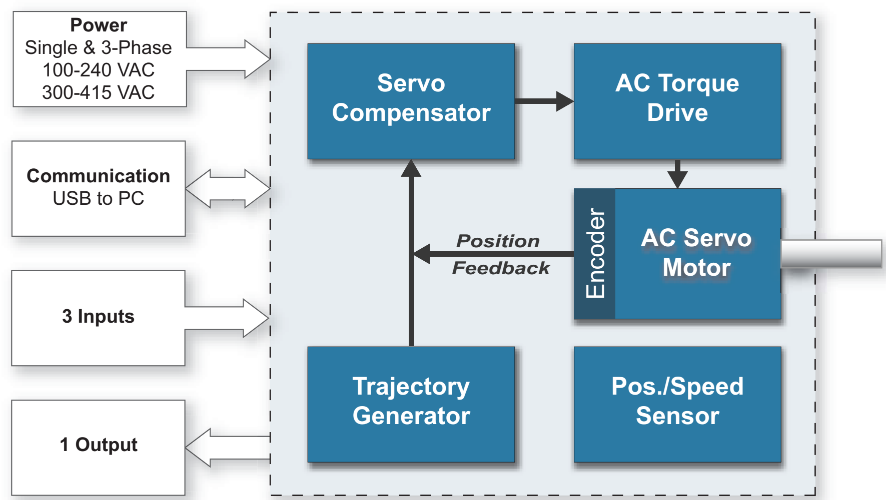
Teknic has made all reasonable efforts to accurately present the information in the published documentation and shall not be responsible for any incorrect information which may result from oversights. Due to continuous product improvements, the product specifications as stated in the documentation are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

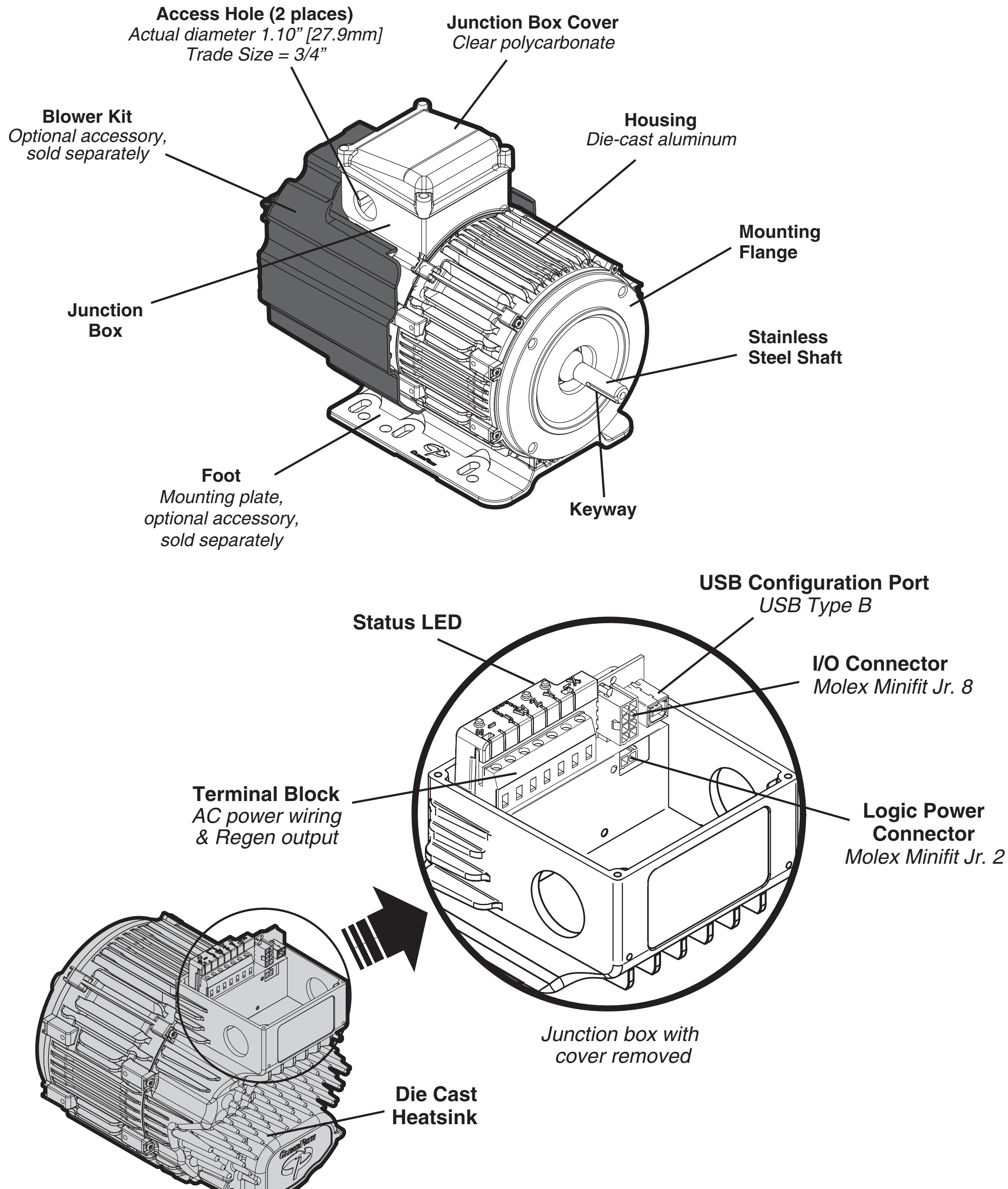
- Stepper Emulation (use standard step-and-direction signals).

ClearPath motors are at home in applications ranging from variable speed conveyors, blowers and pumps, to multi-axis positioning robots and 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 AN AC CLEARPATH MOTOR




***AC ClearPath Motor***

**Terminal Block -** Wire AC mains and optional Regenerated Energy Shunt (RES-225) to this 7 position screw terminal connector.

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

**Configuration Port - C**onnect ClearPath to a Windows PC with a standard USB (Type A to Type B) cable.

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

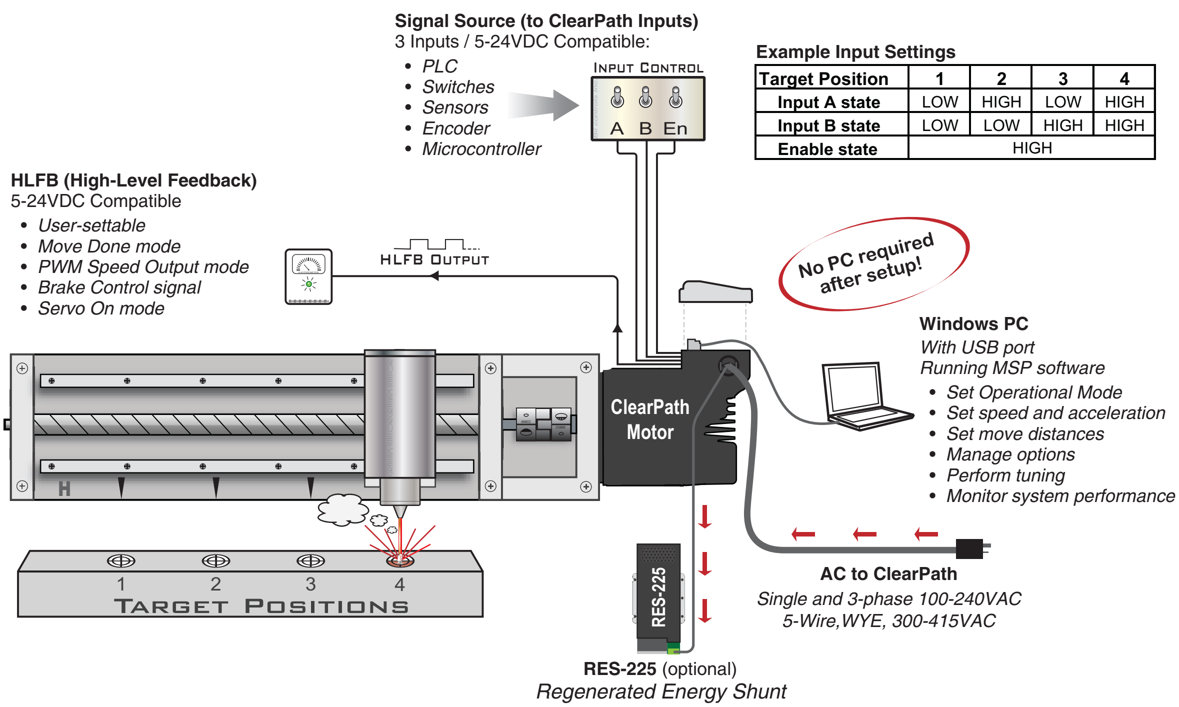
## Example Application: Absolute Positioning Mode

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.




***ClearPath Absolute Positioning (4-Position) Mode***

**Getting started.** To energize the motor, simply apply a DC voltage (5-24VDC) 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 compatible AC power 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 and attached mechanical system.
6. Test and adjust settings as needed to optimize quality of motion and overall system performance.
7. Disconnect the computer and run your application. No computer is needed once setup is complete.

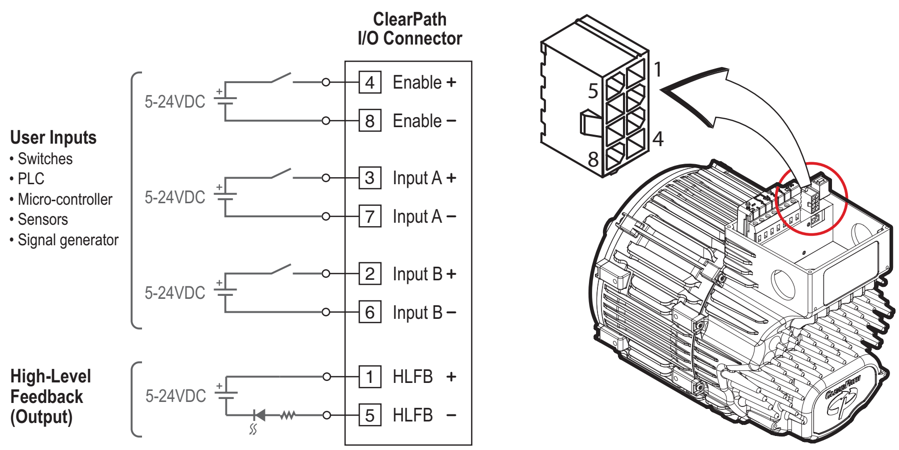
**Save your settings!** You can save your ClearPath settings to a motor configuration file—the file extension is .mtr—at any time. This allows you to easily test and compare various sets of tuning parameters. And, if you build many machines of the same design, you'll appreciate how quickly you can load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

# Overview: ClearPath I/O

ClearPath motors include a flexible, high-level I/O control interface - just three inputs and one output. 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.

**Damage Warning:** Never connect "unprotected" inductive loads (things like relay coils, solenoids, or inductive brakes) across your ClearPath motor's input or output circuits. Please read the section *How Inductive Loads Can Damage ClearPath I/O* for more information.




***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 when a shutdown occurs.
- Signal when ClearPath is running at the target 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.

# WIRING AC POWER TO CLEARPATH

## BEFORE YOU WIRE AC POWER TO YOUR MOTOR

Verify that you have a compatible AC power source and all of the necessary tools and supplies.

### COMPATIBLE AC POWER SOURCES

- Single phase and 3-phase, 100-240 VAC (common in North America).
- 5-wire (3-phase with neutral and ground) 300-415 VAC (common in Europe).
- **Important:** Do not connect 3-phase, 277/480 VAC to your AC ClearPath motor. This will result in an overvoltage condition.

### TOOLS AND SUPPLIES REQUIRED

**Note:** The items listed below are not included with a ClearPath motor.

- T10 (Torx) screwdriver.
- Slotted screwdriver with max. 4mm blade (for terminal block screws).
- Ring terminal sized for a #10 screw, tin plated, crimp style; for connecting AC ground wire to grounding point in motor junction box.
- Wire strippers.
- AC cable and plug rated for your application requirements. **Note: 14-16 AWG wire is appropriate for most installations. (12 AWG is the largest size wire that will fit in the terminal block). The cable's ground conductor must be the same gauge or heavier than the phase conductors. Use cable rated for 80°C or higher.**
- Cord grip, strain relief, or conduit fitting sized for a **3/4" trade size knockout**. Many different types are available from McMaster-Carr, Grainger, MSC, and other industrial supply houses.

## CIRCUIT BREAKER REQUIREMENT

AC ClearPath motors should be protected by a circuit breaker with the appropriate current rating, voltage rating, and trip characteristic. **Select a circuit breaker with a "C" trip curve** to help prevent nuisance trips.

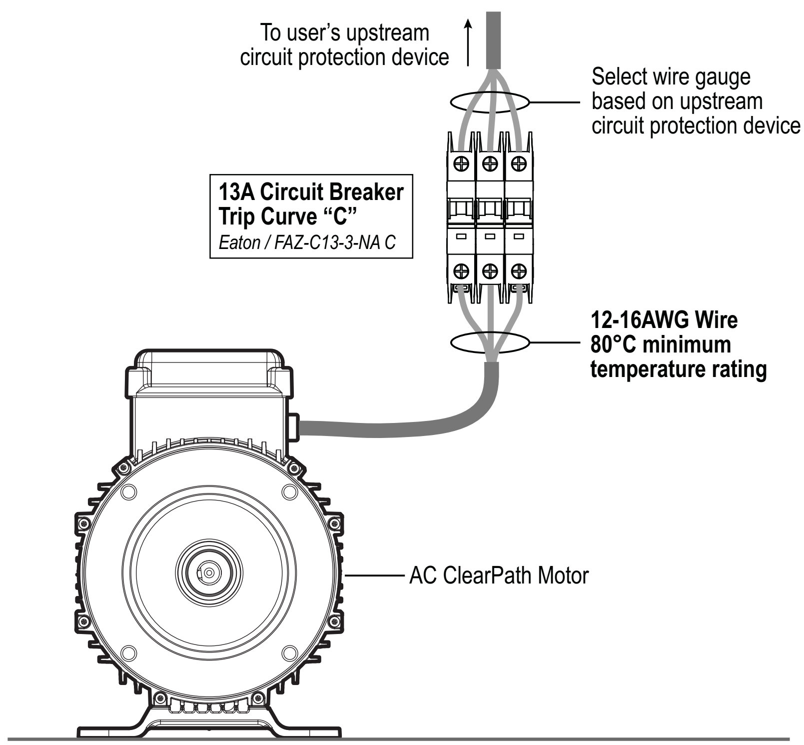
Teknic recommends the following breaker for most AC ClearPath applications. Other circuit breaker manufacturers may offer equivalent products.

**Recommended Circuit Breaker**

**Eaton Part#: FAZ-C13-3-NA C**

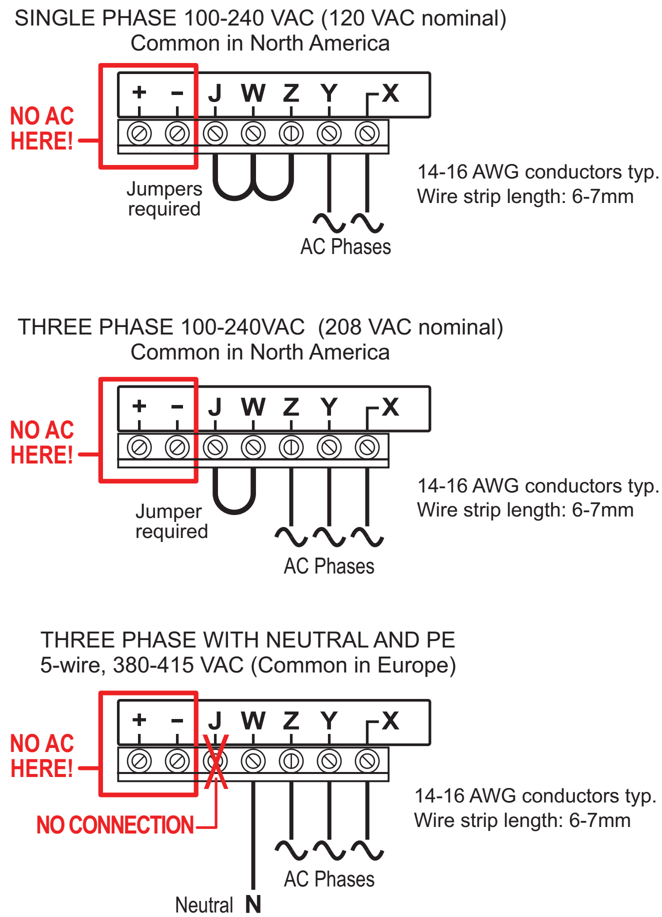
*Description: Eaton miniature circuit breaker, current-limiting, 13 amp, 480Y / 277 VAC / 3-pole, C trip curve, thermal magnetic, 10kA SCCR, 35mm DIN rail mount. This product is UL 489 rated and available at Automation Direct as of this writing.*

**Important:** For US installations, consult the National Electrical Code (NEC) prior to selecting circuit breaker wire. **Use wire rated for 80°C or higher only.** The use of undersized wire and/or wire with temperature rating less than 80°C constitutes a safety and/or fire hazard.




***ClearPath with circuit breaker***

## AC Wiring Instructions




***AC ClearPath Wiring Diagrams***

1. Remove the motor's junction box cover (use a Torx T10 driver).
2. Install your choice of cord grip, strain relief, conduit, or plugs in the junction box access holes. The access holes measure 1.1 " in diameter; these are **3/4" trade size knockouts**.

   **Note:** The **red access hole plugs** that shipped with your motor were designed for cosmetic protection only. **Please recycle** these plugs. Use a cord grip that is, at a minimum, dust tight.
3. Prepare your AC cable by stripping back the outer jacket approximately 4". Note: Use 12-16 AWG wire.
4. Strip individual wires back 7mm +/- 0.5mm (.275" +/- 0.020").
5. If required, make jumper wire(s). See wiring diagrams to determine if you need jumpers. **Use the same wire gauge for your jumper as was used for the AC phase wires.** Strip 6-7 mm (~1/4").

6. Crimp a *tin plated ring terminal*[2] onto the AC cable's grounding wire. See list below for recommended part numbers.

    Molex part number: 0190730170 (10-12AWG)

    Panduit part number: PV10-10R-D (10-12 AWG)

    Panduit part number: PV12-10HDRB-2K (12-16 AWG)

    TE AMP Connectors part number: 40960 (12-14 AWG)

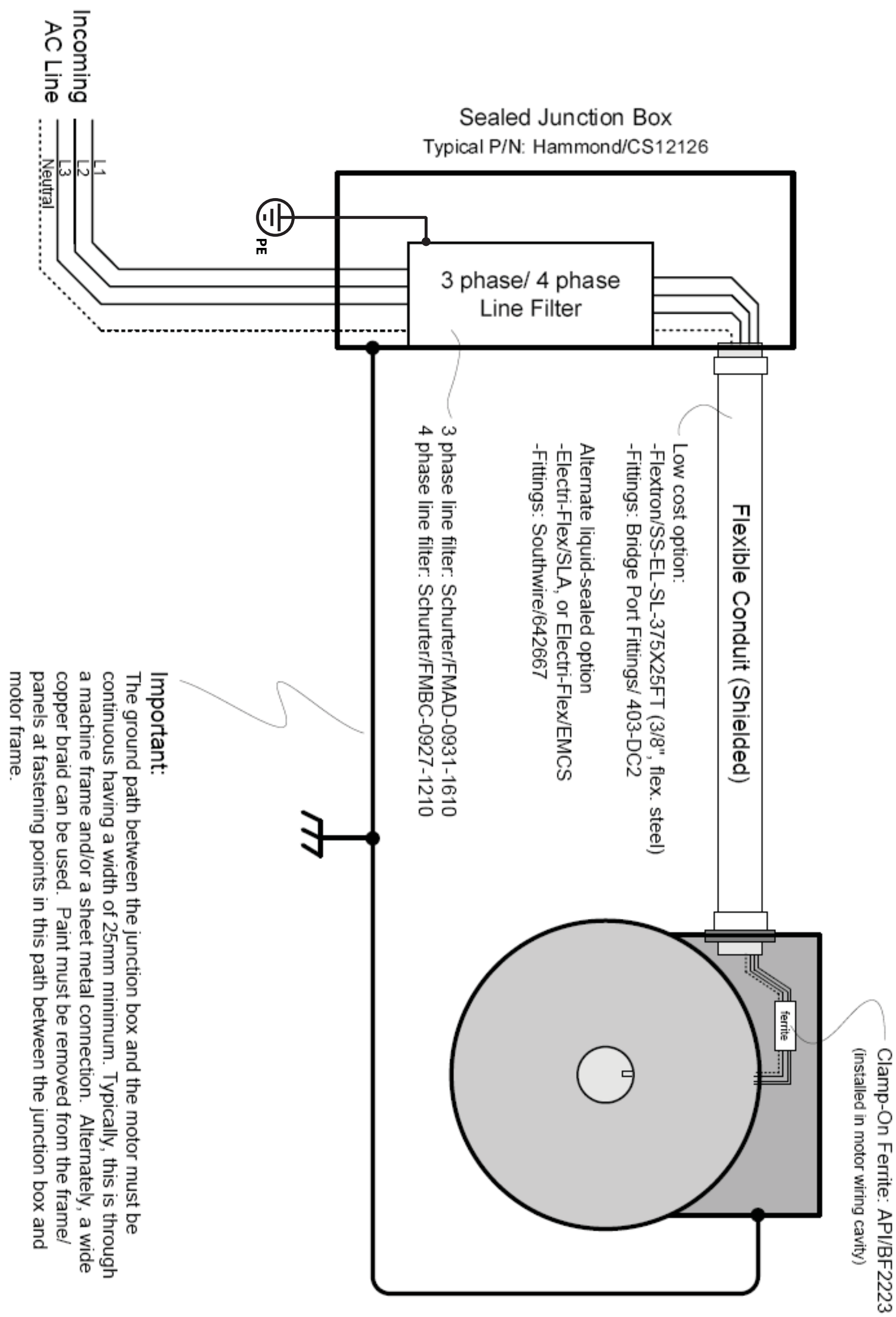
    TE AMP Connectors part number: 36160 (16-14 AWG)

7. With AC power off, feed the AC cable into the motor's junction box. Temporarily secure cable to junction box before installing wires into terminal block.
8. Secure the AC ground wire to the floor of the junction box with a **#10-32 x 3/8"** screw. See instructions inside motor junction box.
9. Determine which wiring diagram below matches your AC power configuration.
10. Insert and screw down wires into the terminal block as indicated by wiring diagram.

[2] To prevent galvanic corrosion between the copper ground wire and the A380 aluminum alloy die cast housing, a tin plated lug ring must be crimped onto the copper wire prior to installation. Copper wire should not directly touch the aluminum housing.

## EMISSIONS FILTER FOR CE COMPLIANCE

The setup below is recommended for users seeking CE certification for their machine. Note: ClearPath conducted and radiated emissions–with no additional filtering–are unlikely to interfere with nearby equipment.



# Logic Power Backup (optional)

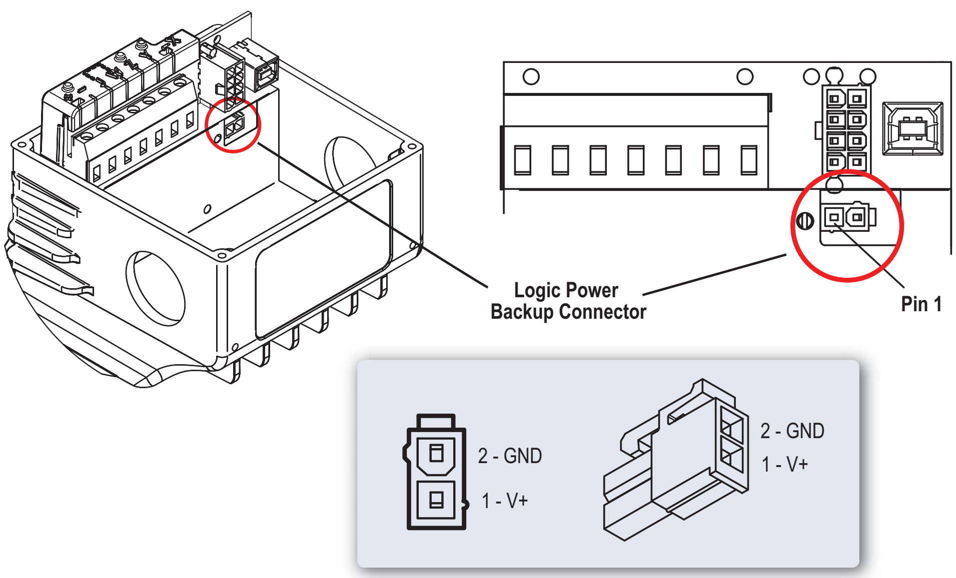
You may optionally connect a logic power backup supply to your ClearPath motor to keep the motor's processor and associated electronics powered up in the event of AC power loss. 24VDC is the most commonly used voltage for logic power backup.

## Logic Power Backup Supply Requirements

- Voltage: 24VDC nominal. Min/max: 20-28VDC
- Power consumption: 5W per motor. See appendix "Logic Power Supply Sizing" for more information.

## Logic Power Backup Connector

Connect your logic power backup supply to the 2-pin Molex connector inside the motor junction box. Connector mating parts and tools are listed below. For instructions on how to make an inexpensive logic power backup cable, see next section.

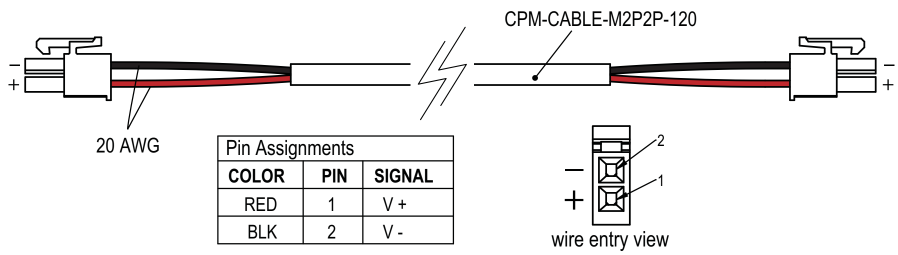



| Ref. | Description | Mating Connector PN | Terminal PN | Terminal Desc. | Crimp Tool | Extraction Tool | Recommended Wire Gauge** |
|---|---|---|---|---|---|---|---|
| A | Molex MiniFit-Jr, Receptacle, 2 circuits | 39-01-2020 (natural, UL 94V-2)<br>39-01-3025 (black, UL 94V-2)<br>39-01-3028 (natural, 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 | 20-24 AWG |

## HOW TO MAKE AN INEXPENSIVE LOGIC POWER BACKUP CABLE

This section describes how to make an inexpensive, no-crimp cable for use with your optional logic power backup supply.

1. Purchase a Teknic **CPM-CABLE-M2P2P-120**. This is a, 120" (3 meter), Molex 2-pin to Molex 2-pin cable as shown below.



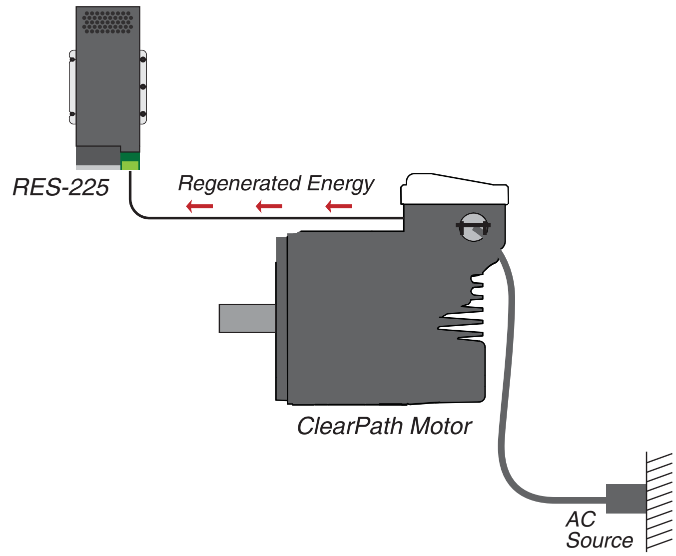

| Pin Assignments | | |
|---|---|---|
| COLOR | PIN | SIGNAL |
| RED | 1 | V + |
| BLK | 2 | V - |

***CPM-CABLE-M2P2P-120***

2. Cut the cable to the desired length. (If you cut the cable exactly in half, you'll have two 5' (1.52 m) cables.
3. Create flying leads by stripping the outer jacket on the unterminated end of the cable.
4. Strip and connect the flying leads to your logic power backup supply. Insulate any exposed conductors with heat shrinkable tubing, electrical tape or similar.
5. **Test DC output polarity before connecting.** Use a DMM to verify proper polarity at the DC output connector. Use the above diagram as a reference.

# RES-225 USE INSTRUCTIONS

This section discusses mounting, wiring, and operation of the optional **RES-225 Regenerated Energy Shunt** (sold separately by Teknic).




***RES-225 and ClearPath motor***

## RES-225 (REGENERATED ENERGY SHUNT) OVERVIEW

The RES-225 monitors and manages your motor's regenerative energy output to facilitate safe, rapid dissipation of excess energy and to prevent nuisance overvoltage shutdowns.

**Background: What is "regen"?**

All electric motors (DC brush, brushless, induction, stepper, or servo) generate a reverse voltage when producing torque against the direction of motion, particularly during hard decelerations. This reverse voltage is referred to as back-EMF, regenerated energy, or just "regen" for short. Unmanaged regen will intermittently increase the motor drive's DC bus voltage which can lead to overvoltage shutdowns.

**How does the RES-225 work?**

Under processor control, the RES-225 detects and channels excess regenerated energy to a large, fan cooled power resistor where it is safely dissipated.

**Does my motor need an RES-225?**

High regen is commonly seen in axes that rapidly decelerate large inertial or gravitational loads; however, most applications do not generate enough regen to cause shutdowns. For applications that do, ClearPath's built-in VRS feature (Vector Regen Shunt) can usually dissipate enough energy to prevent overvoltage events. VRS is a standard feature of all ClearPath motors. It is turned on or off with a checkbox in MSP and requires no external hardware.

If the motor's regenerated energy exceeds what the internal VRS can dissipate, the excess energy will temporarily increase the motor drive's DC bus voltage, (particularly during hard decelerations). If the DC bus voltage rises high enough, an overvoltage shutdown will result, indicating that an RES-225 may be needed. *Note: overvoltage shutdowns are not damaging to the motor. They are an indication that the motor has successfully protected itself.*

**If your ClearPath motor generates more regen than the internal VRS (Vector Regen Shunt) can handle, you may need an RES-225 to dissipate the excess energy.**

**How much regen will my motor produce?**

This is a question Teknic engineers hear often (and it's a good one). What we've found over time is that it is impractical to try to accurately calculate motor regen given the number of electromechanical and motion-related variables involved. The most effective approach is to install a motor on fully loaded mechanics and run test moves that emulate normal machine operation.

**Tip:** ClearPath's built-in diagnostic tools (software scope) can help you determine if and when your motor is experiencing overvoltage shutdowns due to regen.

**Additional Information:**

- The RES-225 is reverse voltage protected.
- The RES-225 provides up to 250 Watts of continuous energy dissipation, and peak power dissipation in excess of 7 kW.
- RES-225 energy dump turns on when ClearPath's DC bus reaches 417VDC; energy dump turns off below 400VDC.
- Intermittent fan operation is normal.
- In the event of an internal failure (one that prevents the microcontroller from turning off energy flow to the dump resistor) the product is protected by a UL Listed internal fuse.
- The RES-225 uses **LED blink codes** to communicate environmental and internal operating status. See the blink code table later in this section for details.

### Important Warning

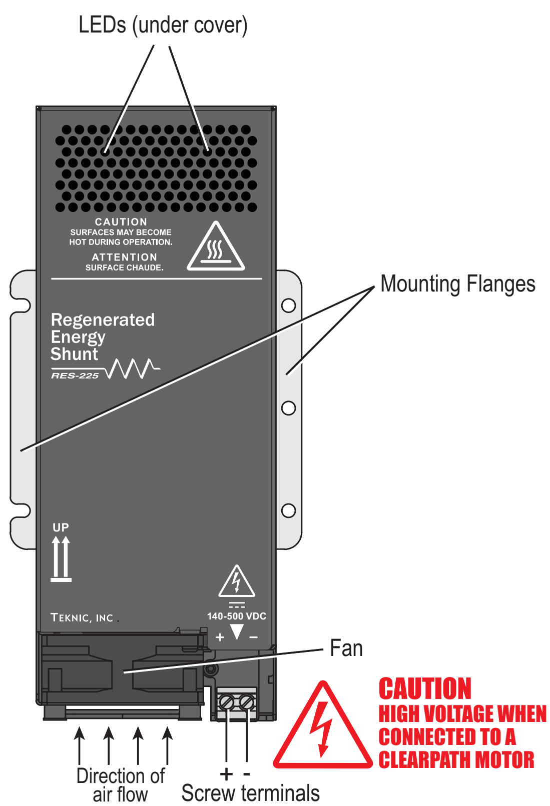
Please read and follow all warnings in this section and on the RES-225 outer case.

**Burn Hazard:** This device may present a burn hazard during operation. Always allow RES-225 to cool before handling.

**Shock Hazard:** RES-225 screw terminals can present a high voltage shock hazard when the unit is connected to a powered ClearPath motor. Never attempt to touch the RES-225 screw terminals unless the unit is completely disconnected from the ClearPath motor.

**No user serviceable parts inside.** Do not open case or attempt to service this product.

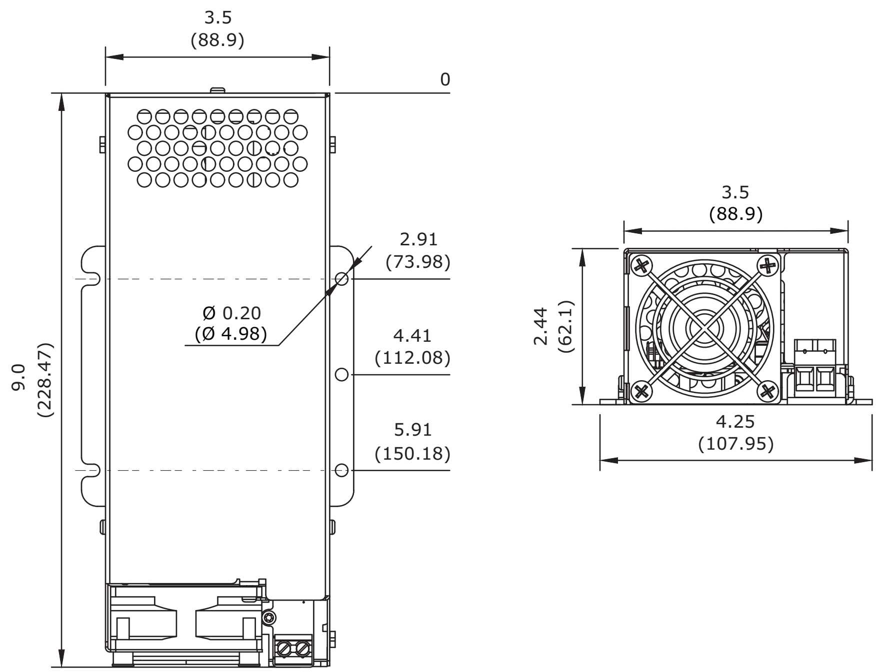
## Parts of an RES-225




***RES-225 Parts***

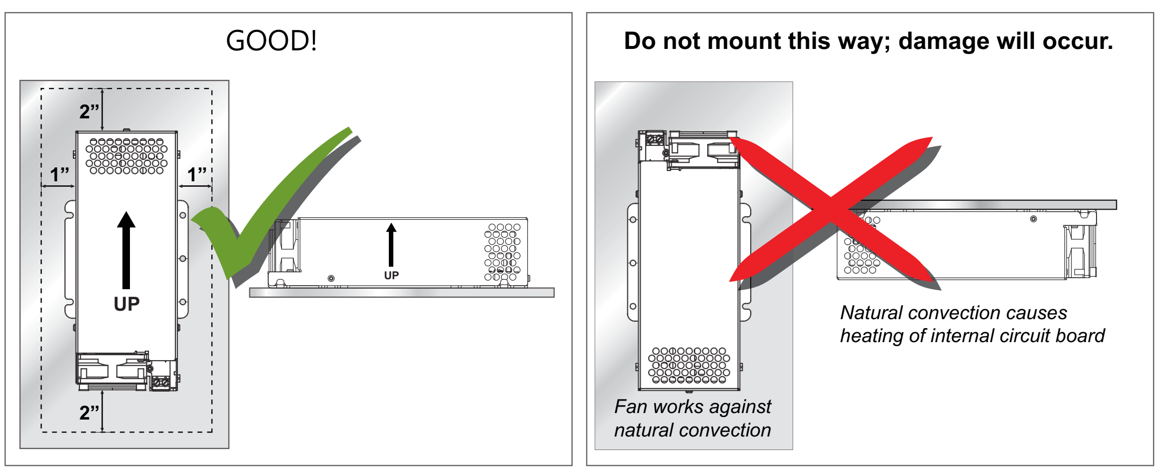
## MECHANICAL/MOUNTING INFORMATION

### RES-225 DIMENSIONS




***RES-225 Dimensions***

### MOUNTING ORIENTATION AND CLEARANCE REQUIREMENTS




***RES-225 mounting orientation and clearance requirements***

- Do not mount RES-225 beneath heat sensitive devices such as power supplies or motor drives. *This device will exhaust heat during normal operation.*
- Do not mount RES-225 in unventilated enclosures.
- Do not expose unit to liquids, mist, or splash.
- Do not allow debris to fall into device housing.

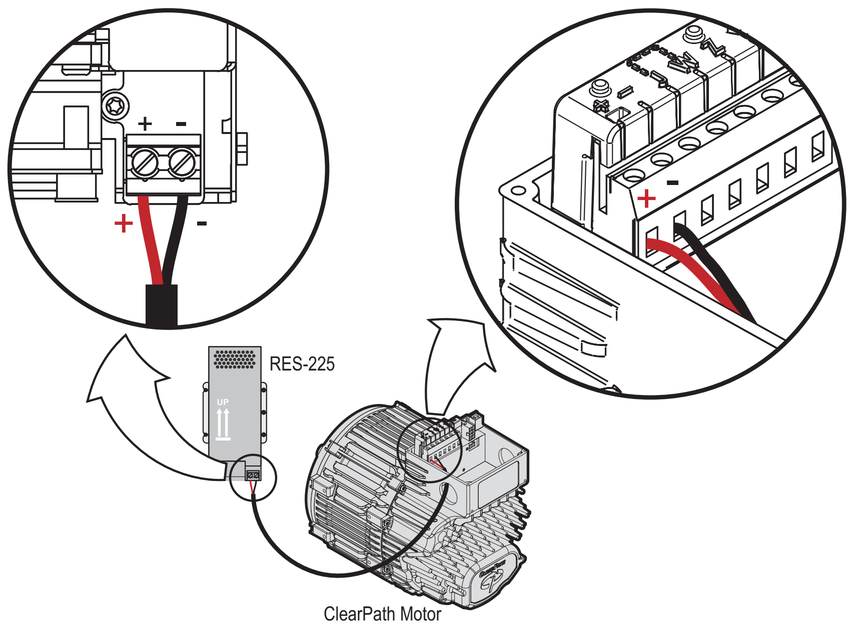
- Leave a minimum of 1" clearance around the unit, 2" clearance at ends.

## WIRING RES-225 TO YOUR CLEARPATH MOTOR

**Hazardous Voltage Warning**

Always disconnect AC mains power from your ClearPath motor before handling or wiring an RES-225.

1. Remove AC mains power from your ClearPath motor.
2. Using 2 conductor, 12-14 AWG wire, connect (+) and (-) terminals from the RES-225 to the (+) and (-) terminals of your ClearPath motor. Follow polarity markings as shown below.




***RES-225 wired to AC ClearPath motor***

### IMPORTANT GROUNDING NOTE (USA)

For applications in most countries, grounding the metal case of the RES-225 is not necessary because the insulation system meets the requirements for Reinforced Insulation per EN 61010. **However, for applications in the USA, the National Electrical Code (NEC) requires that any electrical product with a metal enclosure be bonded to protective earth.** This can be easily accomplished by attaching a grounded lug to one of the RES-225's panel mounting screws or by other means as prescribed by the NEC.

## RES-225 LED CODES

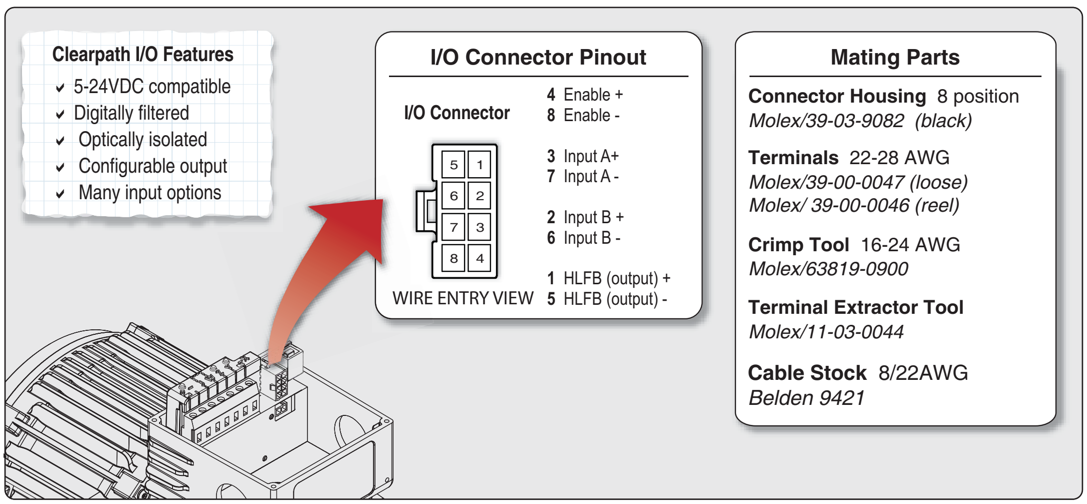
| LED Color | LED State | Blink Pattern | Description | Notes |
|---|---|---|---|---|
| Orange | Solid | On for 1 sec. (applies to start up only) | Normal operation. Power-up self test. | |
| Green | Flicker | 16 Hz (16 blinks/sec) | Normal operation. No regen detected since power up. | |
| Red | Flicker | 16 Hz (16 blinks/sec) | Same as above, plus fan failure detected. | Unit is functional, but RMS capability is reduced automatically. |
| Orange | Blink | 3 Hz (3 blinks/sec) | Normal operation: Regen dump is actively occurring. | |
| Green | Blink | 3 Hz (3 blinks/sec) | Normal operation. Regen dump has occurred, regen not actively occurring. | |
| Red | Blink | 3 Hz (3 blinks/sec) | Same as above, plus fan failure detected. | Unit is functional, but RMS capability is reduced automatically. |
| Orange | Flash | 0.5 Hz (1 flash every 2 sec) | Unit in foldback mode. Regen is actively occurring. | |
| Green | Flash | 0.5 Hz (1 flash every 2 sec) | Unit is In foldback mode. Regen is not actively occurring. | |
| Red | Flash | 0.5 Hz (1 flash every 2 sec) | Same as above, plus fan failure detected. | Unit is functional, but RMS capability is reduced automatically. |
| Orange | Flash | 1 Hz | Over temperature condition. | Board temperature is over 90°C |
| Red | Flash | On solid with brief off pulse every 3 seconds. | Critical hardware failure. | Unit requires repair. Fuse blown or regen circuit damaged. |

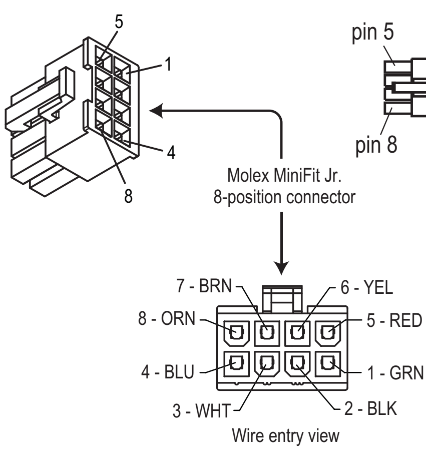
# INPUTS AND OUTPUTS

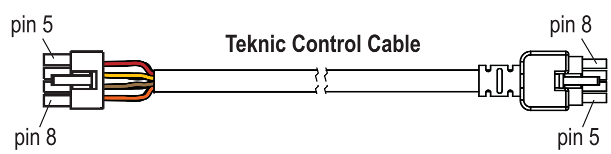
ClearPath inputs and output (I/O) allow the user to send and receive control signals from a ClearPath motor. There are a total of three digital inputs and one digital output accessible through the 8-position Molex MiniFit Jr. connector[3]. Refer to the diagram below for a list of I/O connector mating parts readily available through most electronic component suppliers.

**DAMAGE WARNING:** Never connect unprotected inductive loads (things like relay coils, solenoids, contactor coils, etc.) such that they can discharge across ClearPath Inputs or outputs. Doing so will irreversibly damage the ClearPath motor inputs/outputs. See the section *How Inductive Loads Can Damage ClearPath I/O* for more.

## I/O CONNECTOR PARTS AND PINOUT




**Teknic Control Cable Pin Assignments**

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

***ClearPath I/O connector and mating parts***

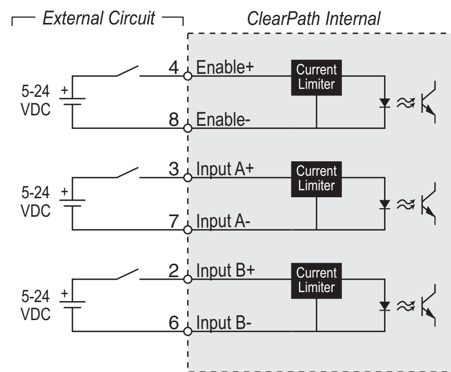
[3] An "overmolded" style Molex 8-position connector will fit tightly against the USB connector inside the junction box. Use a *non-overmolded connector* to prevent interference.

# CLEARPATH INPUTS

**Damage Warning: Protect Your Inputs and Outputs**

To prevent motor I/O damage, never connect unprotected inductive loads (things like relay coils, solenoids, contactor coils, brake coils, etc.) such that they can discharge across ClearPath inputs or outputs. Doing so will blow out the ClearPath motor I/O circuits, causing permanent damage to the motor. See the section *How Inductive Loads Can Damage ClearPath I/O* for more information on preventing this kind of damage.

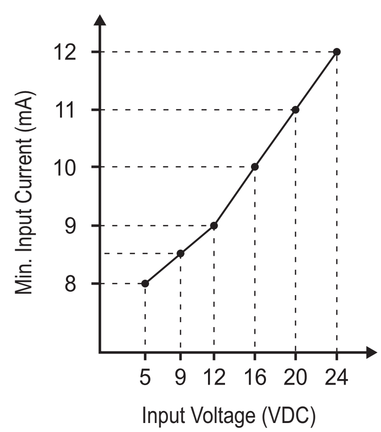
The three inputs, *Enable*, *Input A*, and *Input B*, are designed for use with 5-24VDC logic levels, and pulses from a wide variety of signal sources and devices including PLCs, microcontrollers, and mechanical switches.




***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.

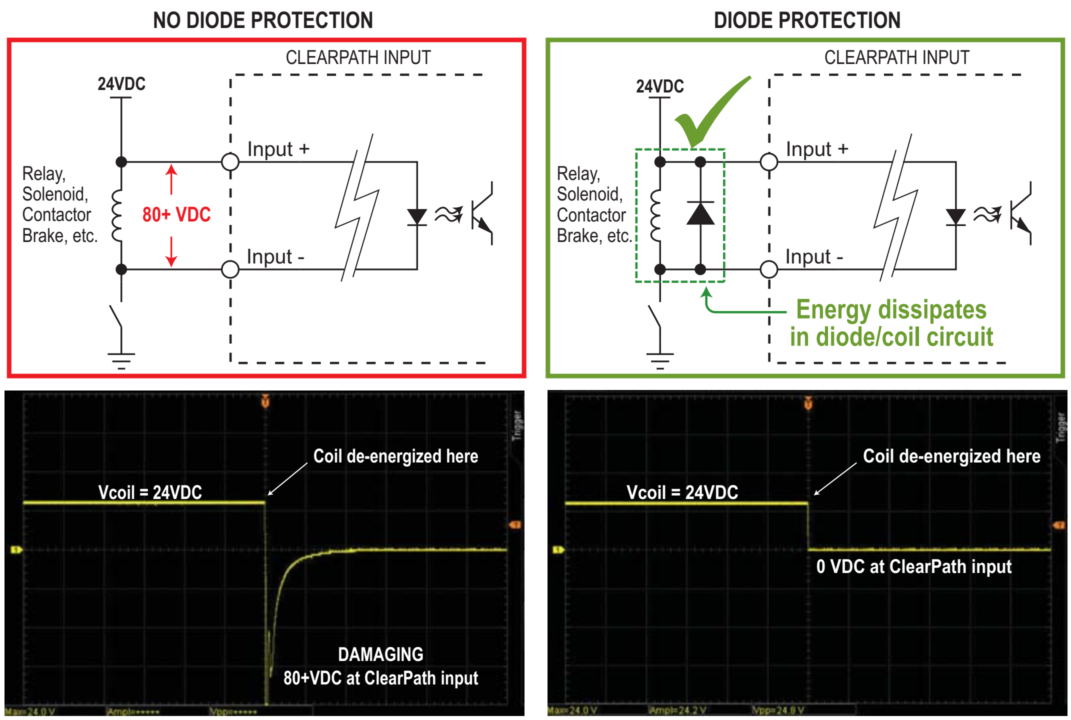



| Voltage at ClearPath Input | Minimum Input Current Required |
|---|---|
| 5 VDC | 8 mA |
| 12 VDC | 9 mA |
| 24 VDC | 12 mA |

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

## How Inductive Loads Can Damage ClearPath I/O

Your ClearPath input and output circuits can be damaged if exposed to high voltage, inductive kickback. Inductive kickback is manifested as the short term, high voltage spikes produced by coil-actuated (inductive) devices when power is removed from the coil. Such devices include contactor coils, mechanical relay coils, solenoids, and power-off brakes.




***Use a flyback diode (right) to protect ClearPath inputs and outputs.***

**Without a "safe" discharge path, such as provided by a flyback diode, when the coil from an inductive device is de-energized it can produce a very high voltage spike that will damage ClearPath inputs connected in parallel with the coil.** These voltage spikes can peak in the hundreds of volts for tens of milliseconds. And, while ClearPath I/O circuits are very robust, they are not designed to manage hundreds of volts above their operating range of 4-28VDC.

## How to Protect Your Motor From Inductive Kickback

1) Avoid connecting inductive loads (coils) such that they can discharge across your ClearPath inputs or output. Use a separate power supply for inductive devices to isolate them from low voltage digital devices.

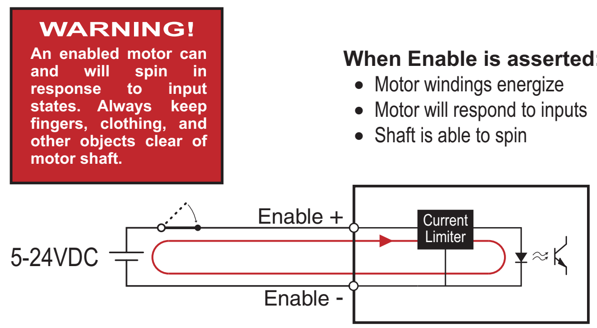
2) If you must connect a coil-actuated device across your ClearPath I/O, **add a protection diode in parallel with the coil in the polarity shown above.** *FYI: Protection diodes are referred to by various names including flyback diode, snubber diode, or catch diode.* We recommend using a common **1N4004** diode for most applications.

## 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[4].

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




***ClearPath Enable Input***

**Caution:** When ClearPath is in "Spin on Power-Up" mode, it can spin as soon as main AC 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 Input Used as a Trigger Signal.** In a few ClearPath modes, the Enable input can also act 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 start a move, change direction of rotation, or change velocity. See individual operation modes for more on trigger mode functionality.

## 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, you'll 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.

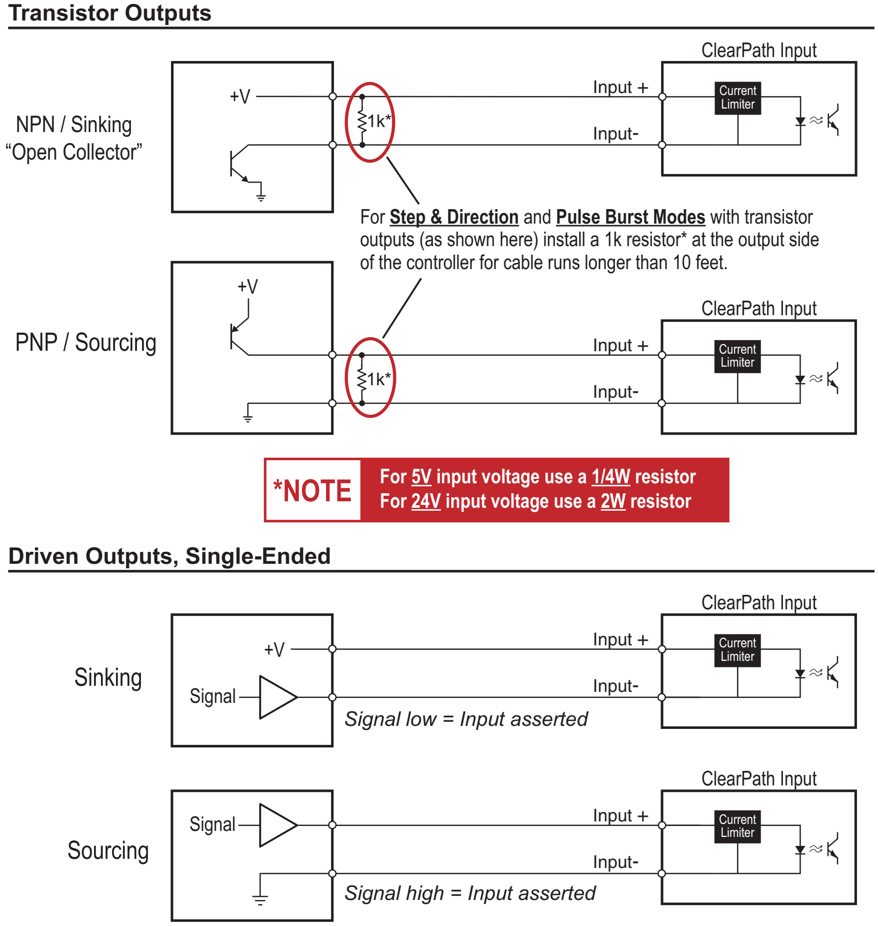
**Engineer's Note:** In all ClearPath motors, the input signals are electrically isolated from the DC power input and motor output circuits, as

[4] **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 are not compromised due to induced currents from the motor, power supply, other sources of common mode noise or ground loops.

## INPUT WIRING EXAMPLES

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




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

**Application Note:** For additional information on selecting the proper resistor for your control input circuitry, see the Step and Direction Timing section of the user manual.

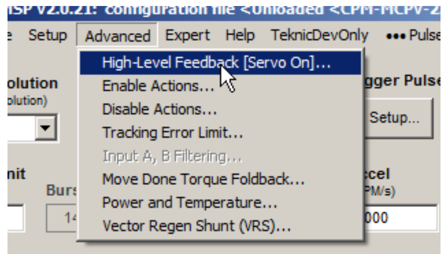
**Engineer's Note:** 5V differential outputs are not directly compatible with ClearPath inputs because differential drivers' guaranteed output voltage swing is typically not guaranteed to meet the ClearPath input minimum input voltage requirements.

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.

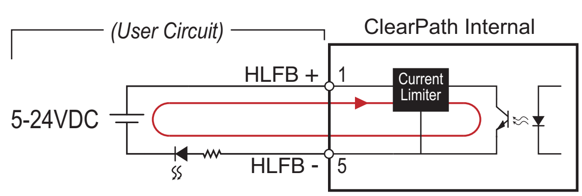
The HLFB configuration dialog is accessed from the Advanced menu as shown below. *Advanced>High-Level Feedback*.




**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***

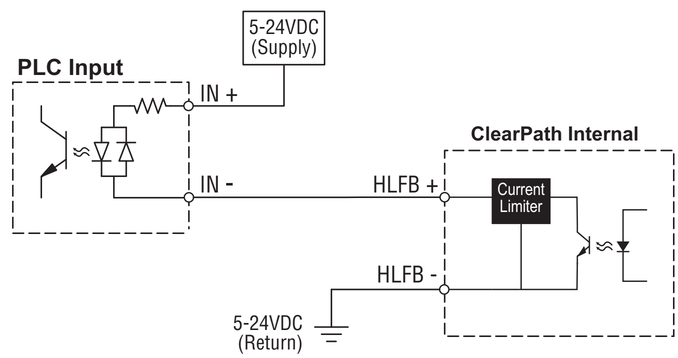
## HLFB OUTPUT WIRING EXAMPLES

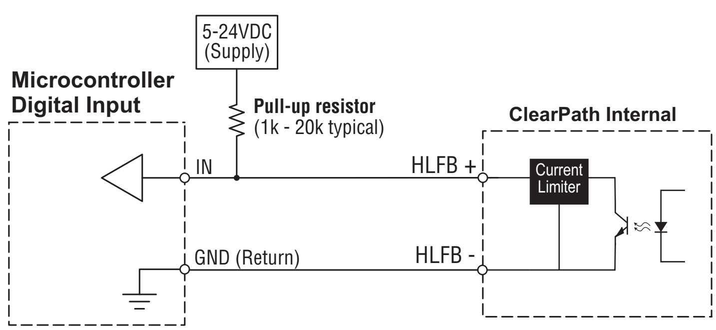
Any external circuit or device to be connected to the ClearPath HLFB output should conform to the guidelines below. Proper circuit design/selection greatly reduces the probability of electrically damaging the output, particularly in the event of a common production mistake such as an accidental short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

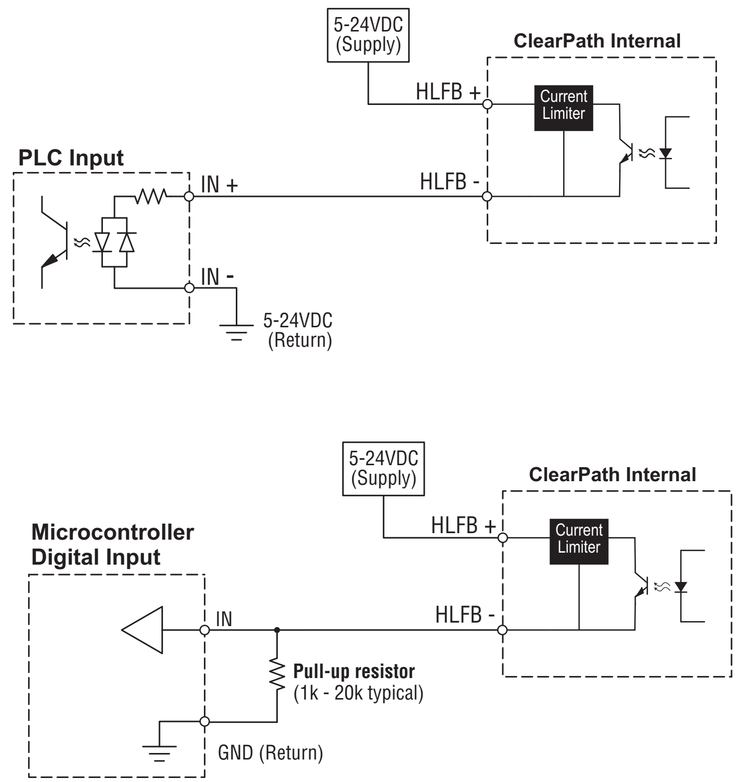



*HLFB as a sinking output*

### 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**

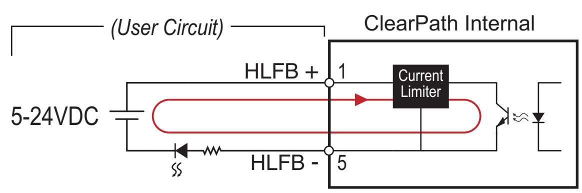
For more information related to Arduino digital inputs and pull-up resistors, check out the following link:

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.

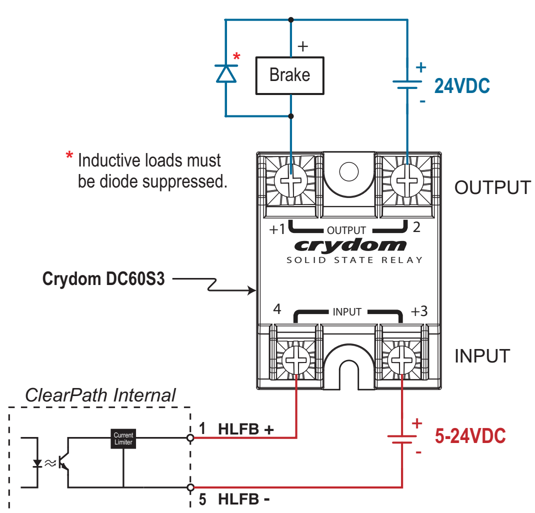



***HLFB Driving LED***

### 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.

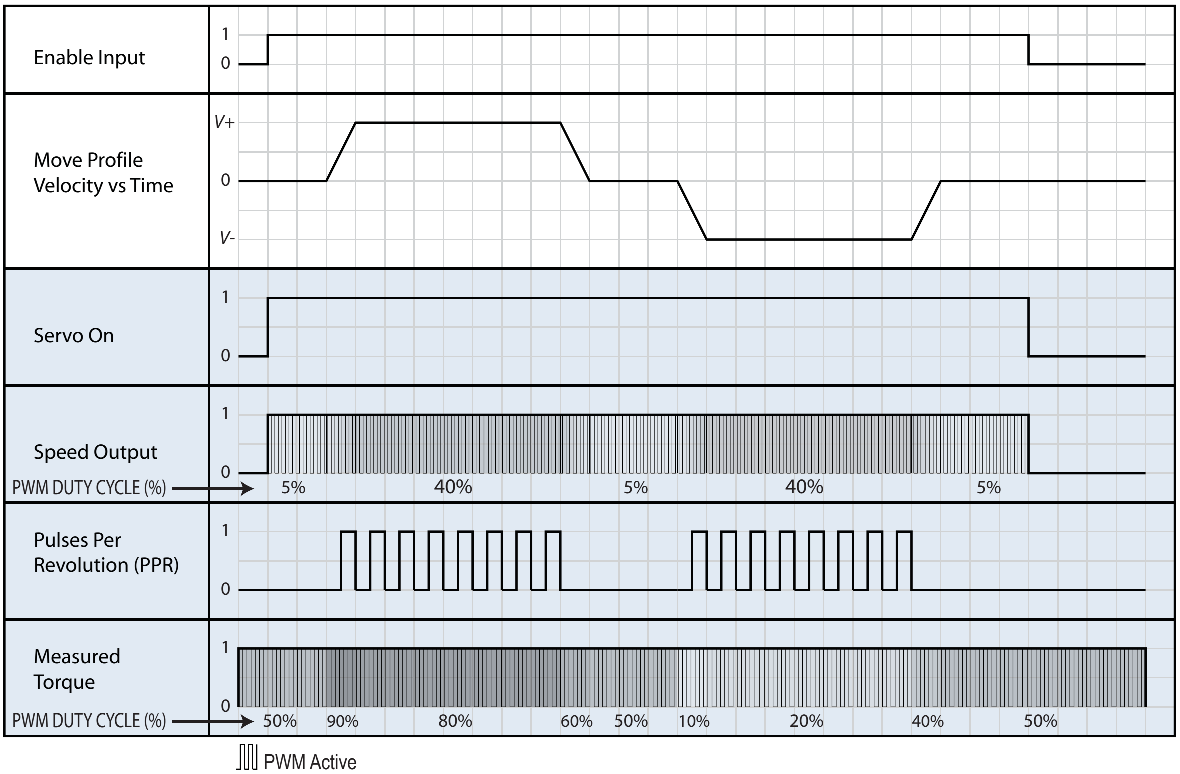
Using the **Servo On** HLFB mode, ClearPath can indirectly control power to devices such as a 24V "power-off" brake. See sketch below for example wiring details.




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

## 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*.

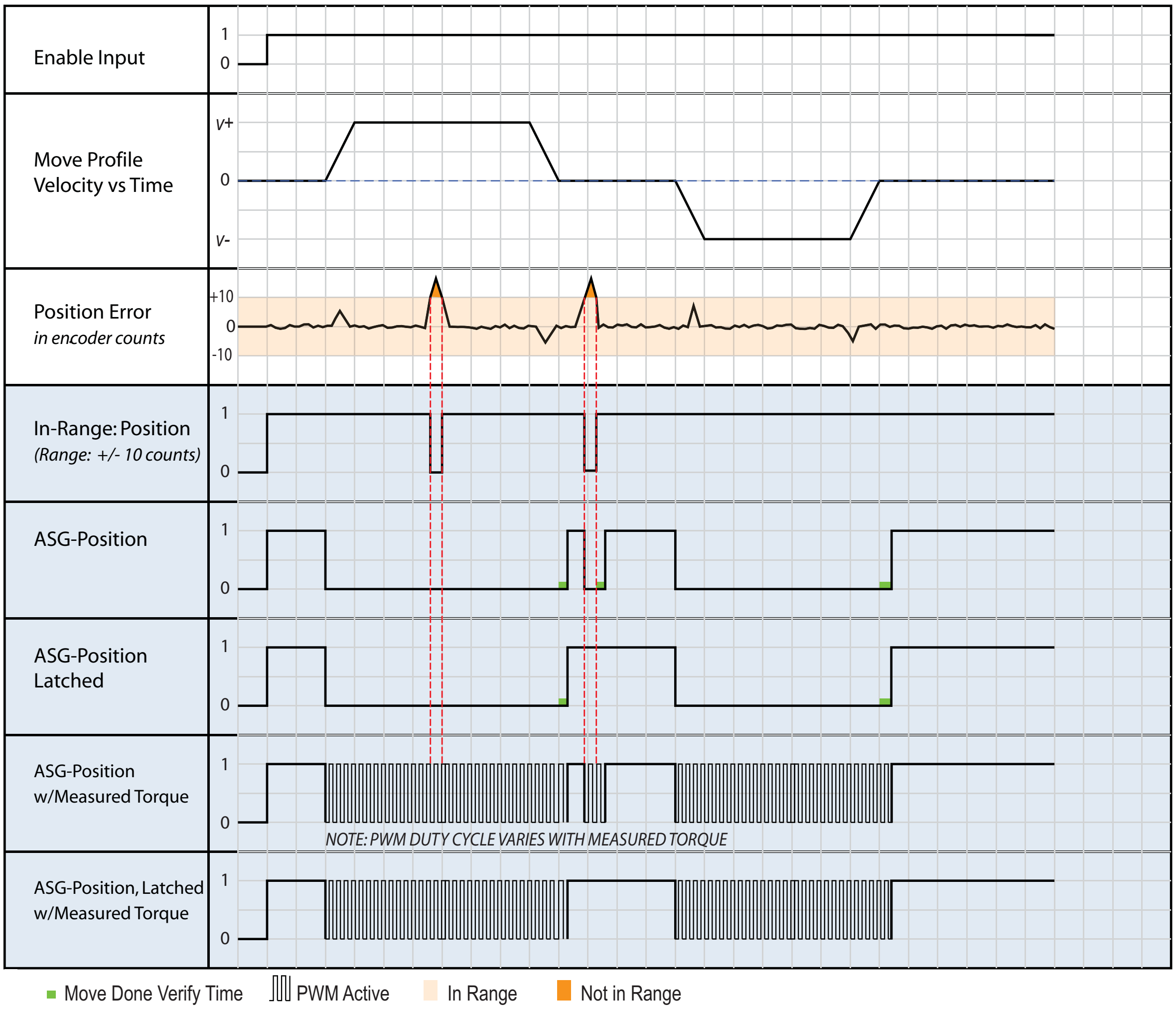
### Measured Torque

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:

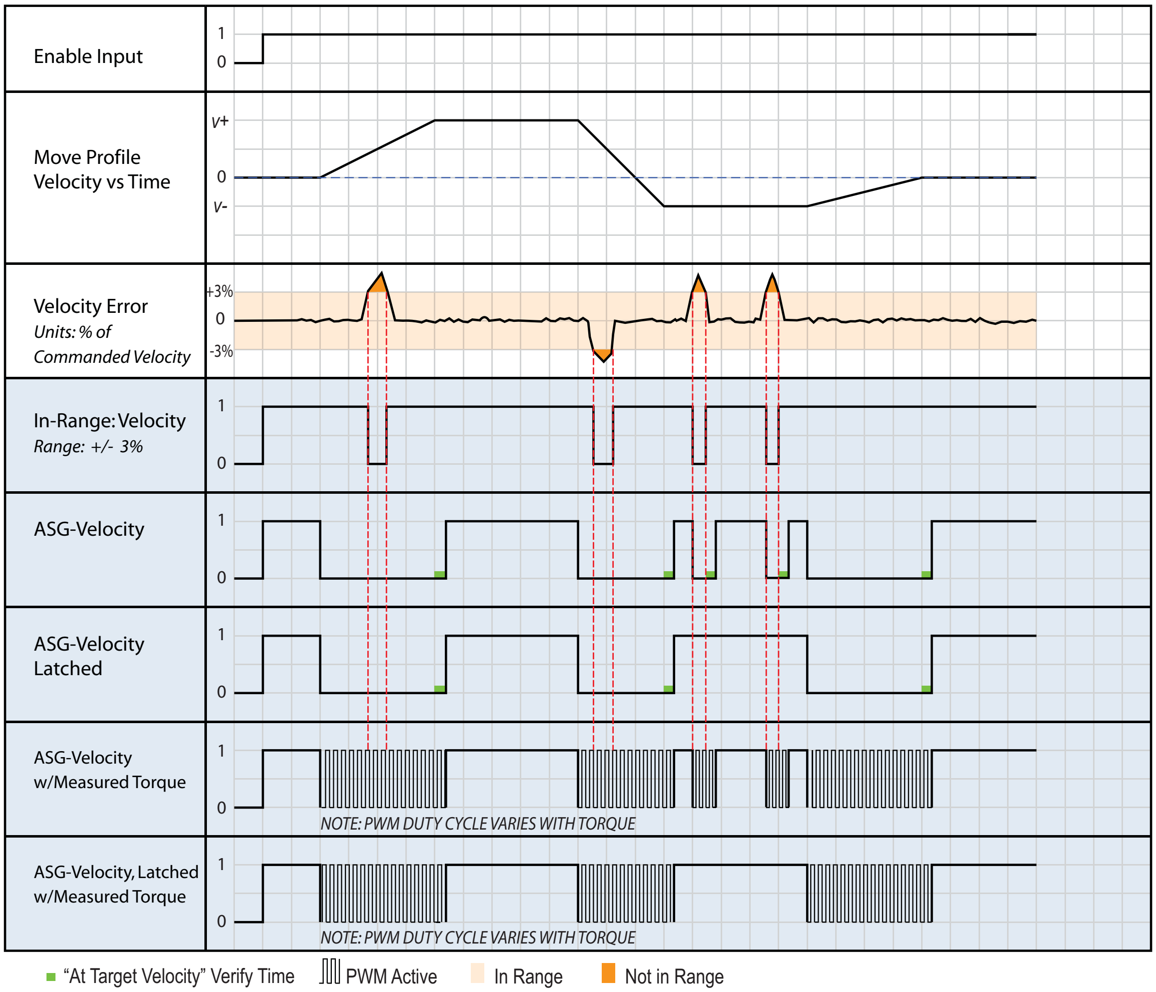
- 5% duty cycle = 100% peak torque, CW direction
- 50% duty cycle = zero torque
- 95% duty cycle = 100% peak torque CCW direction.

### 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.

# Software (ClearPath MSP)

## Section Overview

This section includes the following topics:

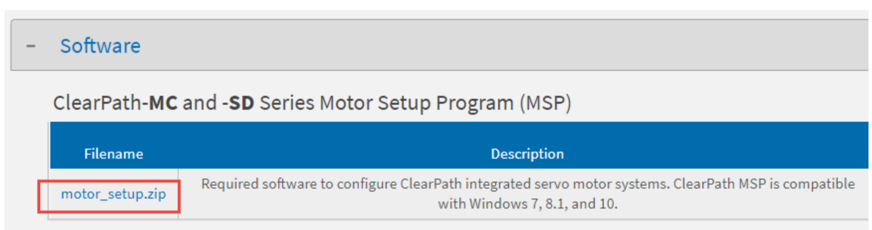
- ClearPath MSP System requirements
- Installing ClearPath MSP software
- Communicating with ClearPath
- Tour of ClearPath MSP
- Overview of ClearPath advanced features

## Minimum System Requirements

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

## Installing MSP

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



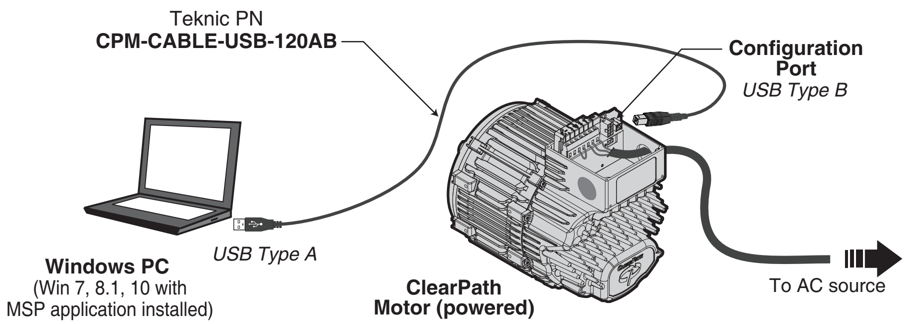

## Communicating With ClearPath

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

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

## ITEMS REQUIRED FOR COMMUNICATION SETUP

- A powered up ClearPath motor
- A PC running Windows 7, 8.1, 10 with ClearPath MSP installed
- A USB cable (Type A to Micro-B) that supports high speed data transfer. **Important:** "Charging only" cables will not work.




***ClearPath Communication Setup***

## FIRST-TIME COMMUNICATION SETUP

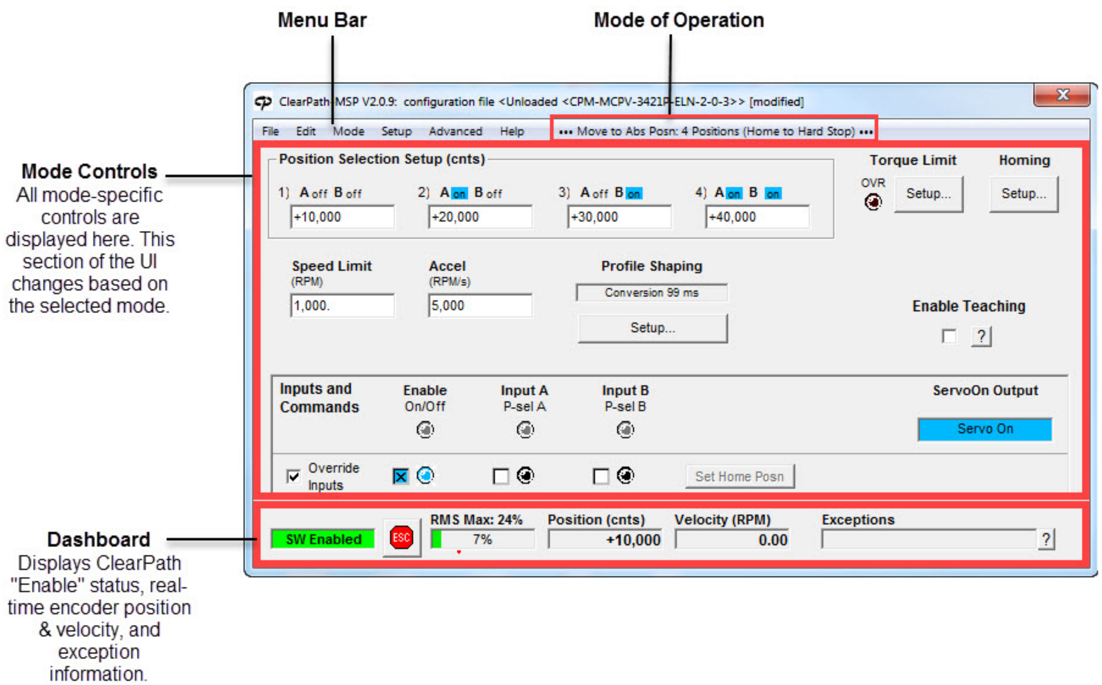
1. **Install MSP** software on a Windows PC. See previous page for Minimum System Requirements.
2. **Power up your ClearPath motor.**
3. **Connect ClearPath to the PC** with a USB Type A to B cable.
4. **Wait!** In most cases Windows will detect the connected ClearPath and install the correct USB driver 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




***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.

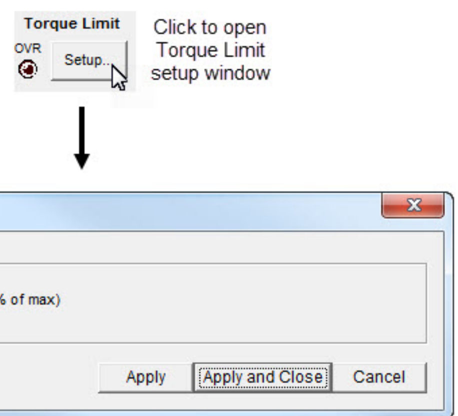
In addition, **Advanced Settings** allow you to specify different torque limits for each direction of travel, and dynamic torque limits based on motor position (Zone Limits).

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).

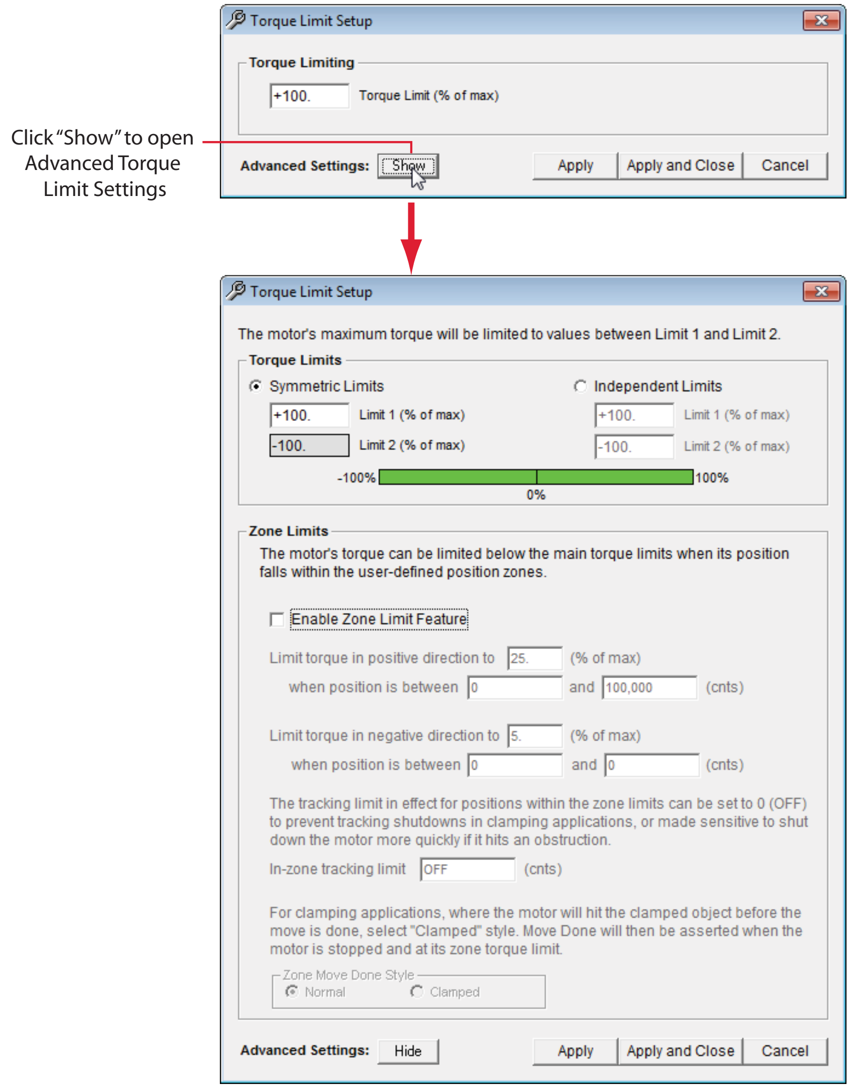
**Negative torque (-)** = torque applied in the **clockwise** direction of rotation (looking into the motor shaft).




***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).

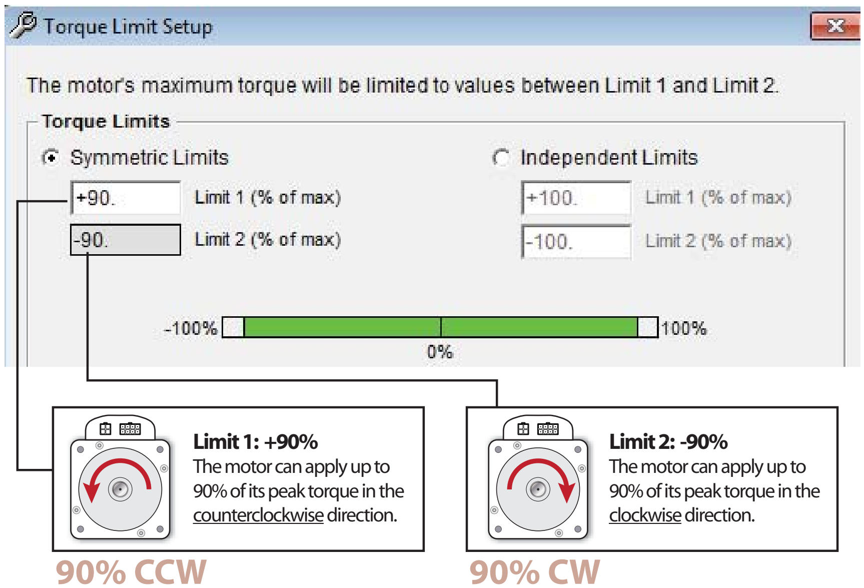



***Advanced Torque Limit Setup dialog***

### Symmetric Torque Limits

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

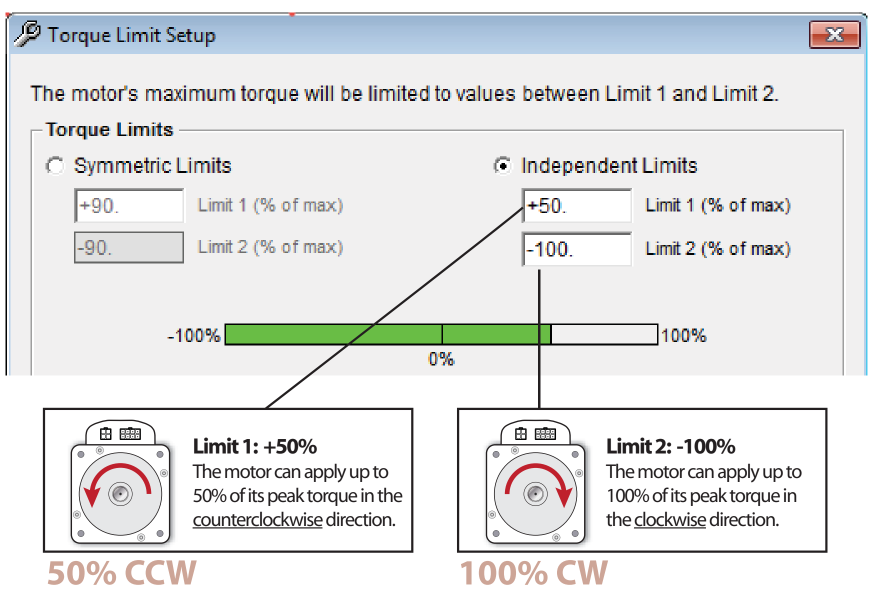
In the example below, torque is capped at 90% of the motor's peak torque in both the CW (-) and CCW (+) directions of rotation.




***Symmetric Torque Limits***

### Independent Torque Limits

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

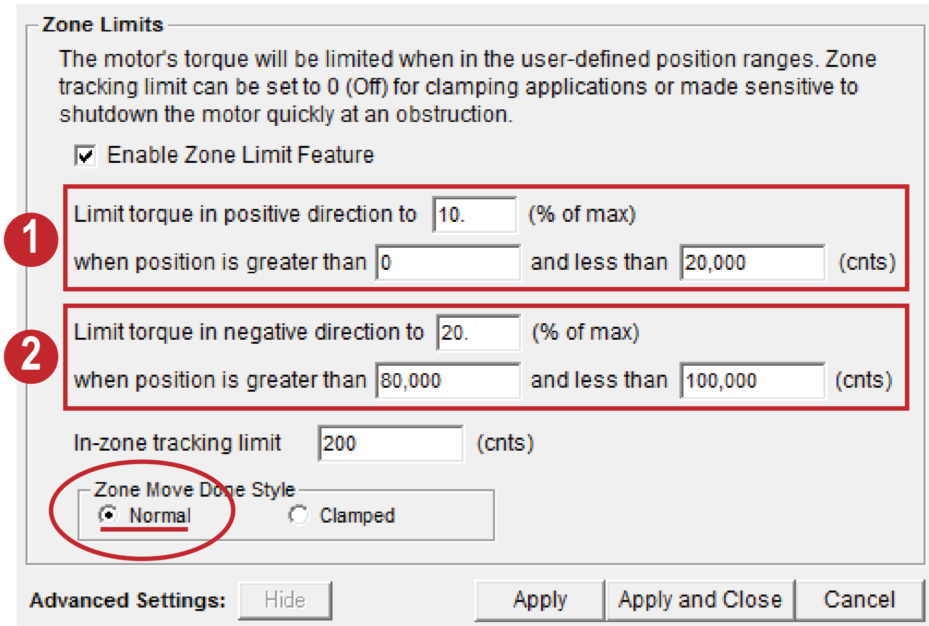


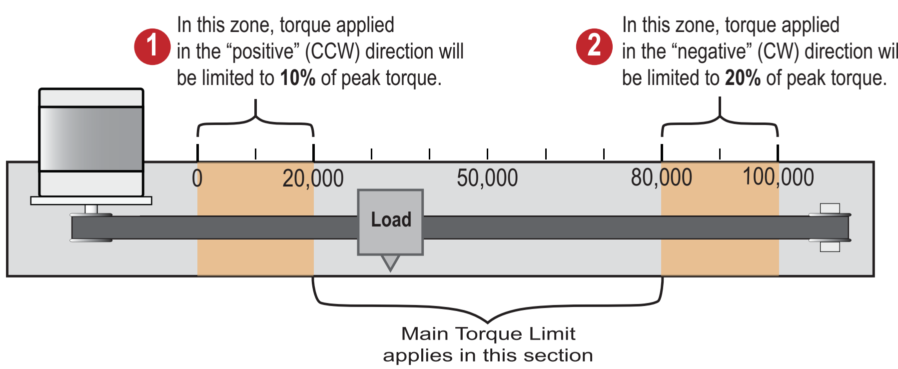

***Independent Torque Limits***

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

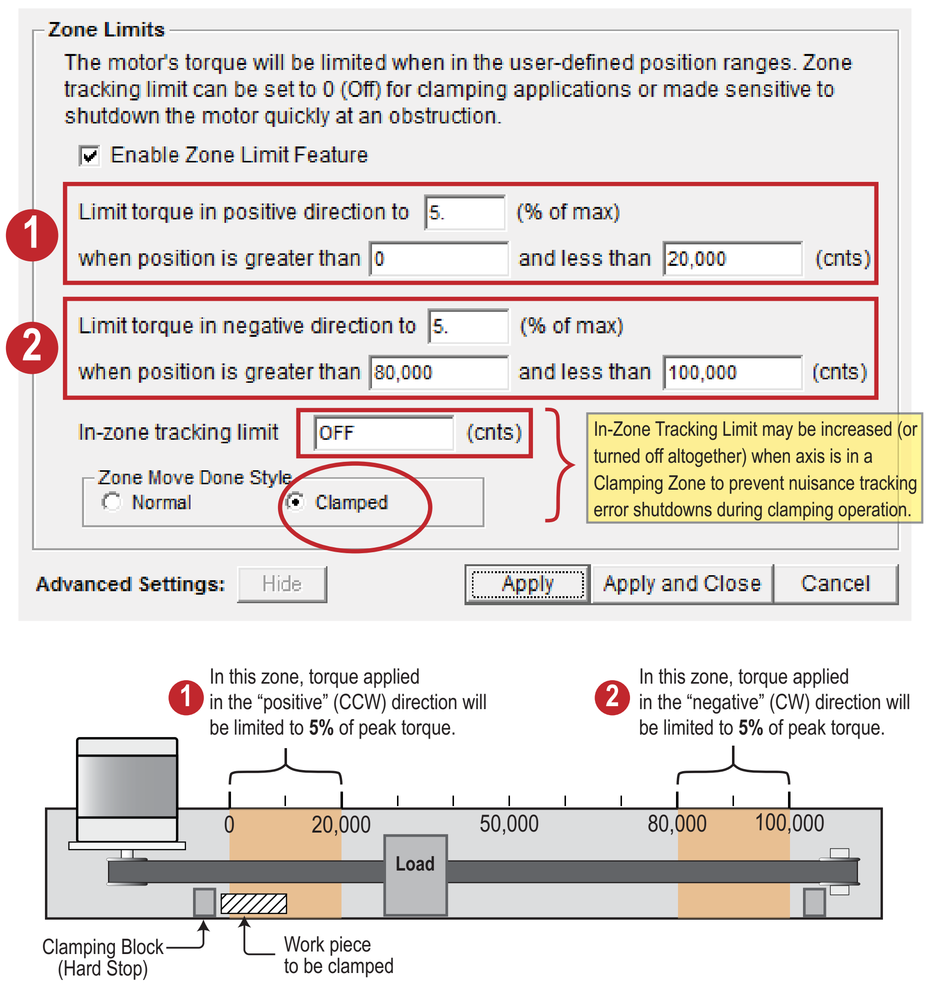
### Zone Limits (Clamped)

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".

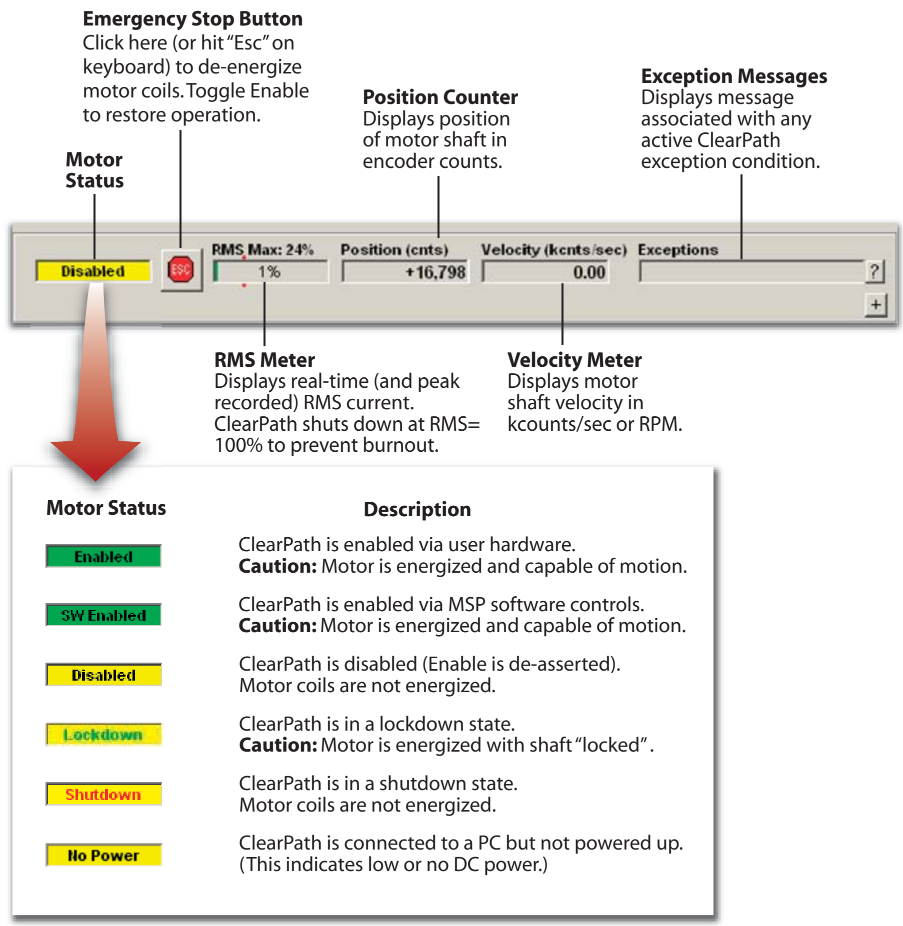
***Application Tip:*** *When moving the motor into a clamping position, you must send enough pulses to ensure that the motor is fully pressed into the object being clamped.*




***Zone 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.




***MSP Dashboard***

## 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.

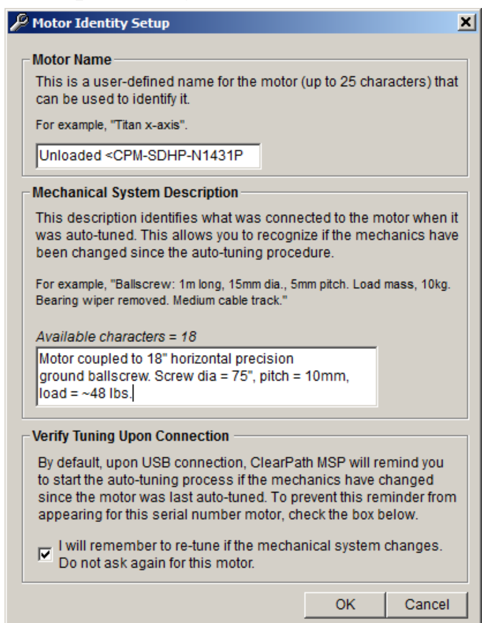
**Export XML File.** This command is primarily used by Teknic engineers to capture motion data for analysis and documentation purposes.

**Firmware Update.** Used to update ClearPath 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 motor, if desired.




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

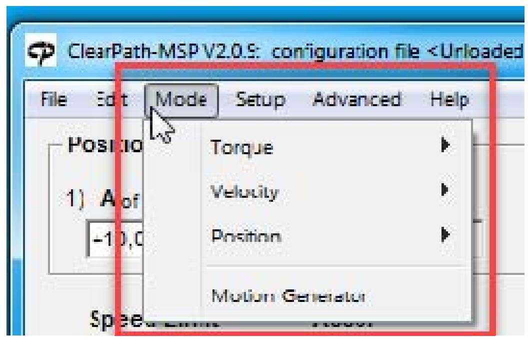
**Reset RMS Peak Note:** This applies to the RMS Meter in the Dashboard section of MSP. Click this menu item to reset *RMS Max* (this is the maximum RMS value recorded since last reset).

### MODE MENU

Select ClearPath operating modes from this drop down menu. Note: the number and type of available operating modes varies by ClearPath model. ClearPath modes of operation are covered in greater detail later in this document.

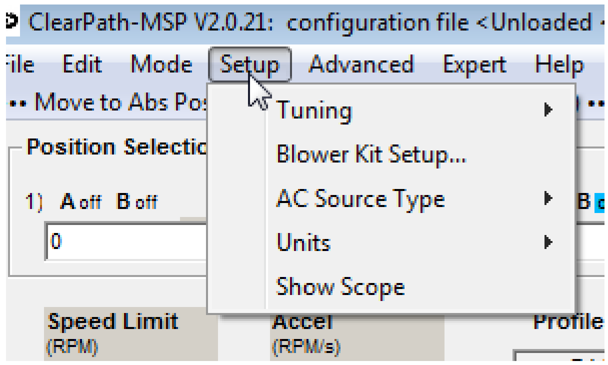
**Motion Generator**

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*

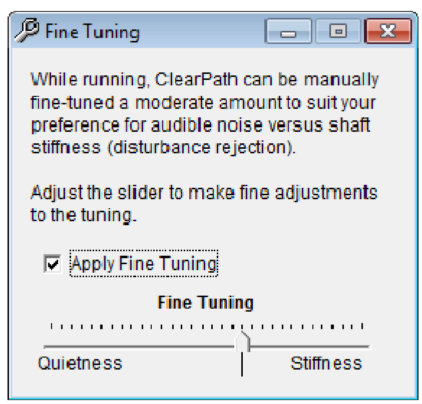
### Tuning>Auto-tune...

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.

### Tuning>Fine Tuning...

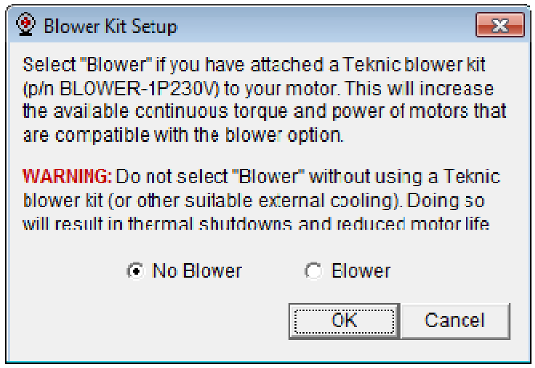
**Fine Tuning.** This menu item provides a convenient way to "touch up" tuning performance. Turn on the control by checking Apply Fine Tuning. Move the slider left for quieter performance, move it right for increased dynamic stiffness. Uncheck to turn it off.




*Fine Tuning Controls*

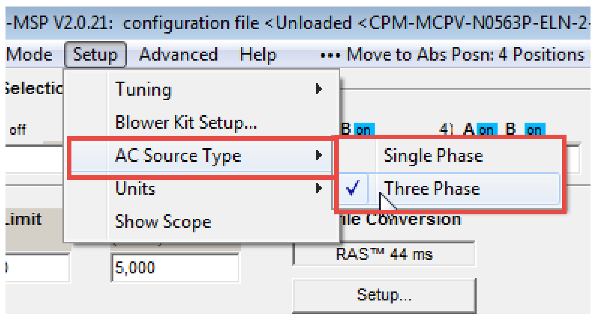
### Blower Kit Setup

Select "Blower" only if you have a blower.



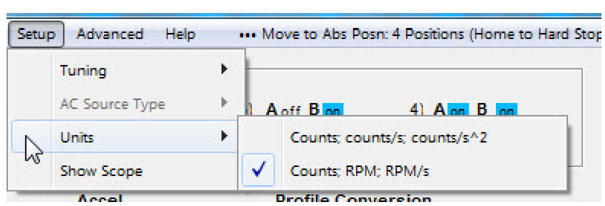

### AC Source Type

Select Single Phase or Three Phase per your AC source.




### Units

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




***Units selection menu***

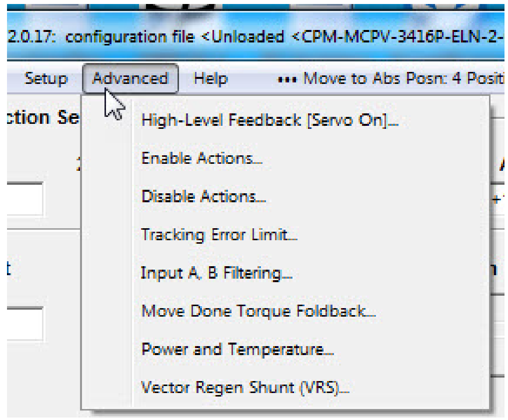
### Show Scope

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.

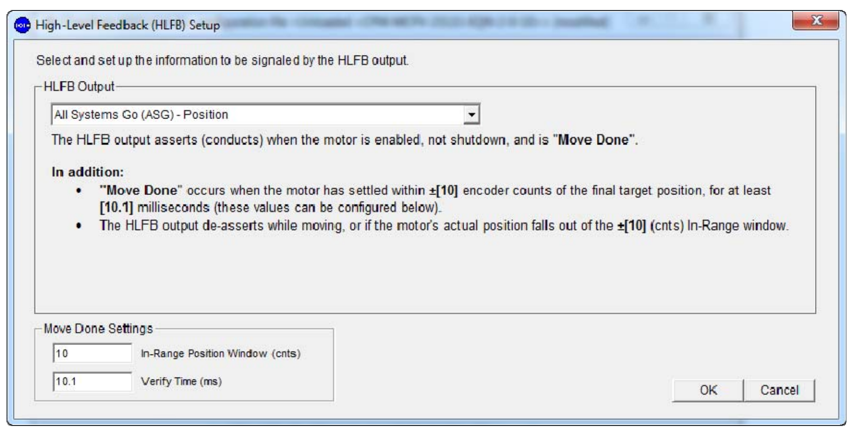



***Advanced Menu***

### 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.

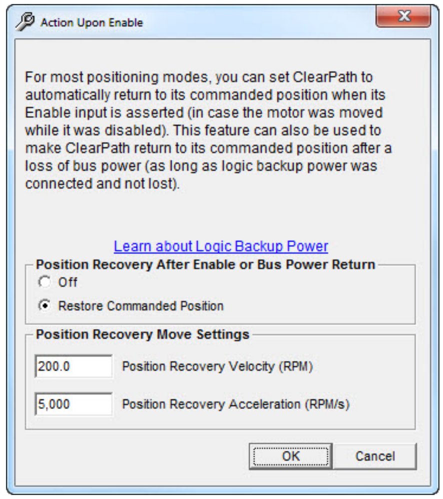
For more details on HLFB modes and timing, please refer to the *Inputs and Outputs* chapter of this manual.




***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.




***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 power to the motor must be on and uninterrupted 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.

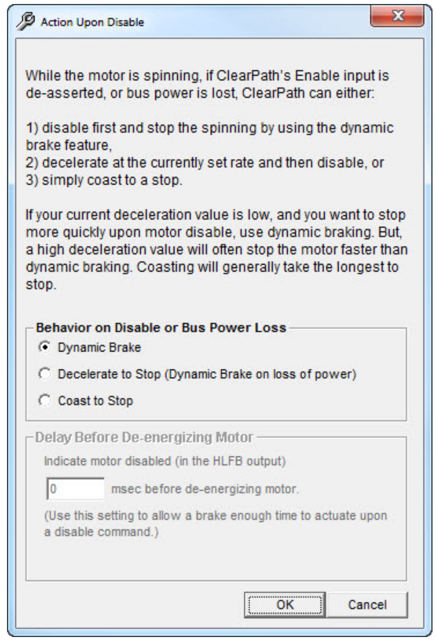
### Position Recovery: Example #2

*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: Uninterrupted 24VDC Logic Backup Power is required.*

**Solution:** If Position Recovery is active, and the Logic Power Backup is present, when main DC bus power is restored the motor will automatically return to its last commanded position.

**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.

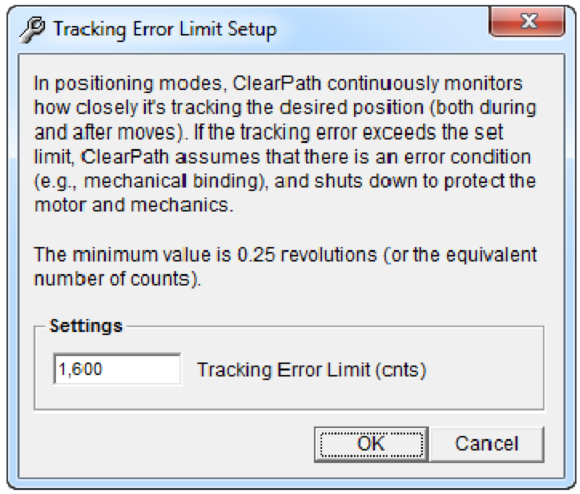



***Action Upon Disable dialog***

### Tracking Error Limit...

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

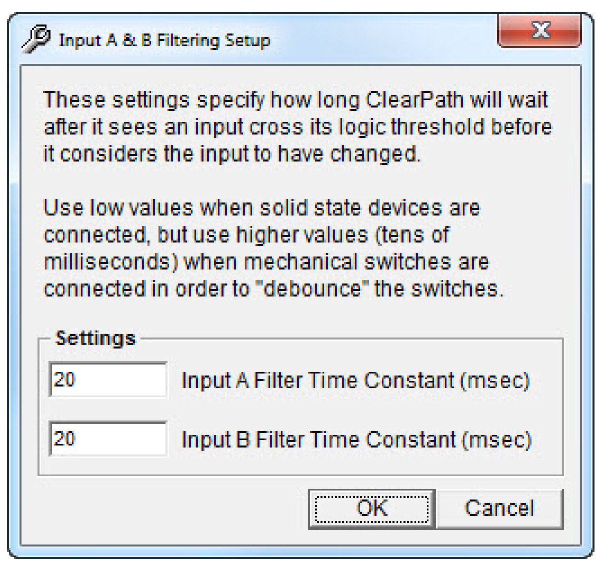
Tracking Error is the difference between ClearPath's *commanded* position and its *actual* position (in units of encoder counts). The phrase "Tracking error" is used interchangeably with the phrase "position error" throughout this manual.




***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.

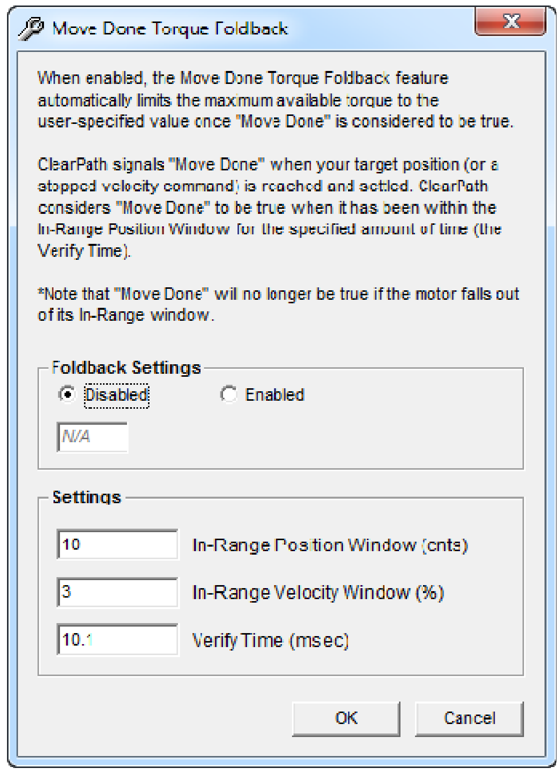



***Input Filtering Setup***

### 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.

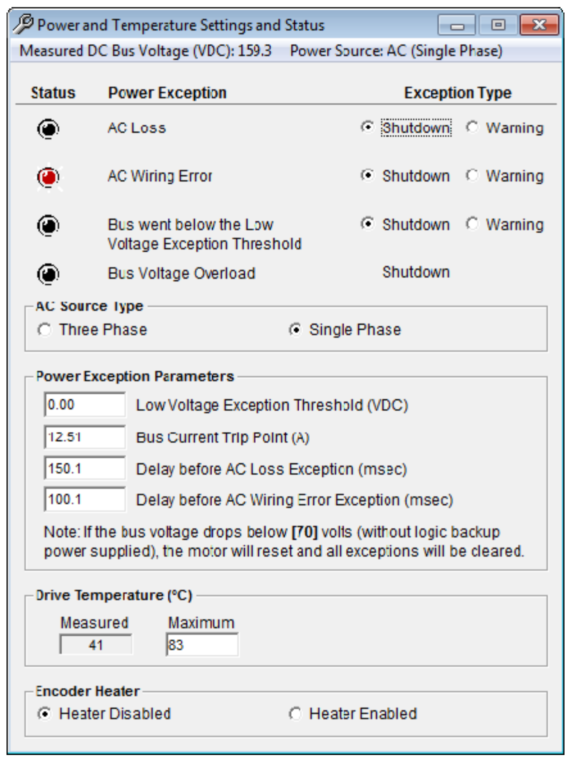



***Move Done Criteria Setup***

**Power and Temperature Settings and Status...**

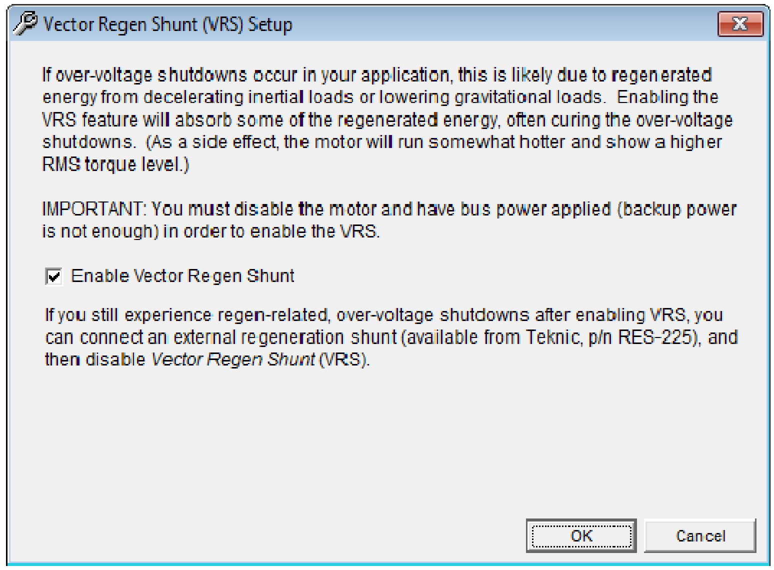
Use this dialog to:

- Set whether the AC source type is single phase or three phase. This setting must match your actual wiring configuration or the motor will not function properly.
- Define how ClearPath responds to different types of power (warning versus shutdown).
- View the current temperature of your ClearPath drive board.
- Set the temperature threshold at which ClearPath throws an over-temperature shutdown. This should typically remain at the default setting.




***Power and Temperature Settings and Status***

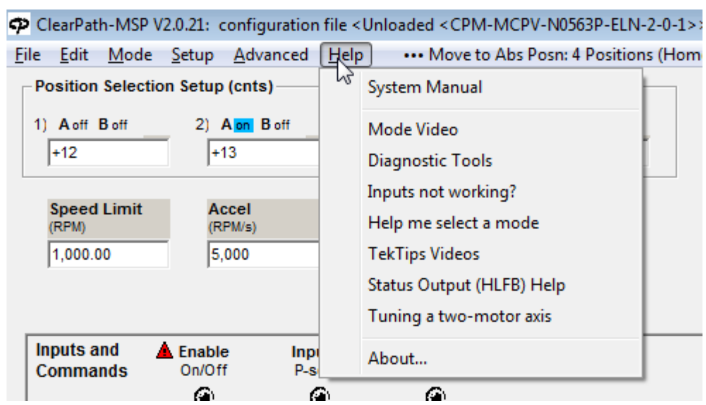
**Vector Regen Shunt (VRS)...**




***Vector Regen Shunt (VRS) Setup***

## HELP MENU

The Help menu provides additional resources with respect to ClearPath 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's "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

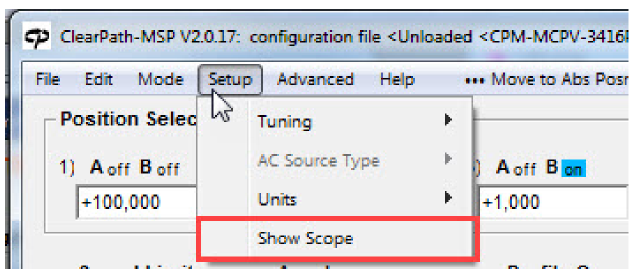
This section contains a discussion of the main features and functions of the MSP Scope.

## 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 indispensable 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***

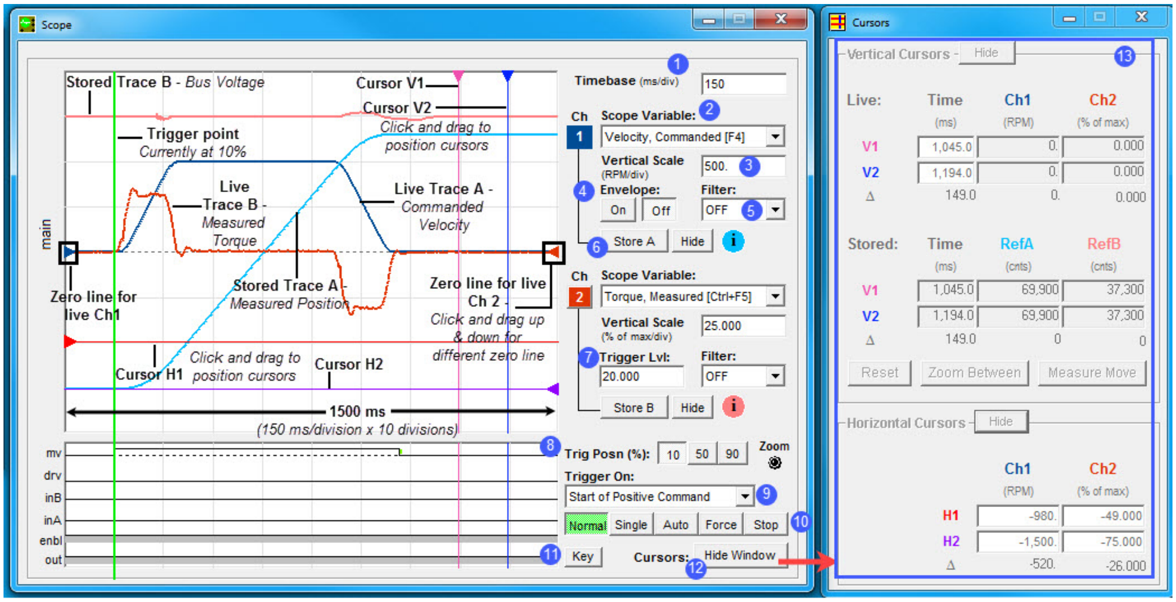
## Scope Features

- 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.




***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

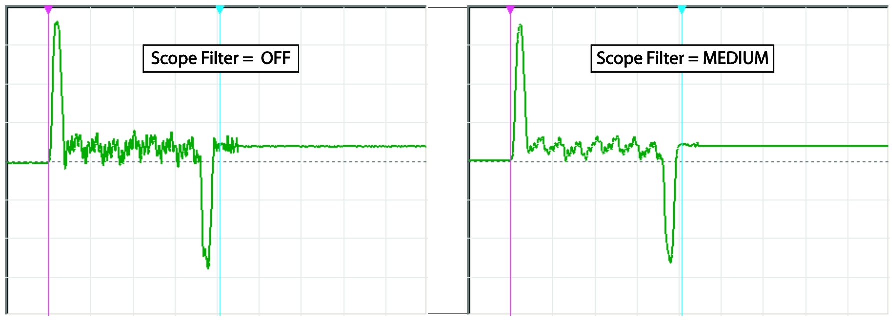
| Scope Variable | Definition |
|---|---|
| Position Error [F3] | Position Error (also referred to as "Tracking Error") displays the difference between commanded position and actual position. |
| Velocity, Commanded [F4] | Commanded Velocity displays the actual commanded velocity vs. time motion profile 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 non-zero 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.

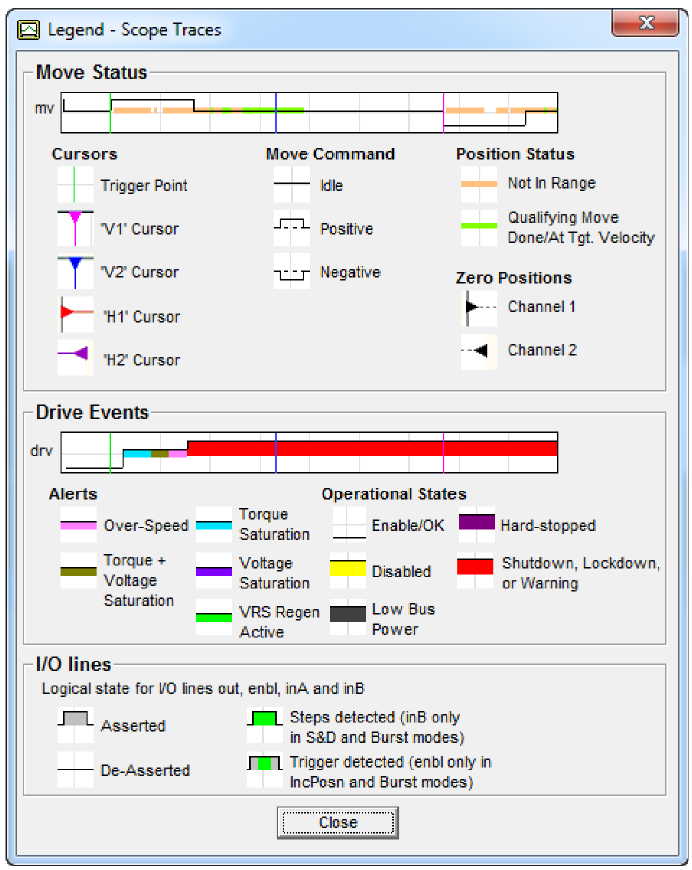
**9 The Trigger Source ("Trigger On")** drop down menu lets you choose what condition(s) must be met before scope data collection begins. The following Trigger Source options are available:

| 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.

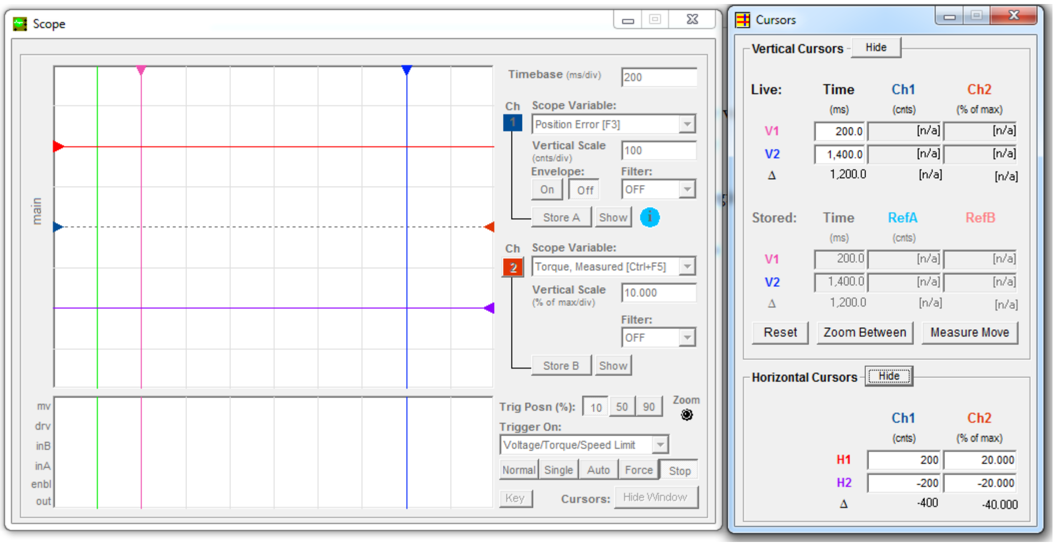
**11 Legend - Scope Traces -** This is a visual key to the symbols you will see on the MSP Scope display.




***MSP Scope Legend***

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

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



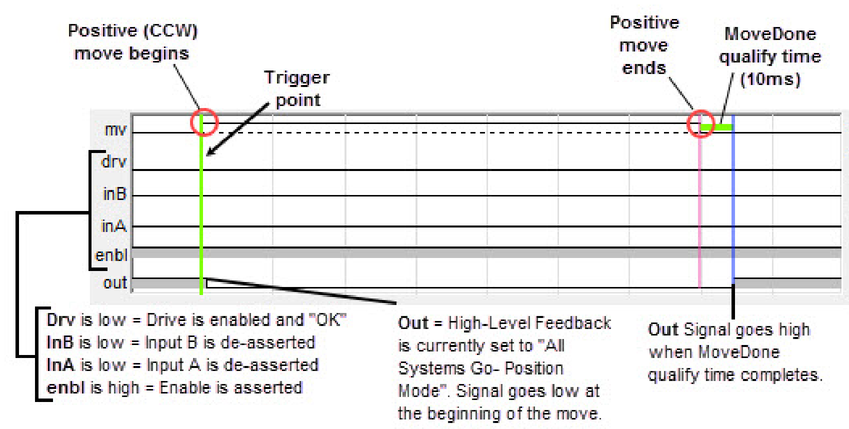

***MSP Scope Display (left) and Cursors window (right)***

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** automatically 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

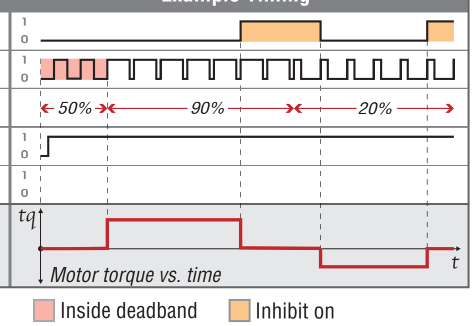
### Mode Description

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 | Example Timing |
|---|---|---|---|
| **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:**

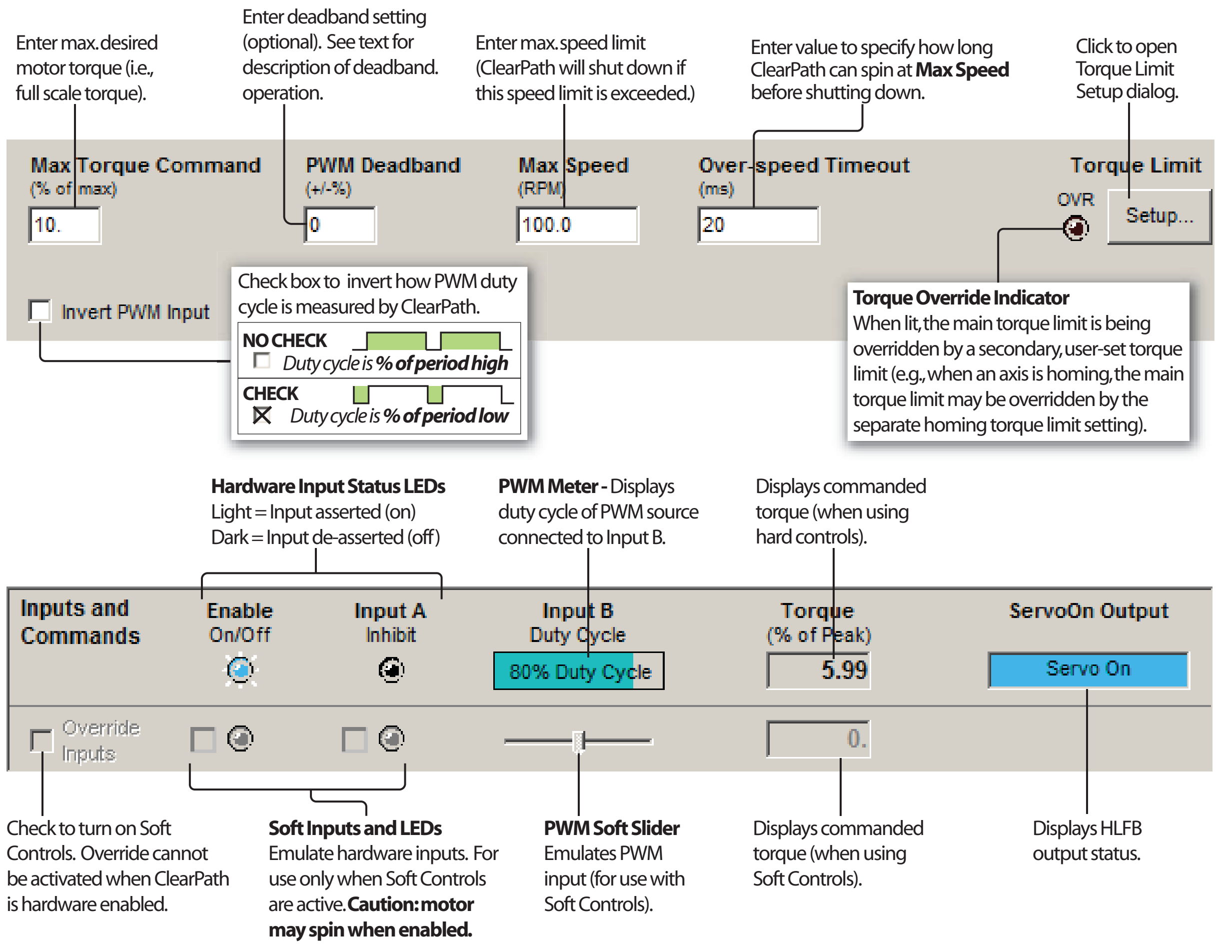
- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

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

***or***

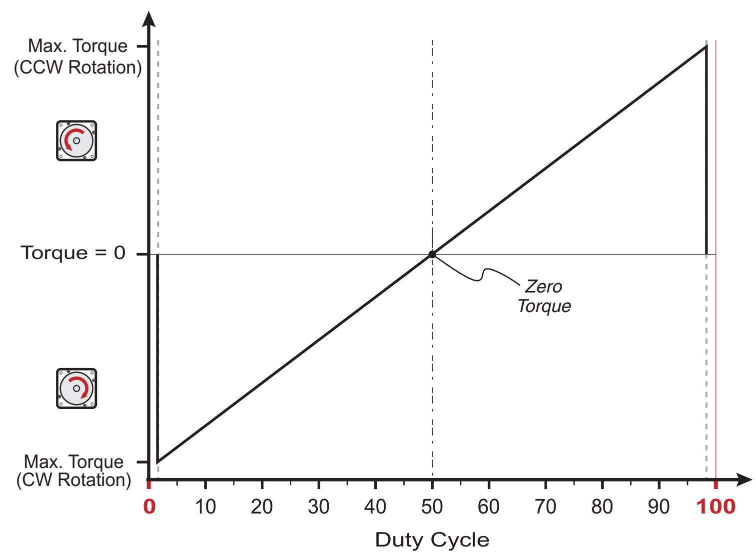
- Set a PWM deadband: to help reliably command zero torque. Refer to text on following pages for details on deadband setup.

## MODE CONTROLS



### Relationship of PWM duty cycle to motor torque

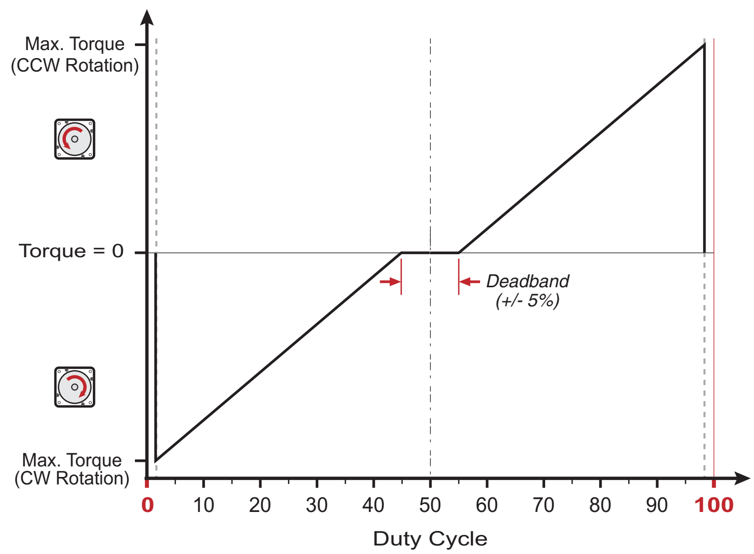
- Shaft torque increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft torque increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50% from either direction, motor torque approaches 0.
- 0% and 100% duty cycle (static low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



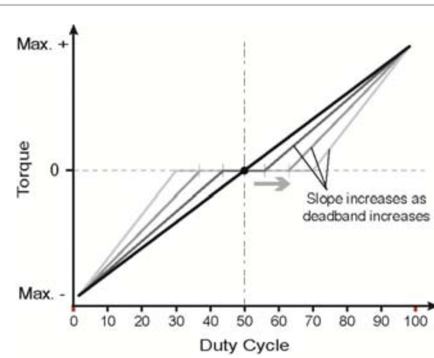

***+/- 5% PWM deadband setting***

**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)

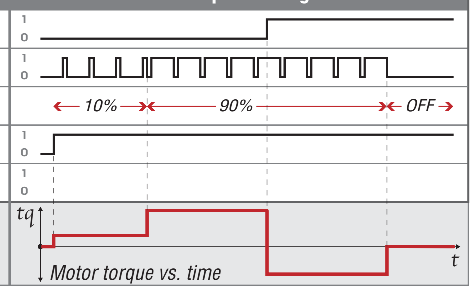
Available on
MCVC + MCPV

### 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.

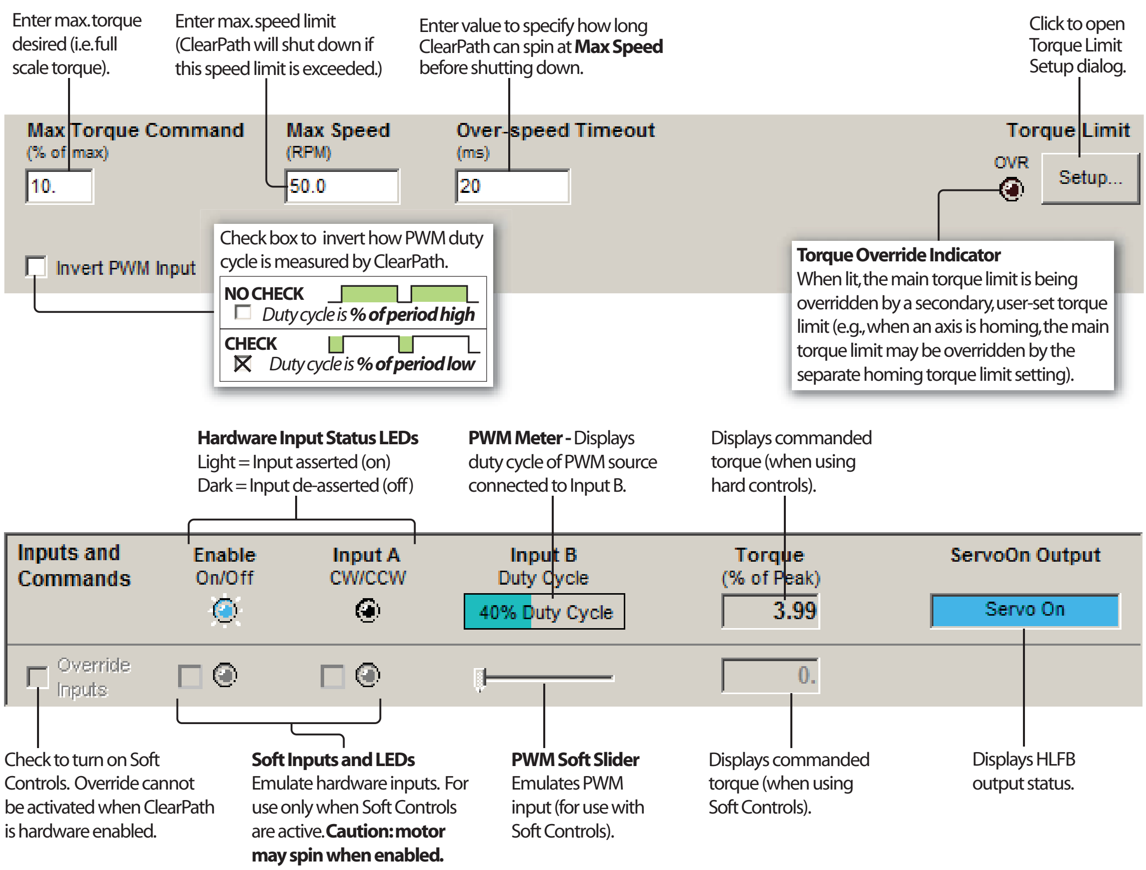
**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired torque.

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

**Notes:**

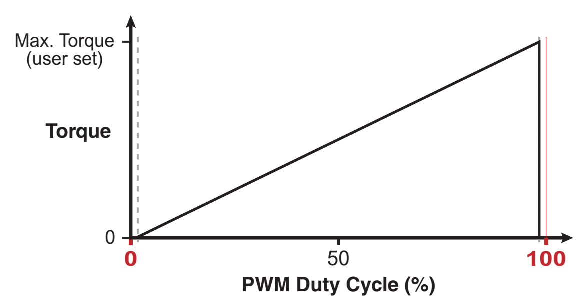
- PWM input frequency range: 20 Hz to 30 kHz.
- If the PWM signal is off for 50mS (or more) the PWM input is considered off. This is interpreted by ClearPath as a zero-torque command.
- Disable time = 10 mS

## Mode Controls




**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

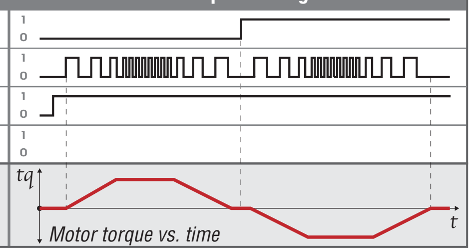
### Mode Description

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 700 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

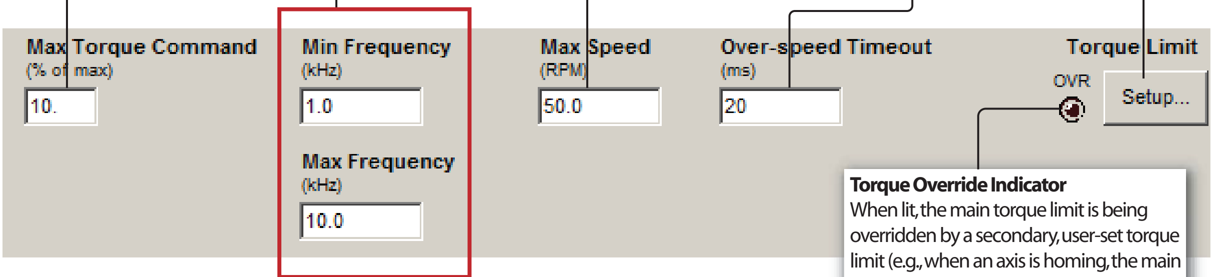
Enter max. desired motor torque (i.e., full scale torque).

**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.

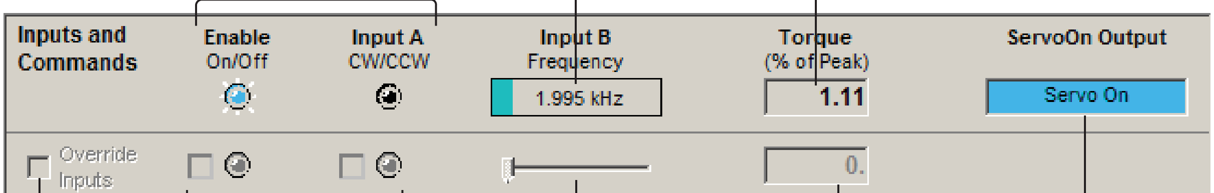



**Torque Override Indicator**
When lit, the main torque limit is being overridden by a secondary, user-set torque limit (e.g., when an axis is homing, the main torque limit may be overridden by the separate homing torque limit setting).

**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).




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.

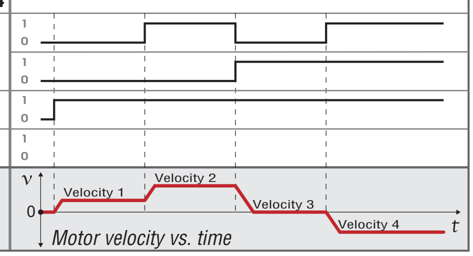
Assert the Enable Input to get started. Once enabled, ClearPath reads the state of Inputs A and B and immediately accelerates to the target velocity indicated. For example, if **Input A is high** and **Input B is low** ClearPath will ramp to “Velocity 2”. Change to a different velocity by changing Inputs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

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

| Signal | Function | Velocity Settings (logic levels) | | | |
|---|---|---|---|---|---|
| | | 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.

Example Timing




*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.

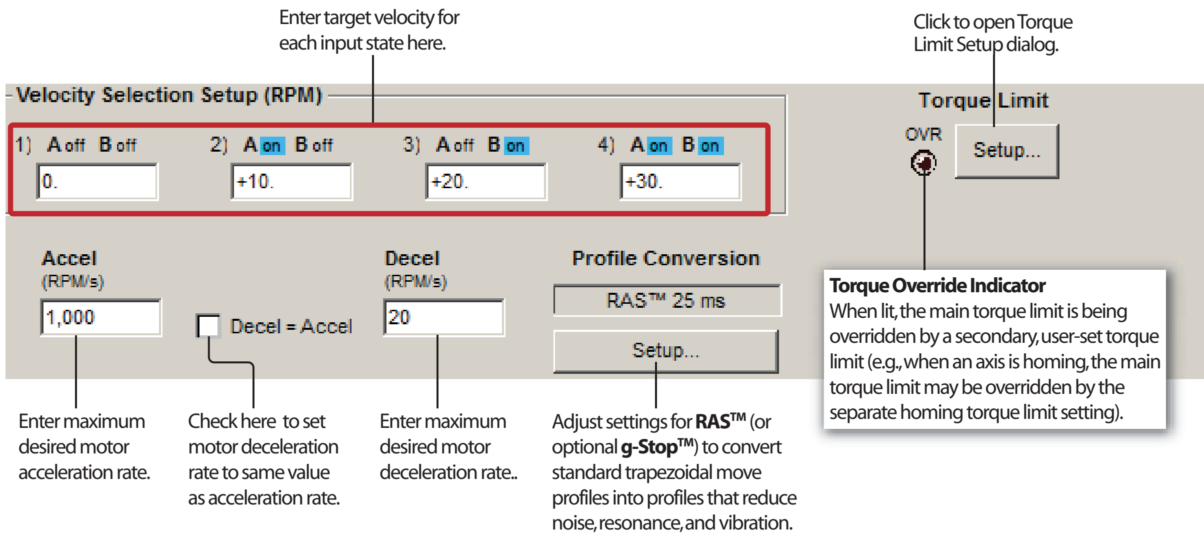
**Input B -** This input, along with Input A, selects which of the four defined velocities ClearPath will run at.

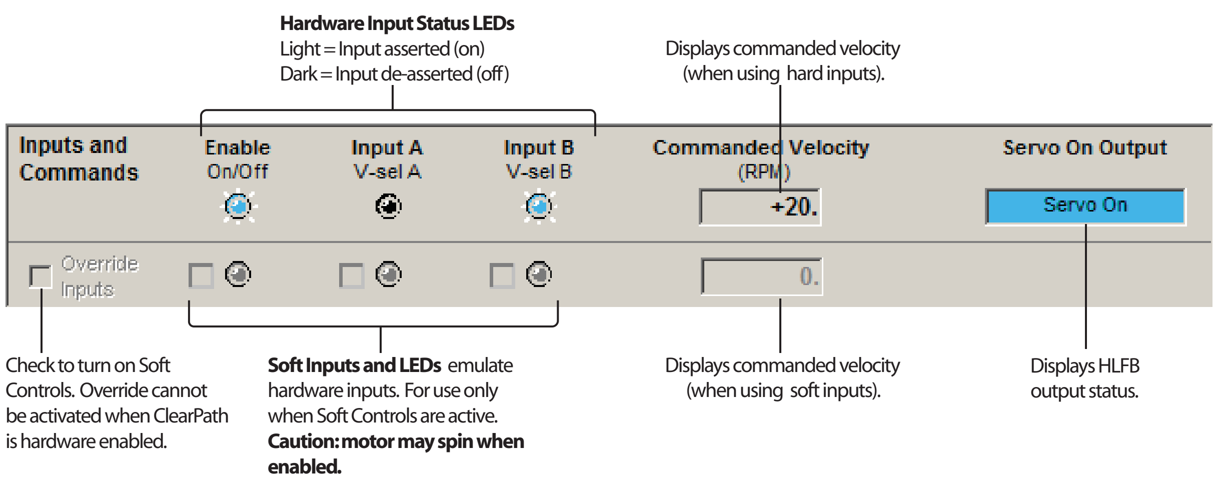
**Output (HLFB) -** See HLFB section for available modes.

**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



# Spin On Power Up

Available on
**MCVC + MCPV**

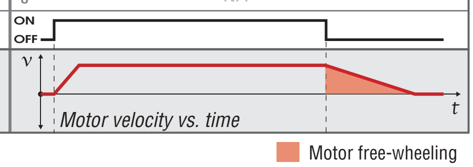
## Mode Description

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 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.
**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

## I/O Functions

**Enable Input -** Not used.

**Input A -** Not used.

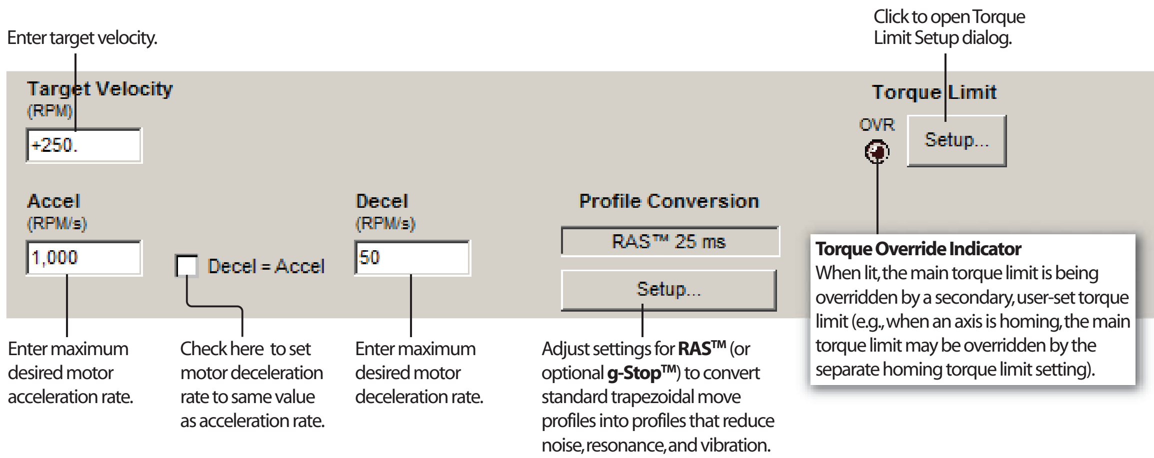
**Input B -** Not used.

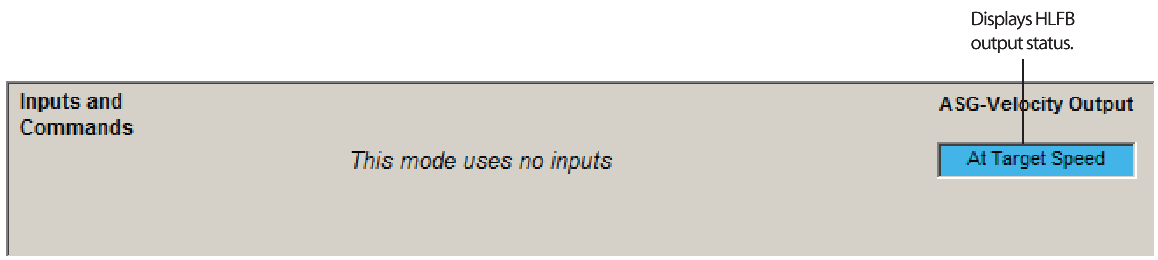
**Output (HLFB) -** See HLFB section for available modes.

**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



# Manual Velocity Control

## Mode Description

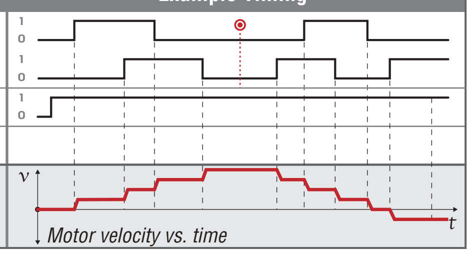
Available on
MCVC + MCPV

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.

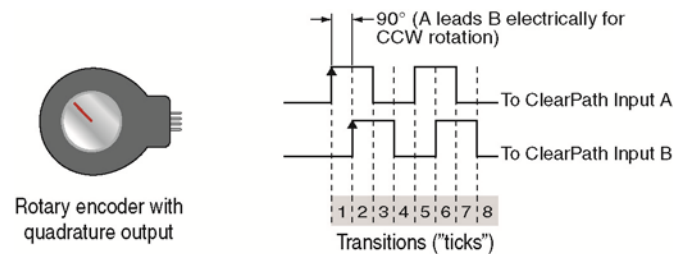
**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

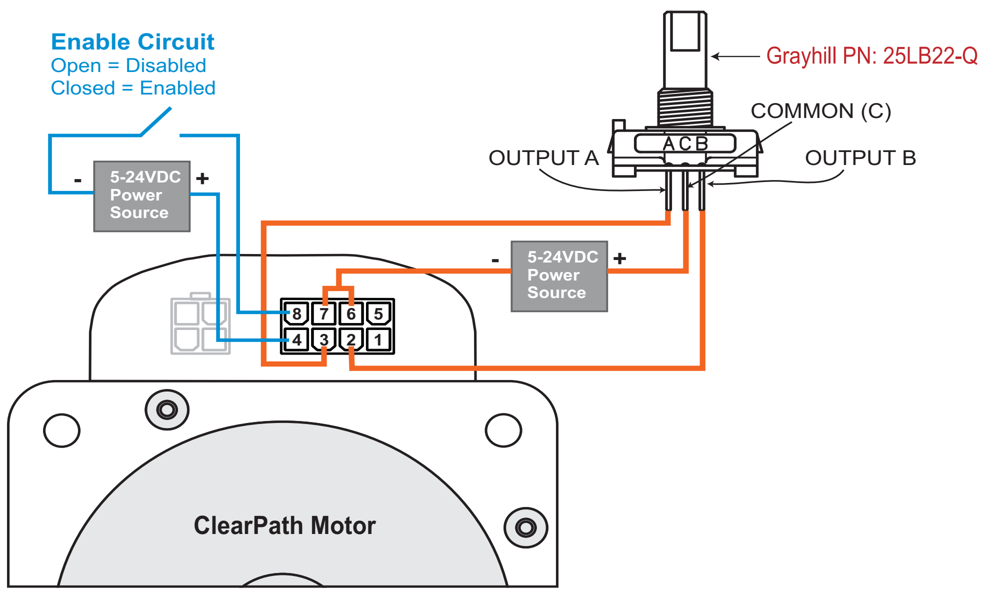
- Disable time = 10 mS
- Rotating the quadrature knob in one direction will cause an increase in speed; the other direction causes a decrease (which can be thought of as an increase in the opposite direction).
- If you want to only spin in only one direction, set one of the Max Velocity values in MSP (CW or CCW) to zero.

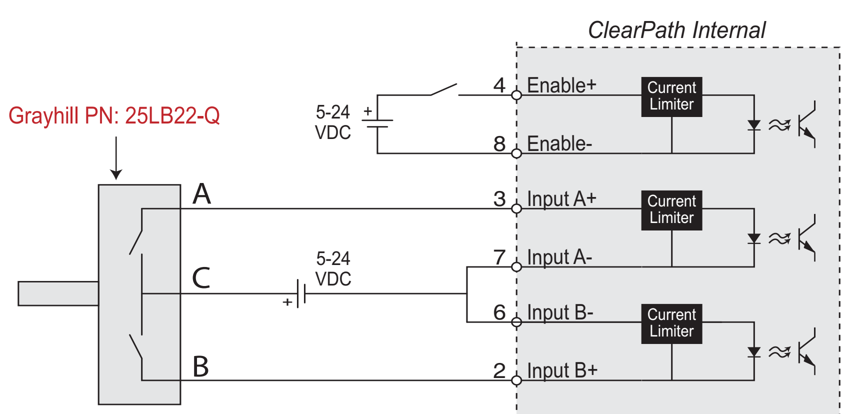
## The Quadrature Signal Source

To use this mode you'll need a quadrature output device (usually an encoder) that can generate two channel (quadrature A/B) 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.

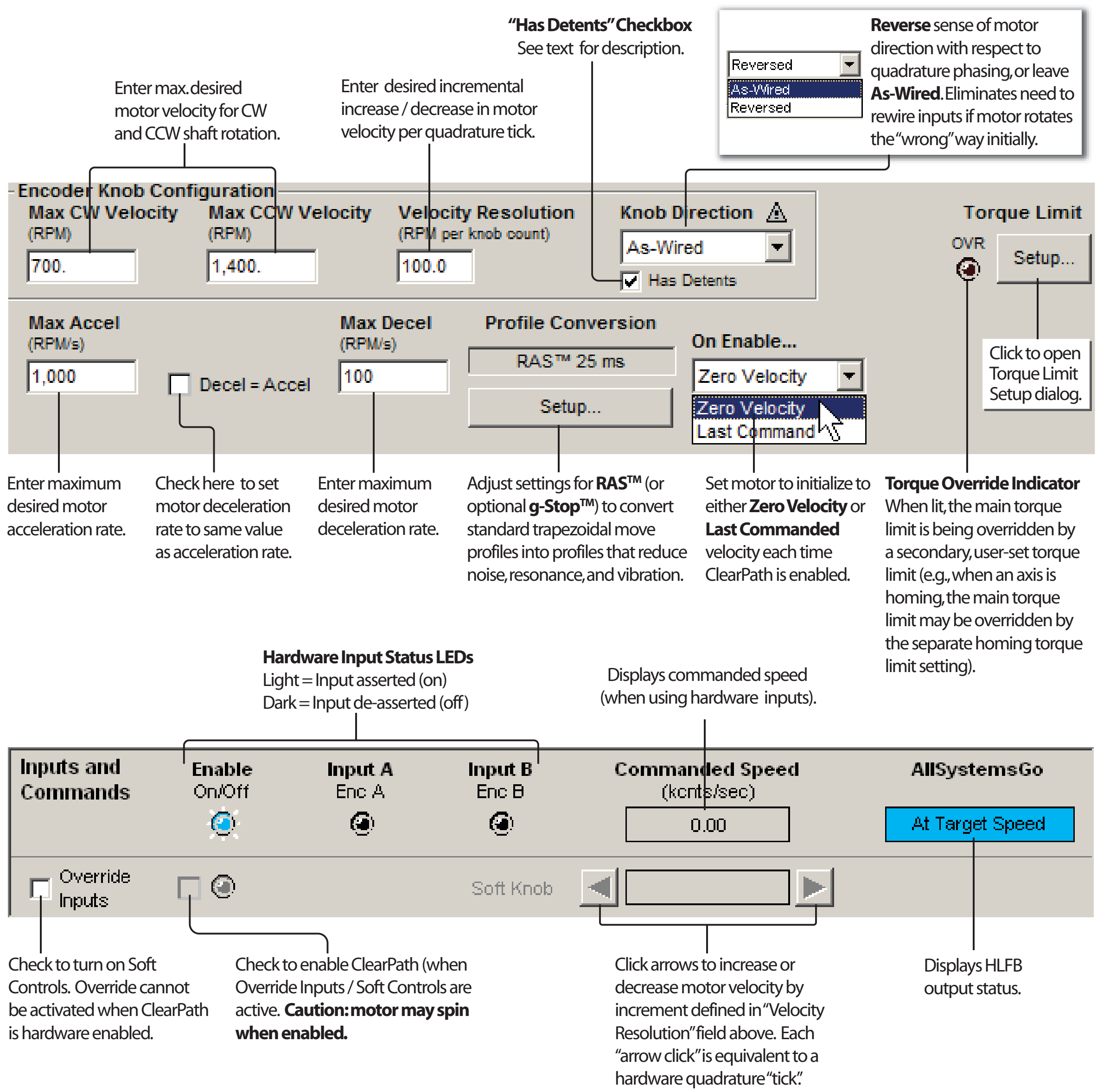



Example: Wiring a Mechanical Quadrature Output Device to ClearPath



## Mode Controls




## Description of Encoder/Knob Settings

### Max CW Velocity

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

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

### "Has Detents" Checkbox

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

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

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

Available on
MCVC + MCPV

## MODE DESCRIPTION

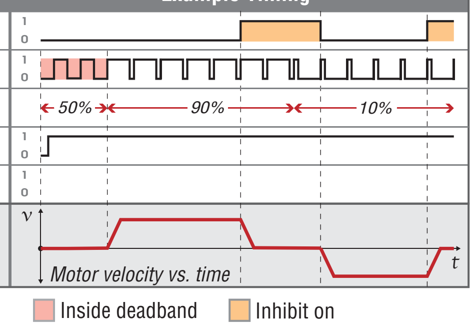
Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a velocity proportional to the duty cycle of that waveform. Or, use the PWM output from an H-bridge driver of a brushed motor setup and ClearPath becomes a high-performance drop-in replacement.

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.

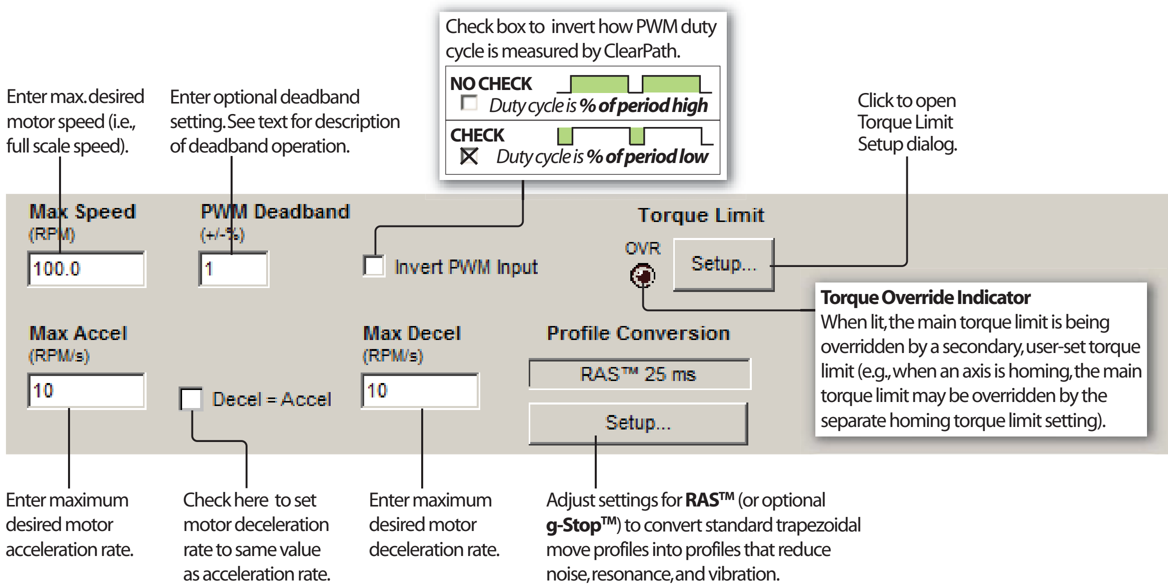
**Notes:**

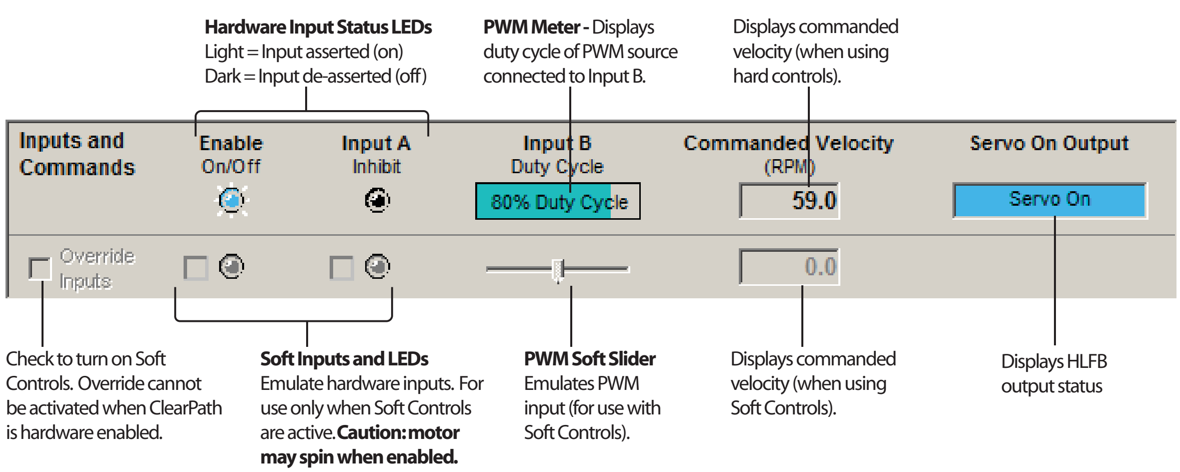
- PWM input frequency range: 20 Hz up to 30 kHz.
- The output of a standard H-bridge driver for a DC brush motor is bipolar PWM, so it can be used to allow ClearPath to replace a DC brush motor without changing anything else in the system.
- A 50% PWM duty cycle means zero speed; near 100% and near 0% 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).

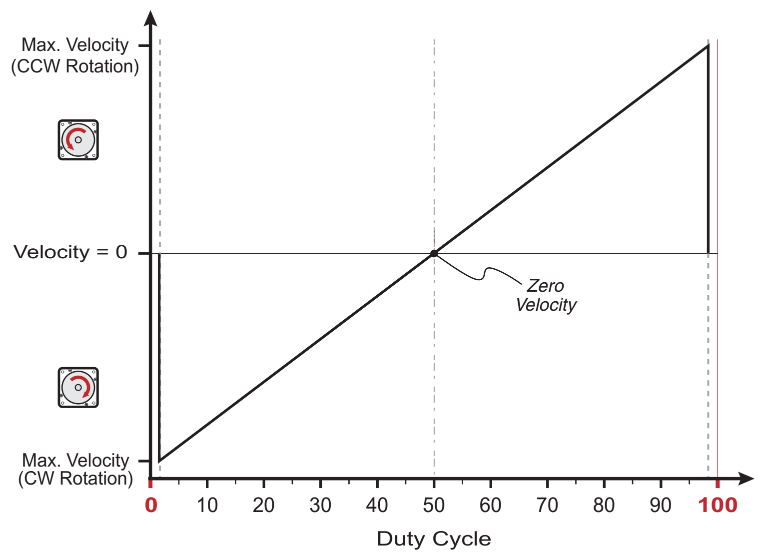
## MODE CONTROLS



### Relationship of PWM duty cycle to motor velocity

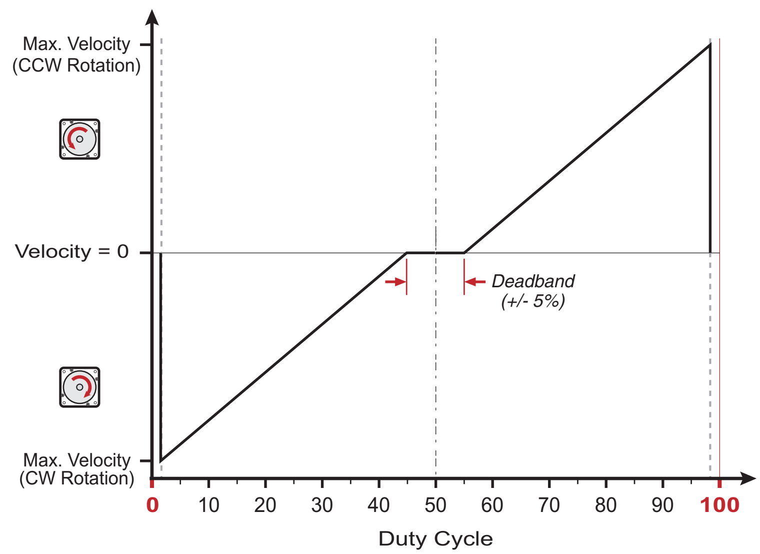
- Shaft velocity increases in the CW direction as PWM duty cycle decreases from 50% to 0%.
- Shaft velocity increases in the CCW direction as PWM duty cycle increases from 50% to 100%.
- As PWM duty cycle approaches 50%—from either direction—motor velocity approaches 0.
- In practice, O% and 100% (static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



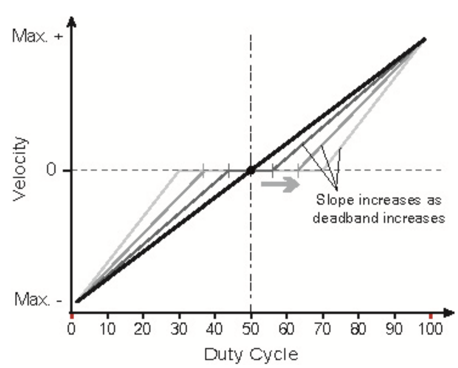

***+/- 5% PWM dead band setting***

**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.

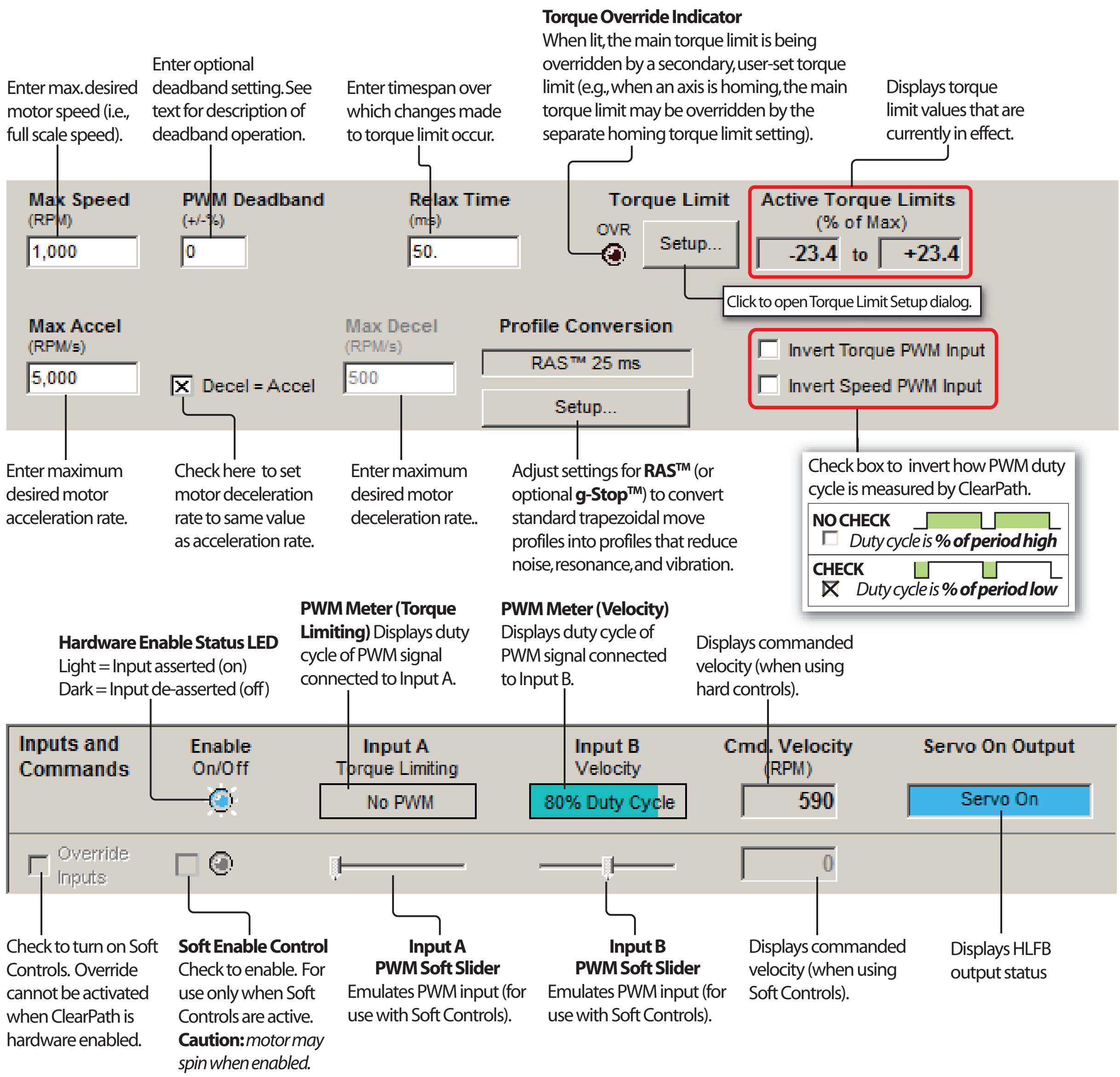
For **PWM torque limit control**, you can vary the active torque limit linearly between the two torque limit settings by varying the PWM duty cycle sent to Input A as follows:

- 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



## Follow Digital Velocity Command (Unipolar PWM Input)

Available on
MCVC + MCPV

### Mode Description

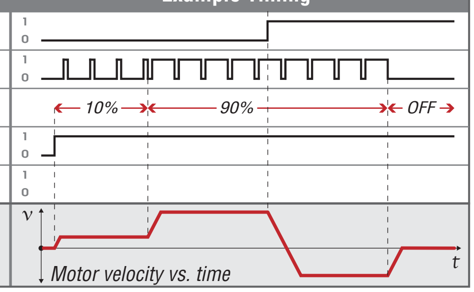
Connect a digital PWM waveform from your PLC or other device, and ClearPath will run at a speed proportional to the duty cycle of the PWM waveform.

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.

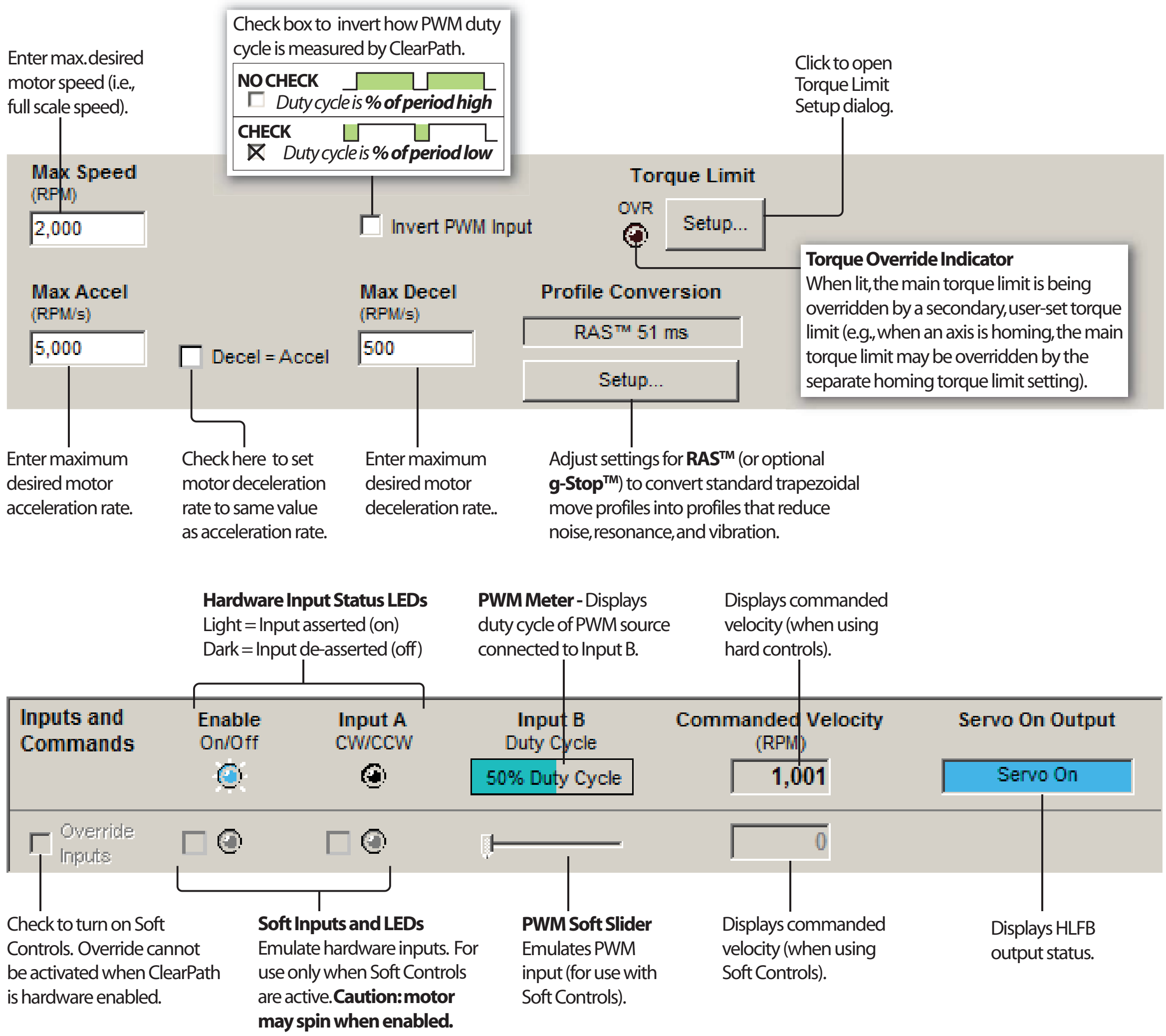
**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired speed.

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

**Notes:**

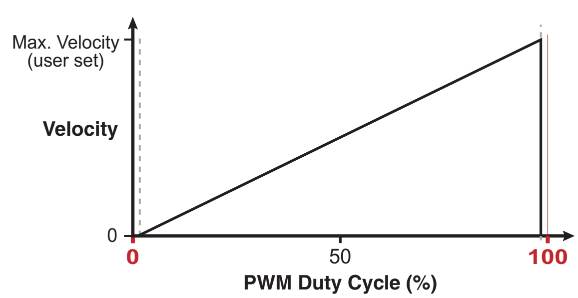
- PWM input frequency range: 20 Hz up to 30 kHz.
- If the PWM signal is off for 50mS or more the PWM input is considered off. This is interpreted by ClearPath as a zero-velocity command.
- Disable time = 10 mS
- For applications with the highest sensitivity to velocity accuracy, consider using frequency input control (described in next section).

## Mode Controls




**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

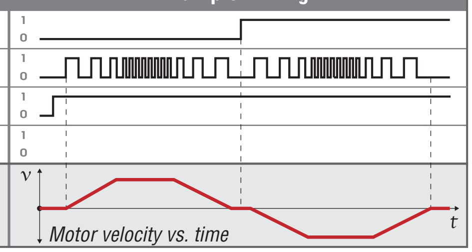
## MODE DESCRIPTION

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.

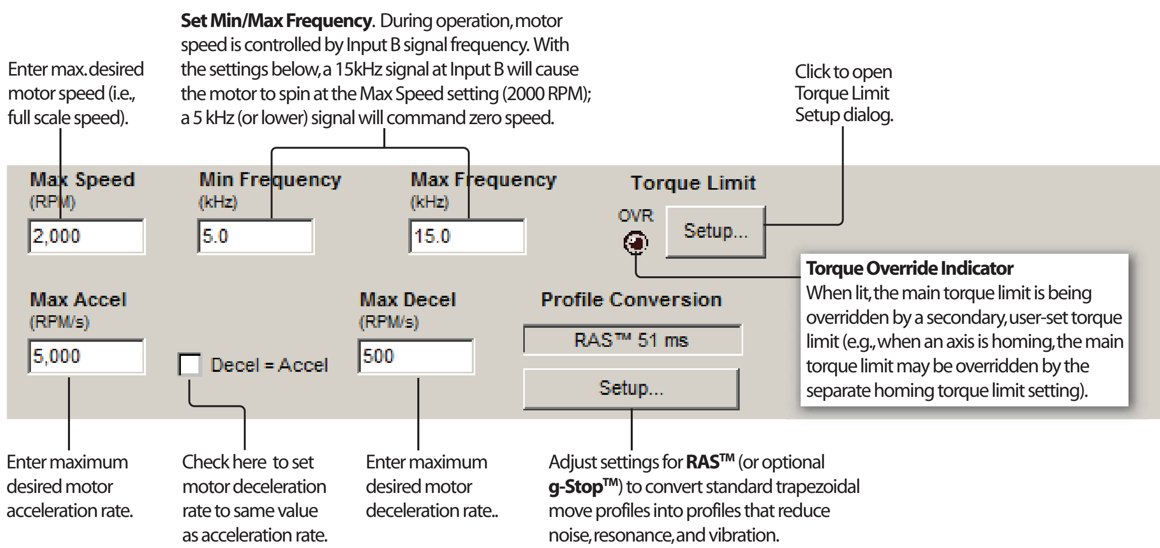
**Input B -** This input is connected to a pulse train whose frequency represents the desired speed.

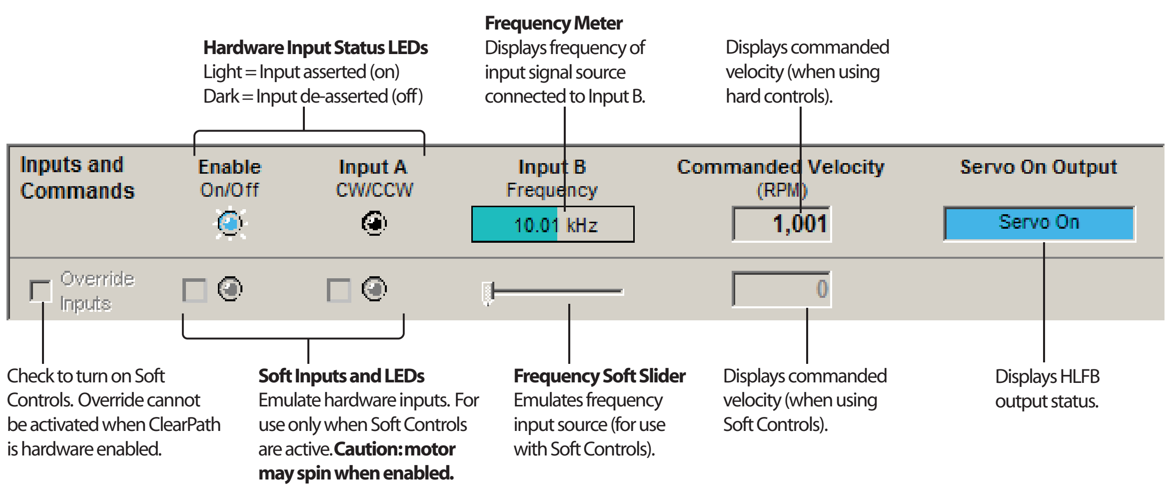
**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- Input frequency range: 20 Hz to 700 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



# MOVE TO SENSOR POSITION

Available on
MCVC + MCPV

## MODE DESCRIPTION

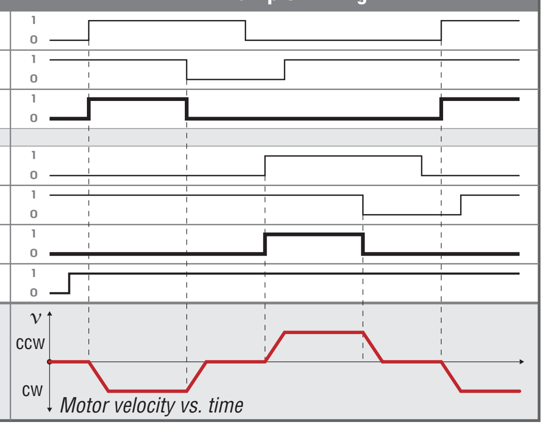
This mode is mainly intended to be used in two-position back and forth applications (like replacing a pneumatic cylinder). Use ClearPath digital inputs to spin the shaft CW or CCW. Wire position sensors or switches in series with ClearPath inputs to make an inexpensive two position actuator.

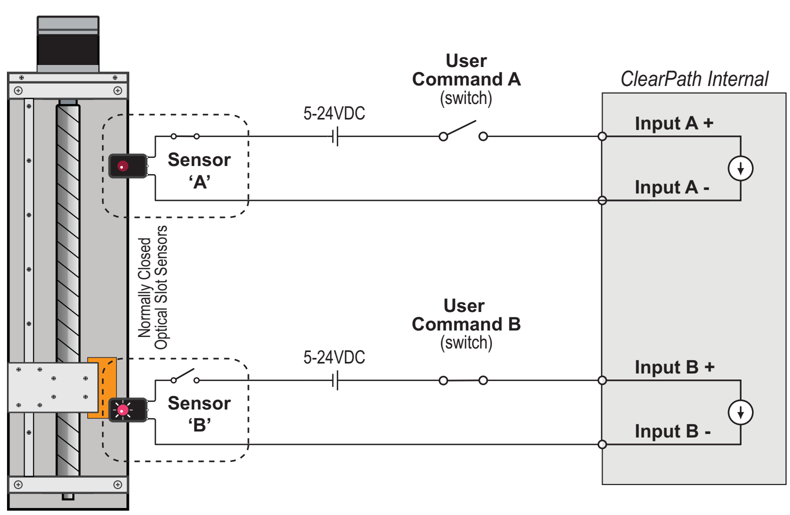
Place sensors at opposite ends of your motion path and wire them into the appropriate ClearPath inputs. See illustration below.

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.

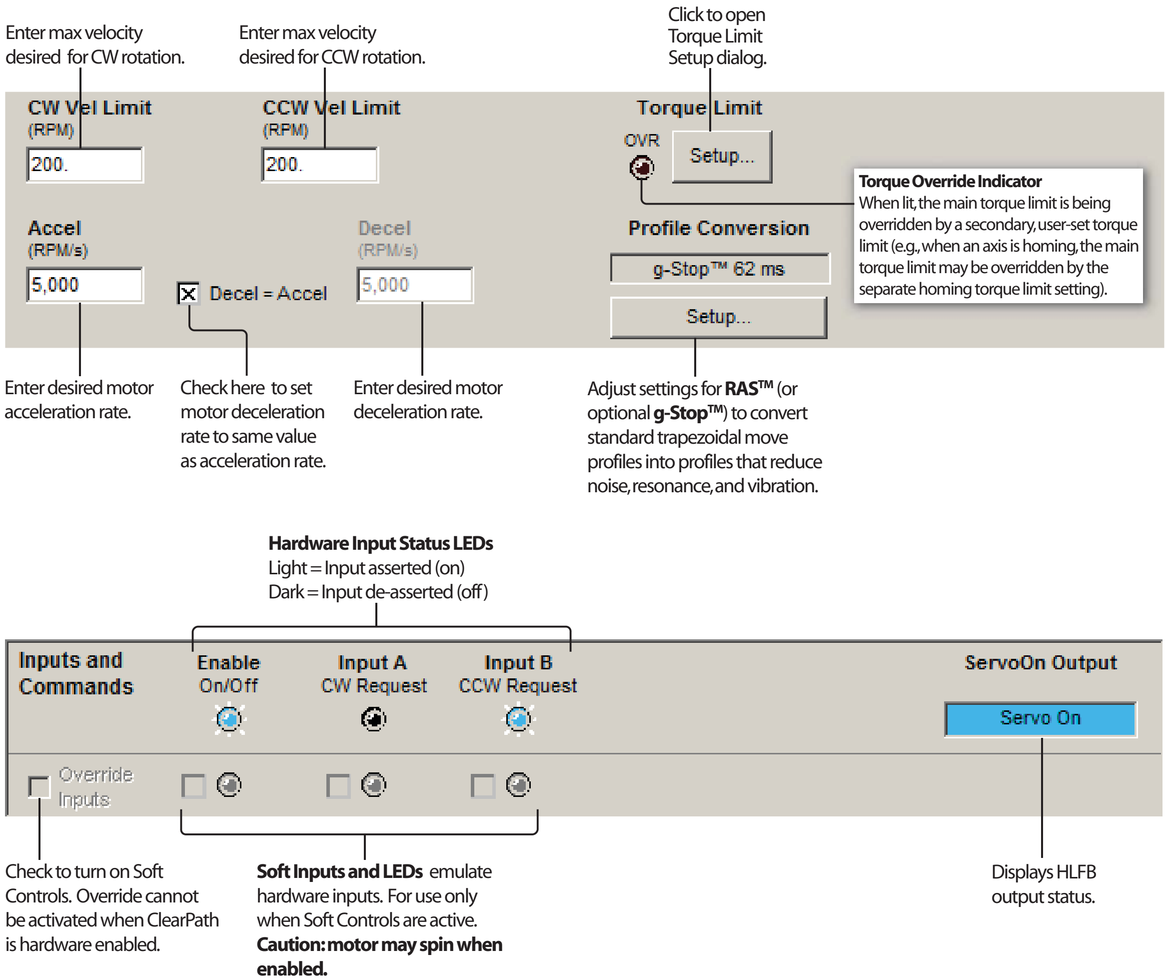
**Output (HLFB) -** See HLFB section for available modes.

**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[5] is received.
- Disable time = 10 mS

[5] 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



# 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.

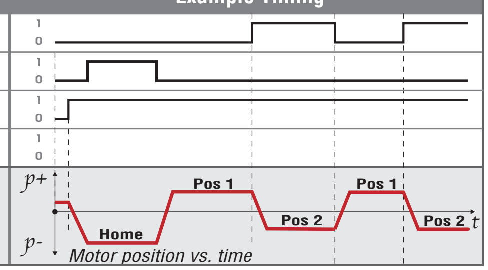
Assert the Enable Input to energize the motor. Once enabled, ClearPath automatically executes a homing move to a [user-supplied] switch or sensor wired to Input B. Once a home position is established, ClearPath automatically moves to one of the two user-defined positions (based on the state of Input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

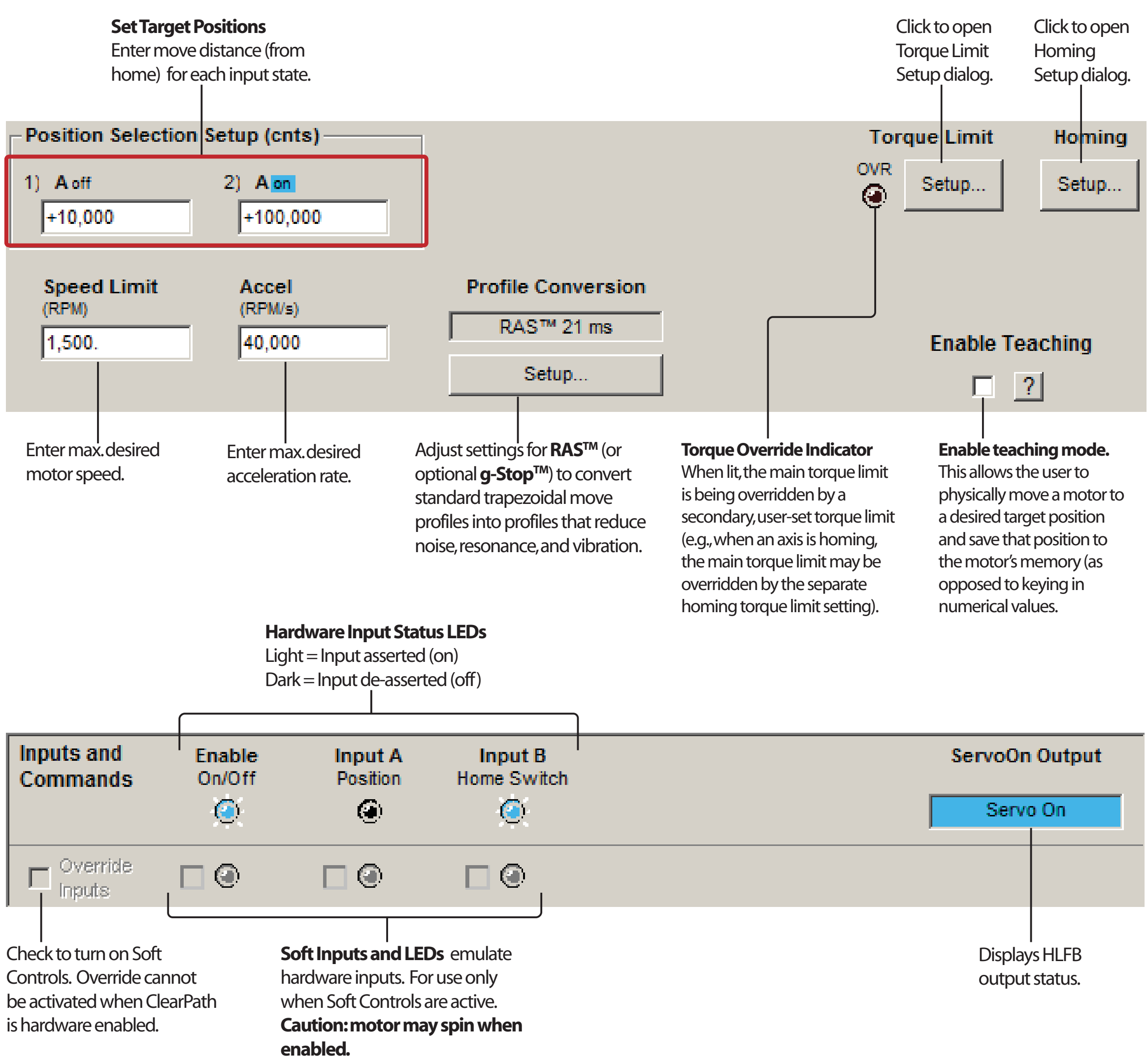
**Output (HLFB) -** See HLFB section for available modes.

**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



# 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.

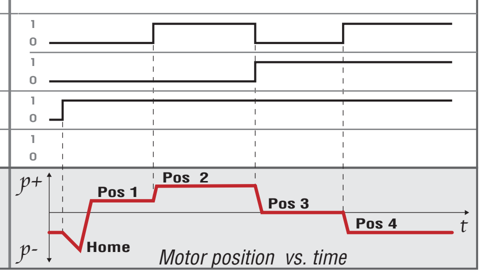
After homing, ClearPath can be commanded to move to any of four user-defined positions by changing the state of Input A and B. Changing these inputs has the dual effect of selecting target position, and triggering the move. See table below for timing and input details. All moves execute at the user-defined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

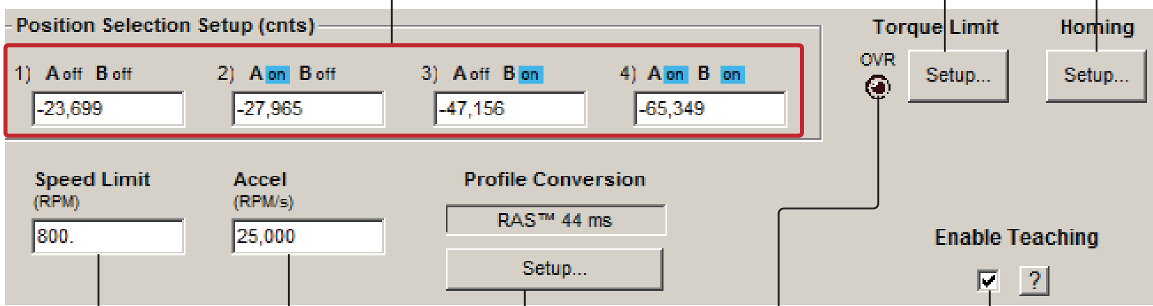
- The user-defined positions can be 'taught' instead of entered numerically through MSP. To do this, the motor must be in a Logic Power Backup (LPB) state (using a ClearPath POWER4-HUB board). The main bus power must be off.
- **To teach a position**, deassert the Enable input with the motor in the position 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.




Enter max. desired motor speed.

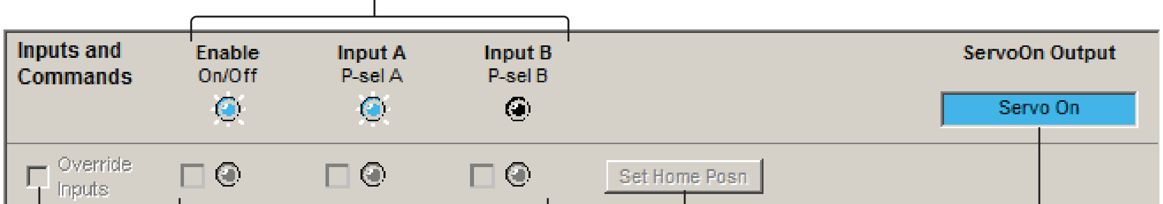
Enter max. desired acceleration rate.

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)




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**

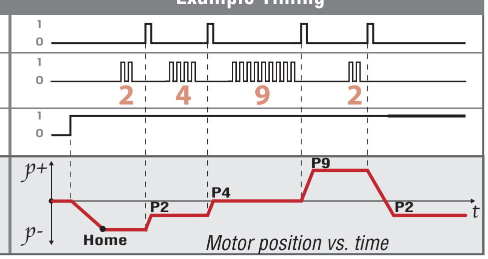
An absolute position is referenced to an established "home" position. Your target positions, in this context, are defined in terms of *distance from the home position*. For example, Position 1 might be defined as 1000 encoder counts from home, while Position 2 might be defined as 2000 encoder counts 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 9 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 | Example Timing |
|---|---|---|---|
| **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 | |
| **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.

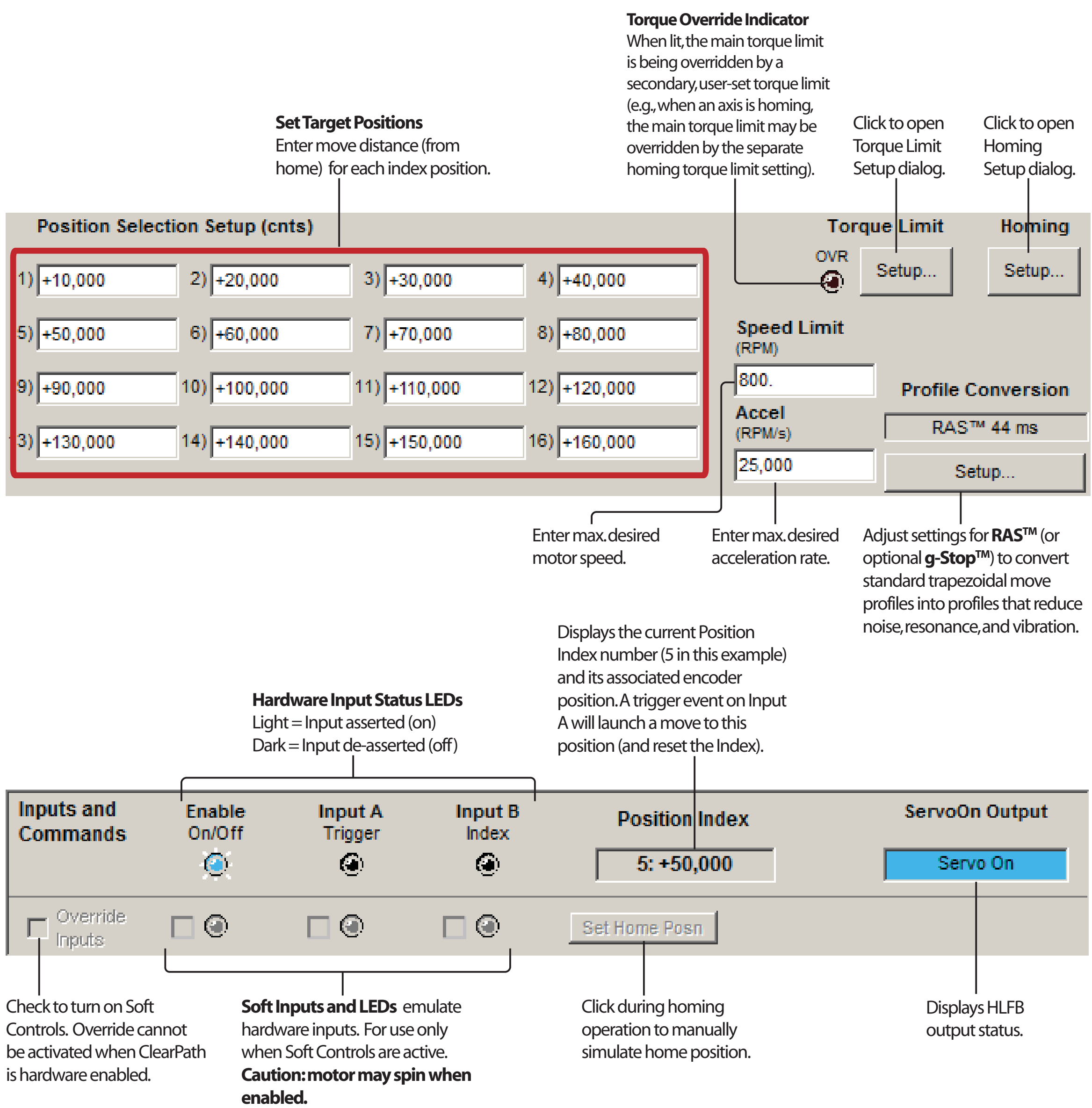
**Output (HLFB) -** See HLFB section for available modes.

**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



## 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.

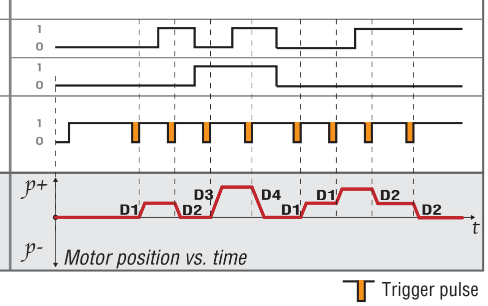
**Incremental Positioning**

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 Trigger | Logic: High=Enable Low=Disable Pulse Enable line to trigger moves | | | | |
| **Notes:** ClearPath can be programmed to home upon enable (see text for full details). Moves are triggered on rising edge of trigger pulse. | | | | | | |




### 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.

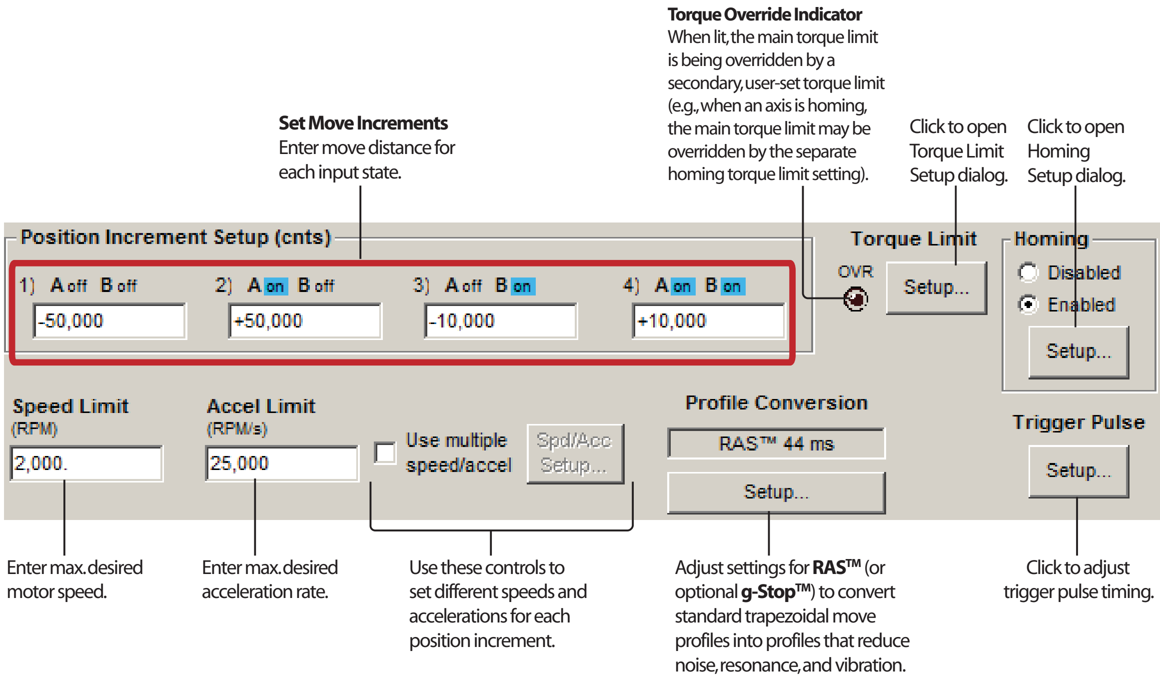
**Notes:**

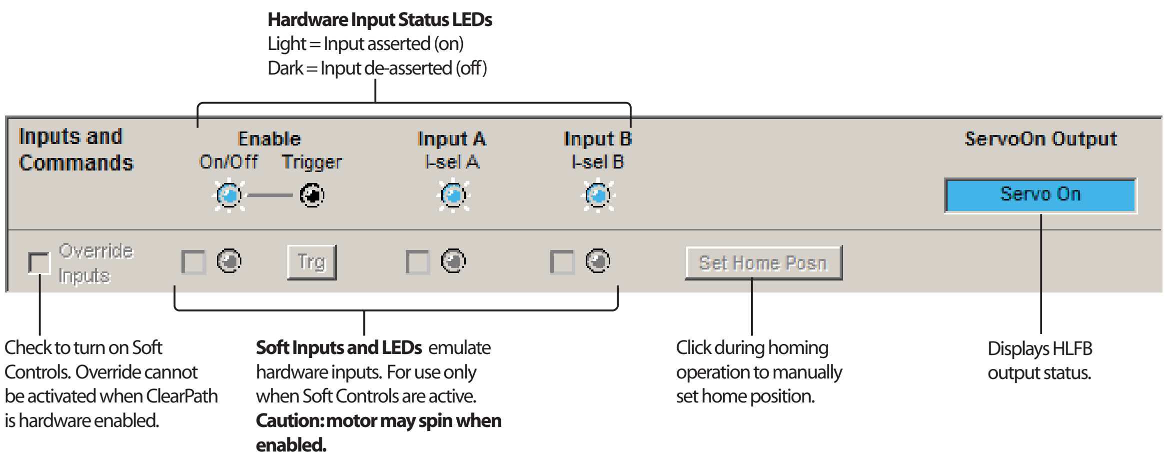
- A trigger pulse is required to launch each move. Move distance is selected with Input A and B.
- To create a longer continuous move, send multiple trigger pulses and ClearPath will automatically "chain" the move

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



# 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.

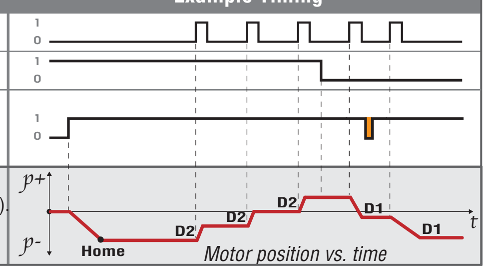
Assert the Enable Input to energize the motor. (ClearPath can be set up to perform an optional home to hard stop upon enable.) Change the state of Input B to select which of the two move increments is currently active. Change the state of Input A to launch each move at the user-defined speed and acceleration.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

Example Timing




Trigger pulse

## I/O FUNCTIONS

**Enable Input -** Asserting this input energizes the motor shaft. A short trigger pulse 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.

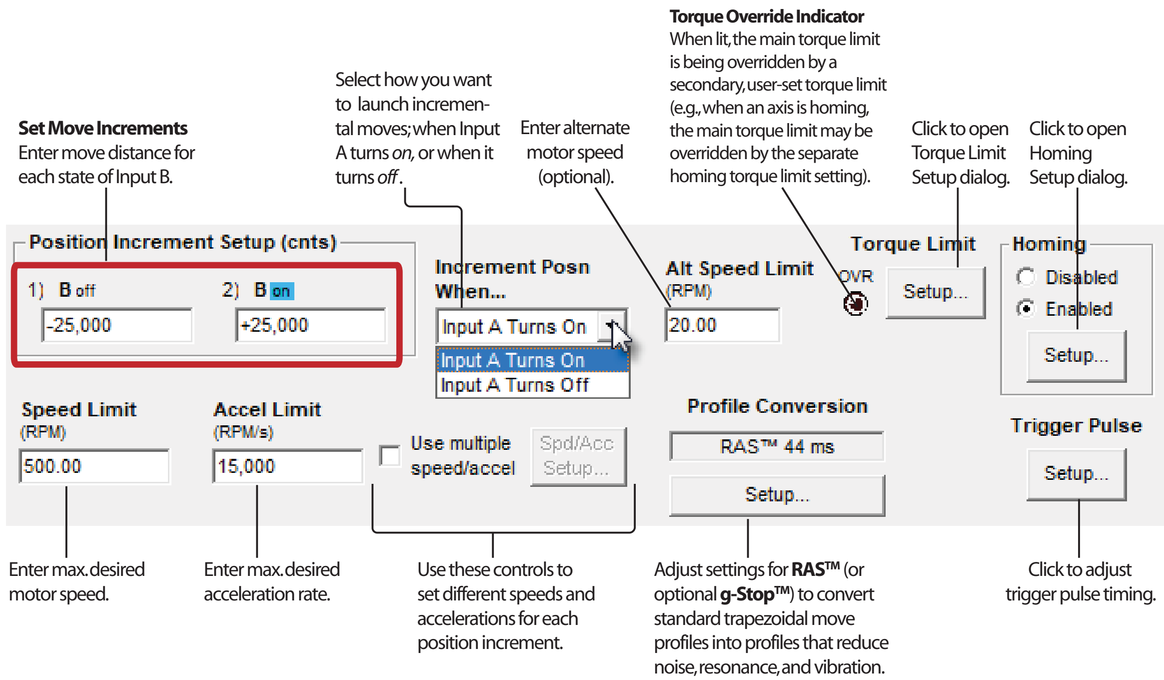
**Output (HLFB) -** See HLFB section for available modes.

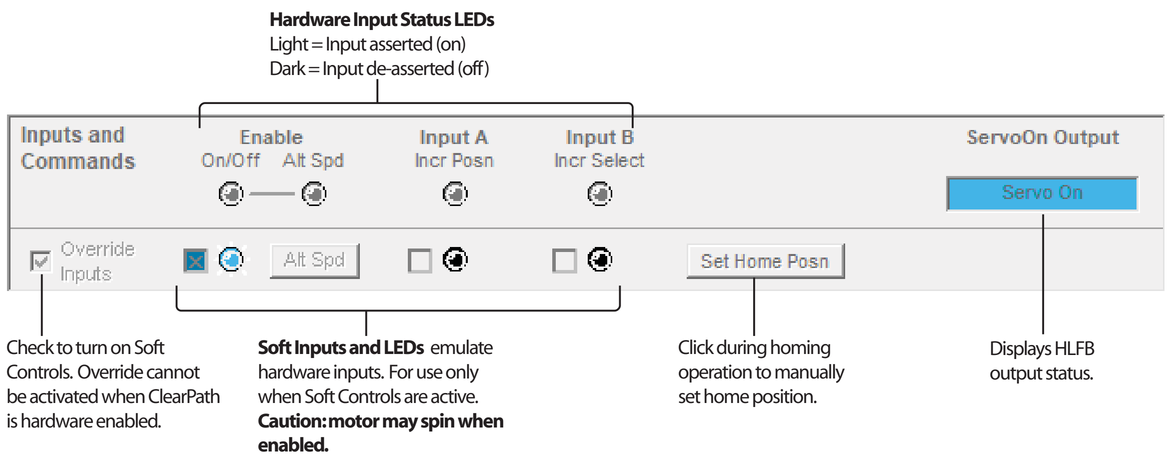
**Notes:**

- 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



## 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.

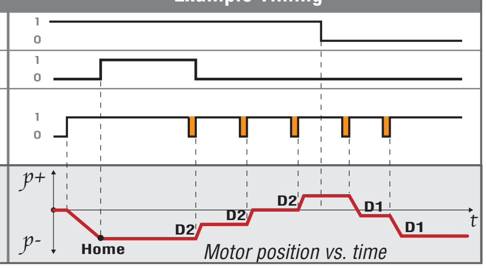
**Incremental Positioning**

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 Trigger | Logic: High=Enable Low=Disable Pulse Enable line low to trigger moves | |
| **Notes:** ClearPath can be programmed to home upon enable (see text for full details). Moves are triggered on rising edge of trigger pulse. | | | |




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.

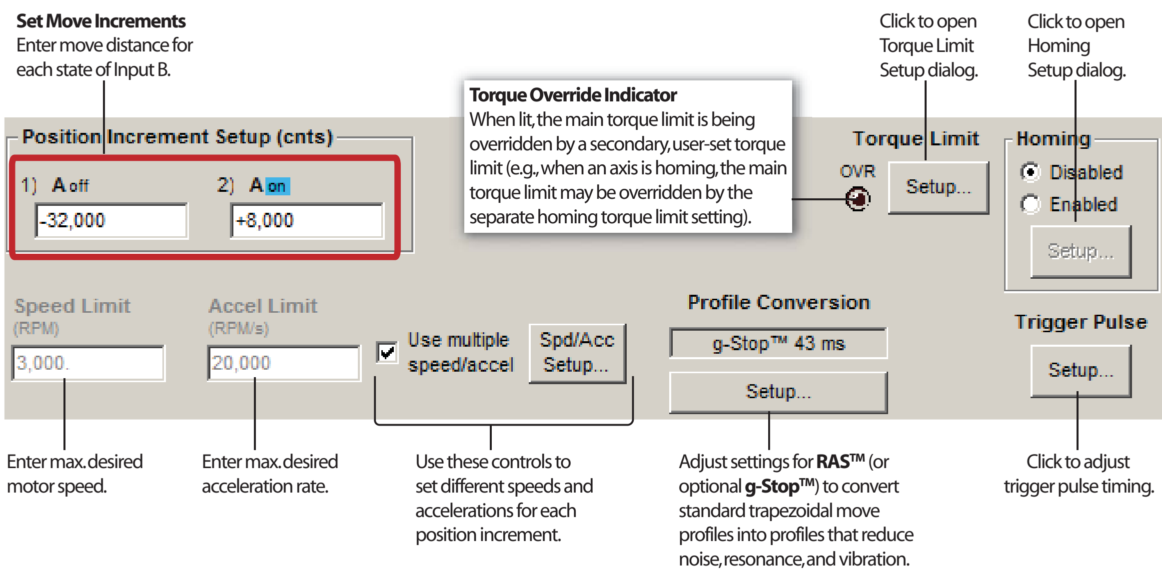
**Output (HLFB) -** See HLFB section for available modes.

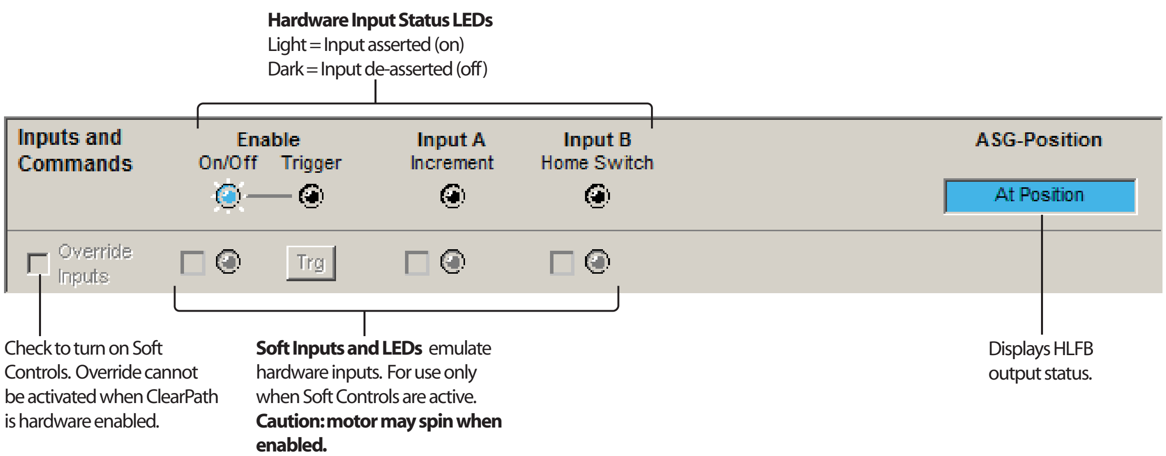
**Notes:**

- 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



## 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.

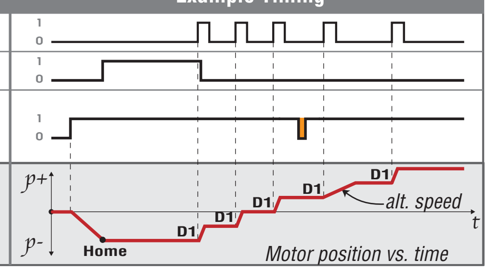
**What is Incremental Positioning?**

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 Trigger | Logic: High=Enable Low=Disable 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 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 is connected to the home switch/sensor. Its function is defined in the homing setup dialog.

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

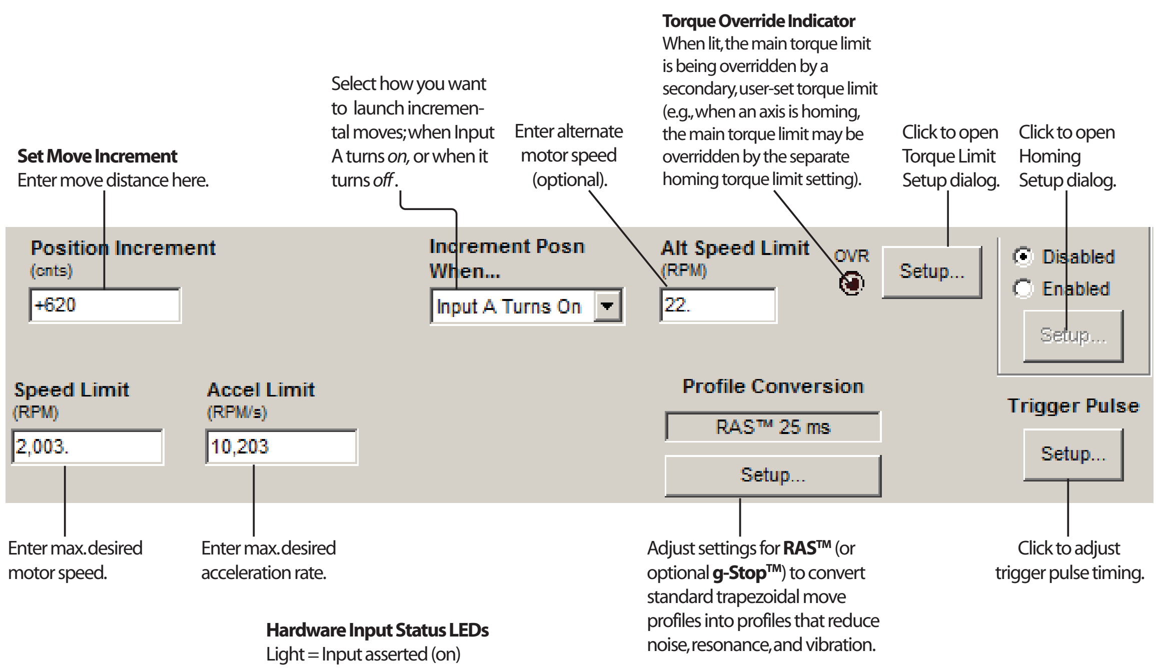
**Notes:**

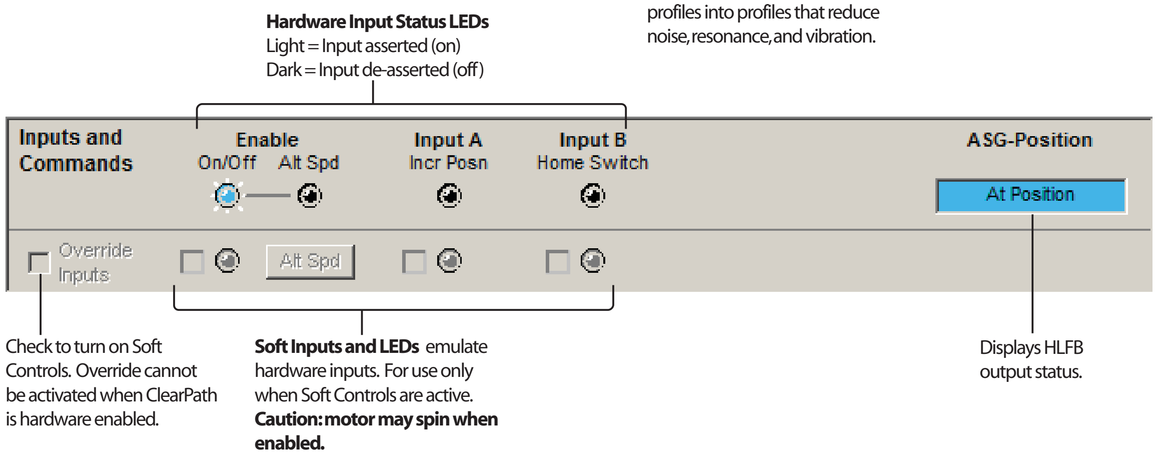
- Send incremental moves by turning Input A either on or off (this is user settable).
- Multiple position increments can be smoothly chained together (i.e., with no stops in between) by toggling Input A before

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



# Pulse Burst Positioning

Available on MCPV

## Mode Description

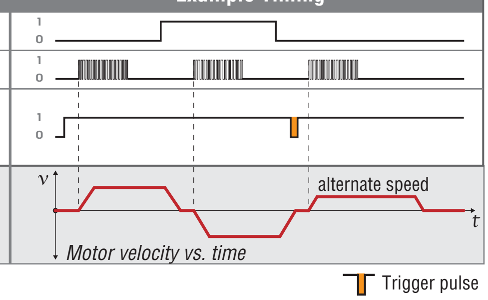
ClearPath will move a distance proportional to the number of pulses sent to Input B. This mode offers much of the flexibility of a “step-and-direction” system, without the need for an expensive indexer to create smooth move trajectories (that function is handled by ClearPath’s internal trajectory generator). 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: Absolute Minimum Pulse Width = 750nS**. See notes below for important information on how to determine min/max pulse input frequency range. | | | |




## 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.

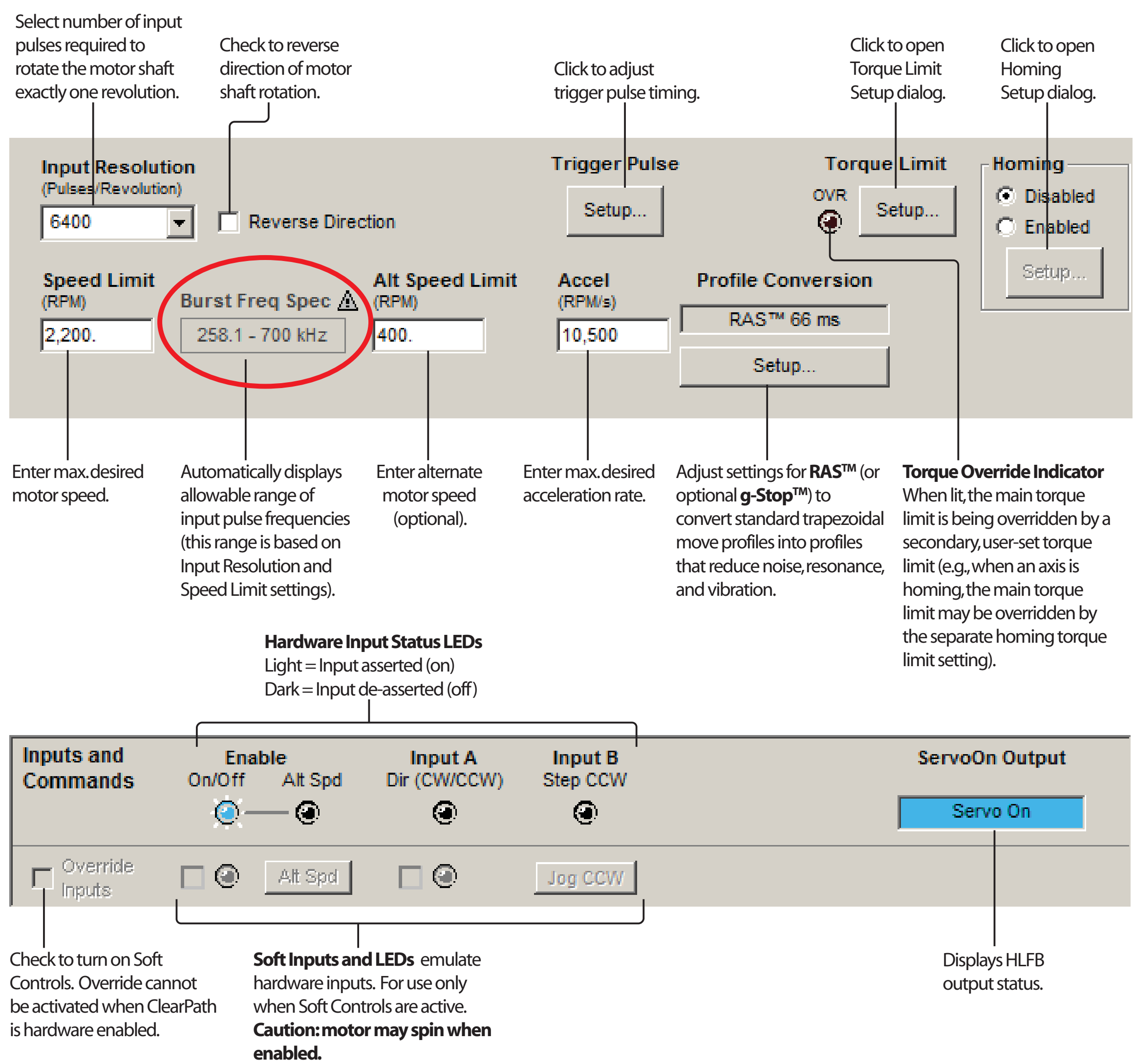
**Output (HLFB) -** See HLFB section for available modes.

**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




**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.

**Note: Pulse Width Requirements.** The minimum step pulse width used with this mode is dependent on the type of controller output and the control cable length. Refer to the Step and Direction Timing section of the user manual for details.

# Multi-Sensor Positioning: Bi-directional (Home to Hard Stop)

Available on
MCPV

## Mode Description

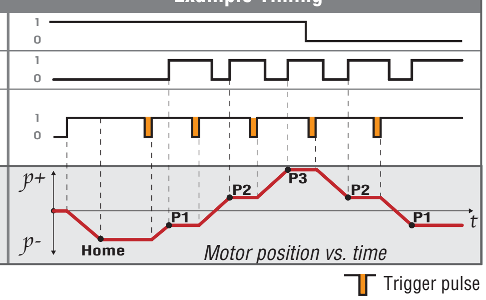
Move to a maximum of 16 different positions using simple I/O from your PLC, microcontroller or similar to control ClearPath's direction and position.

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 | Example Timing |
|---|---|---|---|
| **Input A** | Direction Select | Logic: High=CW Low=CCW | |
| **Input B** | Sensors | Logic: High=On Low=Off | |
| **Enable/ Trigger** | Enable Trigger | Logic: High=Enable Low=Disable Pulse Enable line low to trigger moves | |

**Notes:** ClearPath must be homed before use.
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 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.

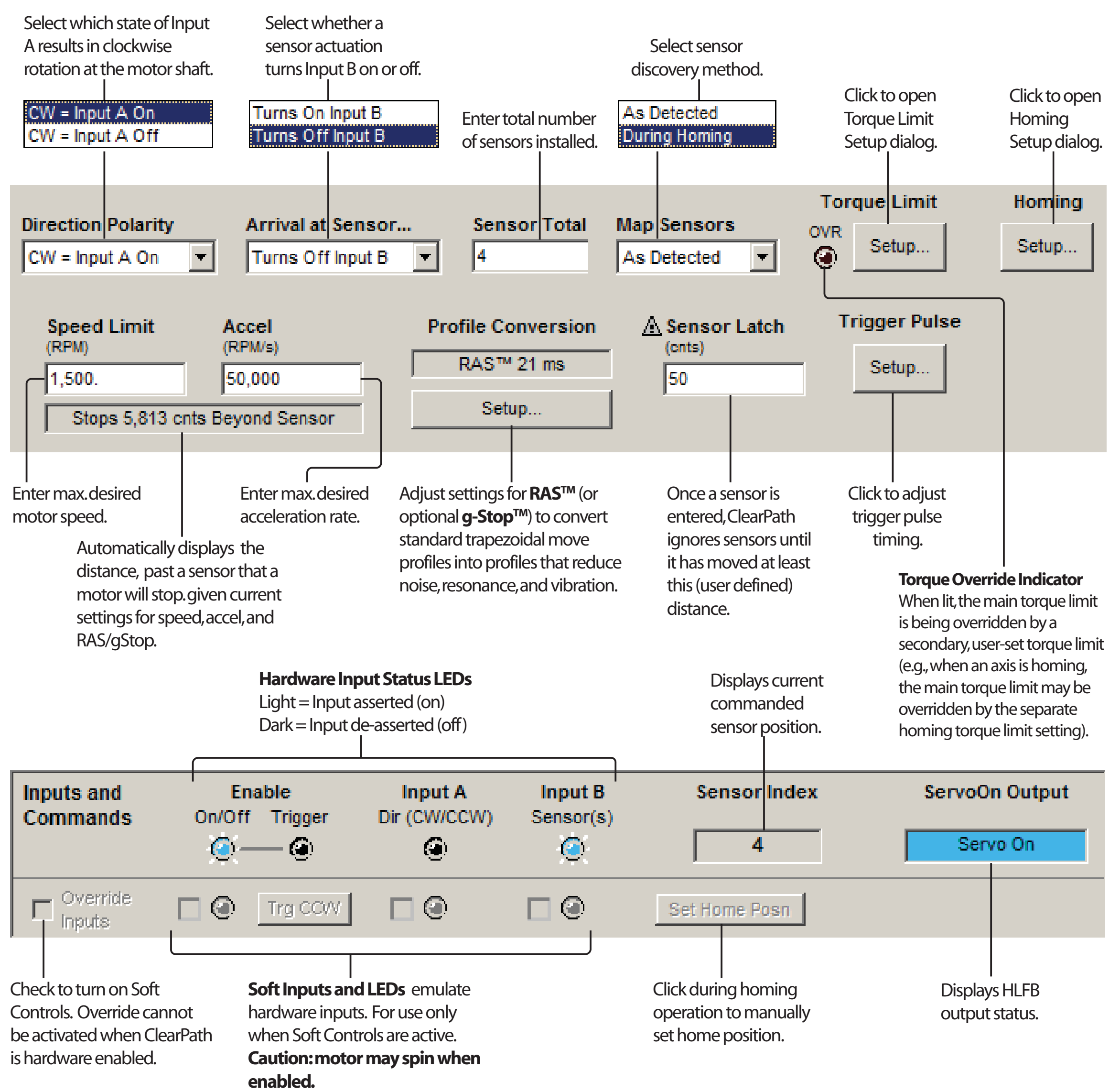
**Output (HLFB) -** See HLFB section for available modes.

**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



## MULTI-SENSOR POSITIONING: UNIDIRECTIONAL (SENSORLESS HOMING)

Available on
MCPV

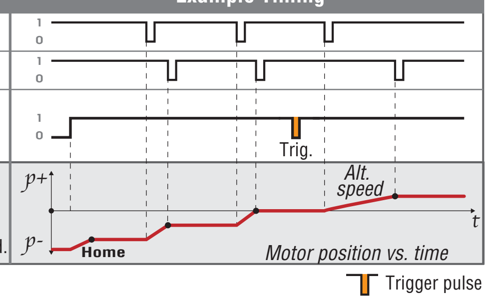
### MODE DESCRIPTION

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. | | | |




### 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.

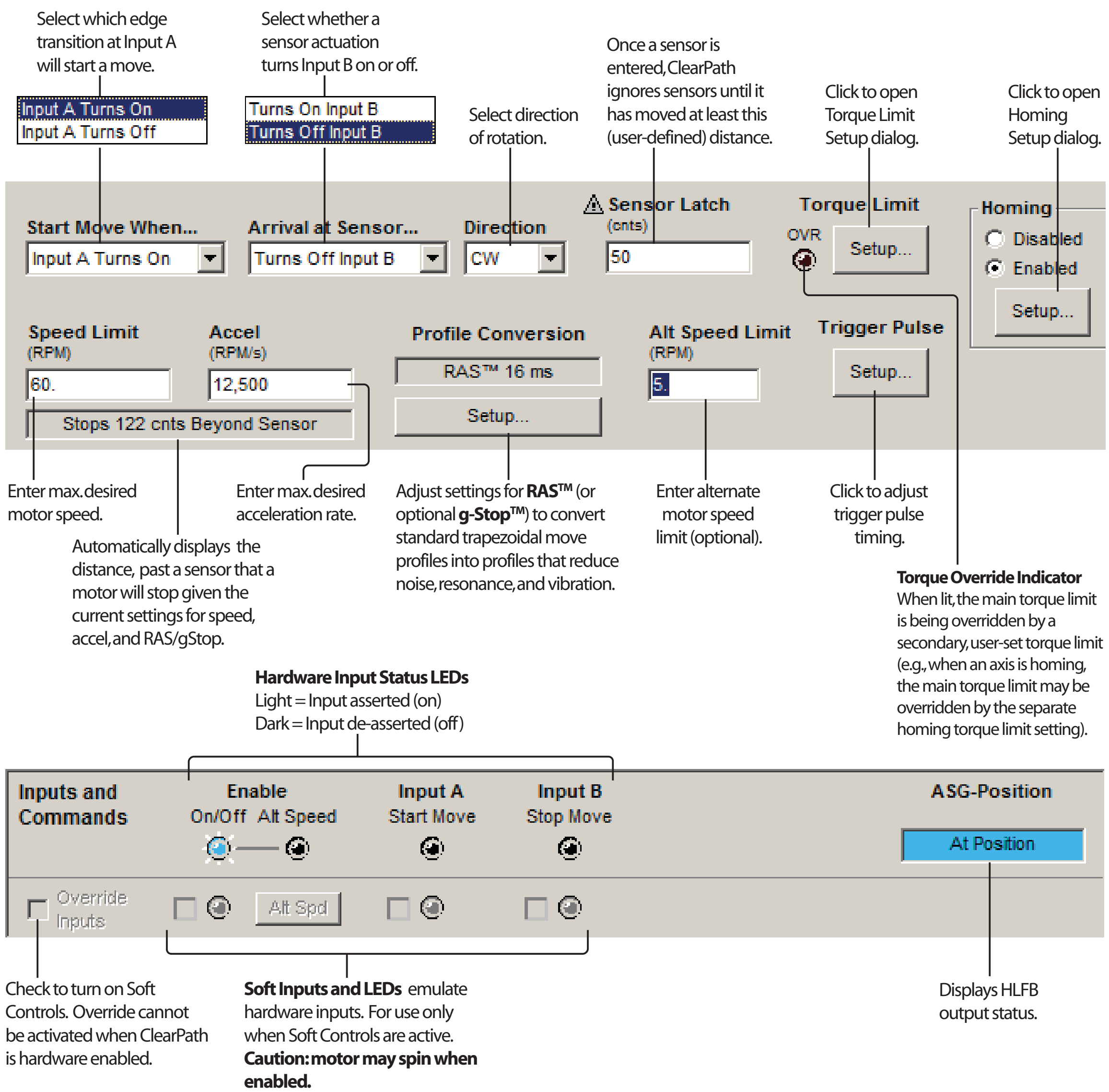
**Input B -** Transitions on this input count up until they equal the count of transitions seen on Input A, at which time ClearPath will ramp to a stop.

**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



## Multi-Sensor Positioning: Unidirectional (Home to Sensor)

Available on
MCPV

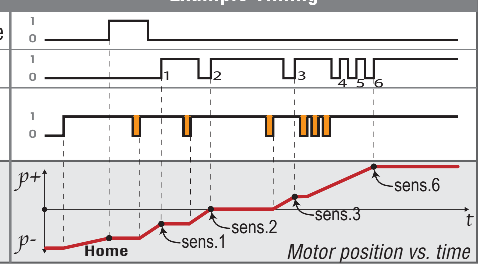
### Mode Description

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 Trigger | Logic: High=Enable Low=Disable 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.)

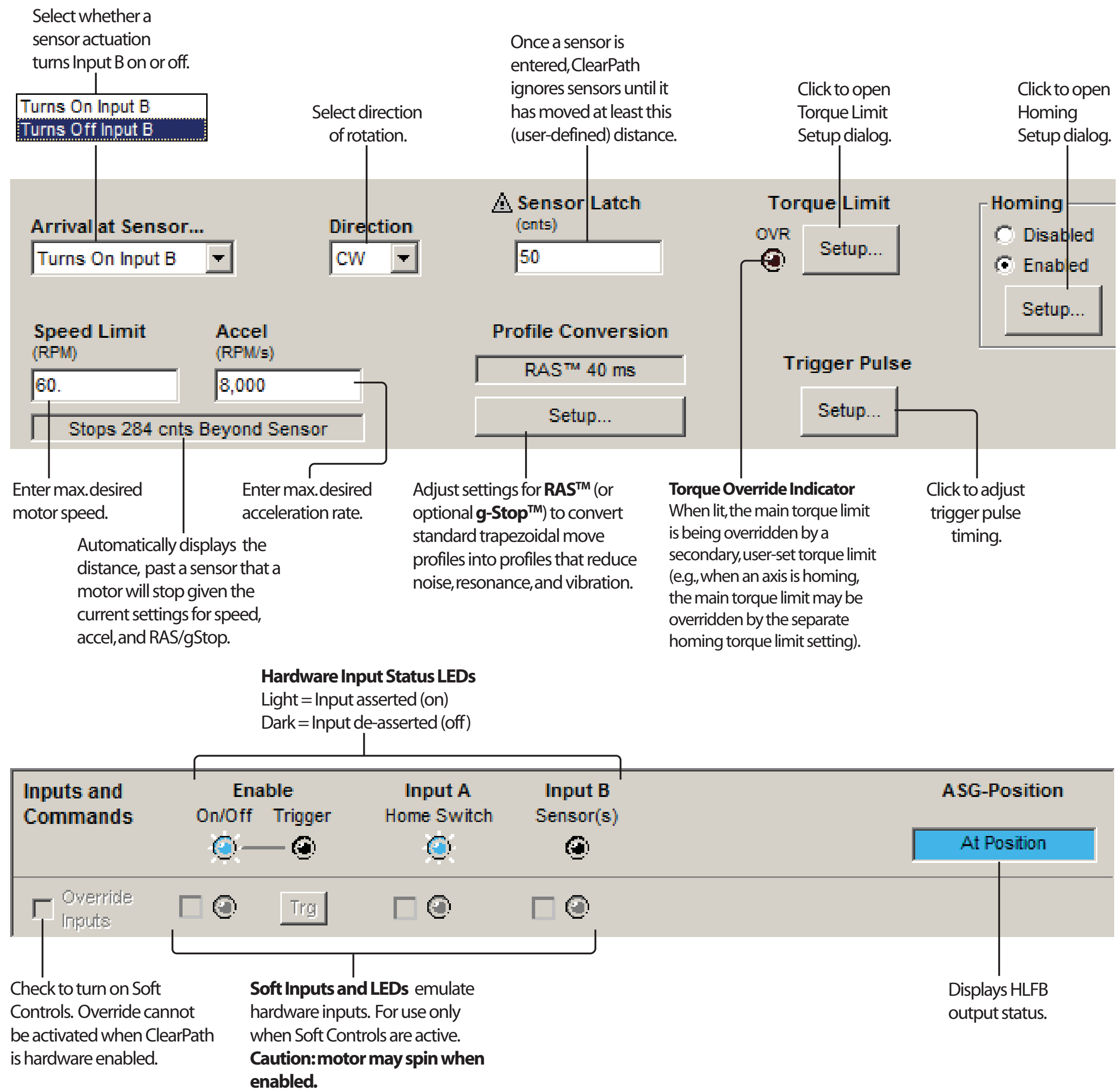
**Input A -** This input is connected to the home switch. Homing options are set in the Homing Setup dialog.

**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



# FOLLOW DIGITAL POSITION COMMAND: UNIPOLAR PWM COMMAND

## MODE DESCRIPTION

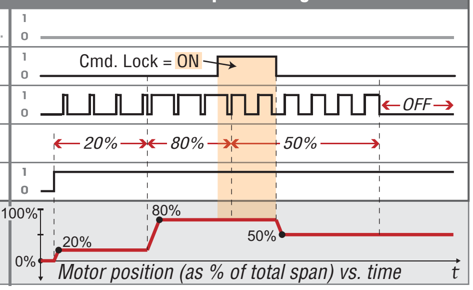
Available on
MCPV

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 | Example Timing |
|---|---|---|---|
| Input A | Home Sensor | Logic: High=In Sensor Low=Not in Sens. | |
| | or Command Lock | 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.

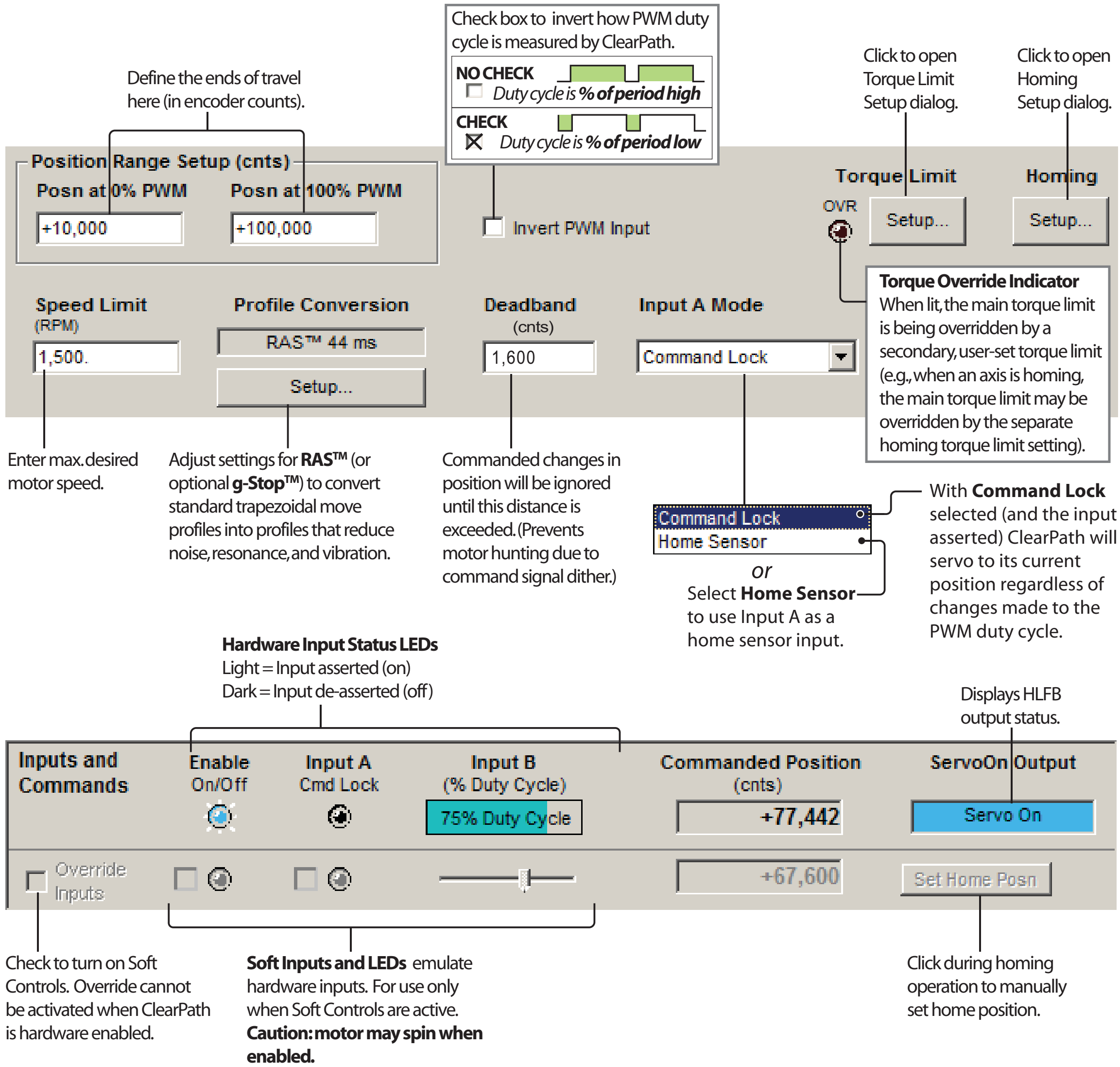
**Input B -** This input is connected to a PWM signal whose duty cycle represents the desired position.

**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.
- PWM input frequency range: 20 Hz to 30 kHz.

## Mode Controls



# Follow Digital Position Command: Frequency Command

Available on
MCPV

## Mode Summary

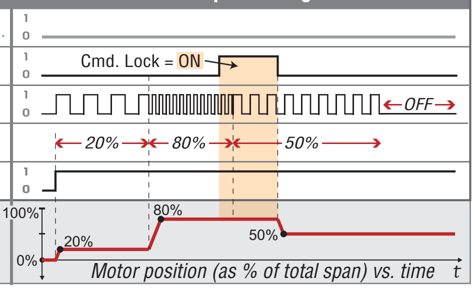
ClearPath will servo to a position between two user-defined limits based on the frequency of the signal on Input B.

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

| Signal | Function | Input Type |
|---|---|---|
| Input A | Home Sensor or | Logic: High=In Sensor Low=Not in Sens. |
| | 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.

Example Timing




## 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.

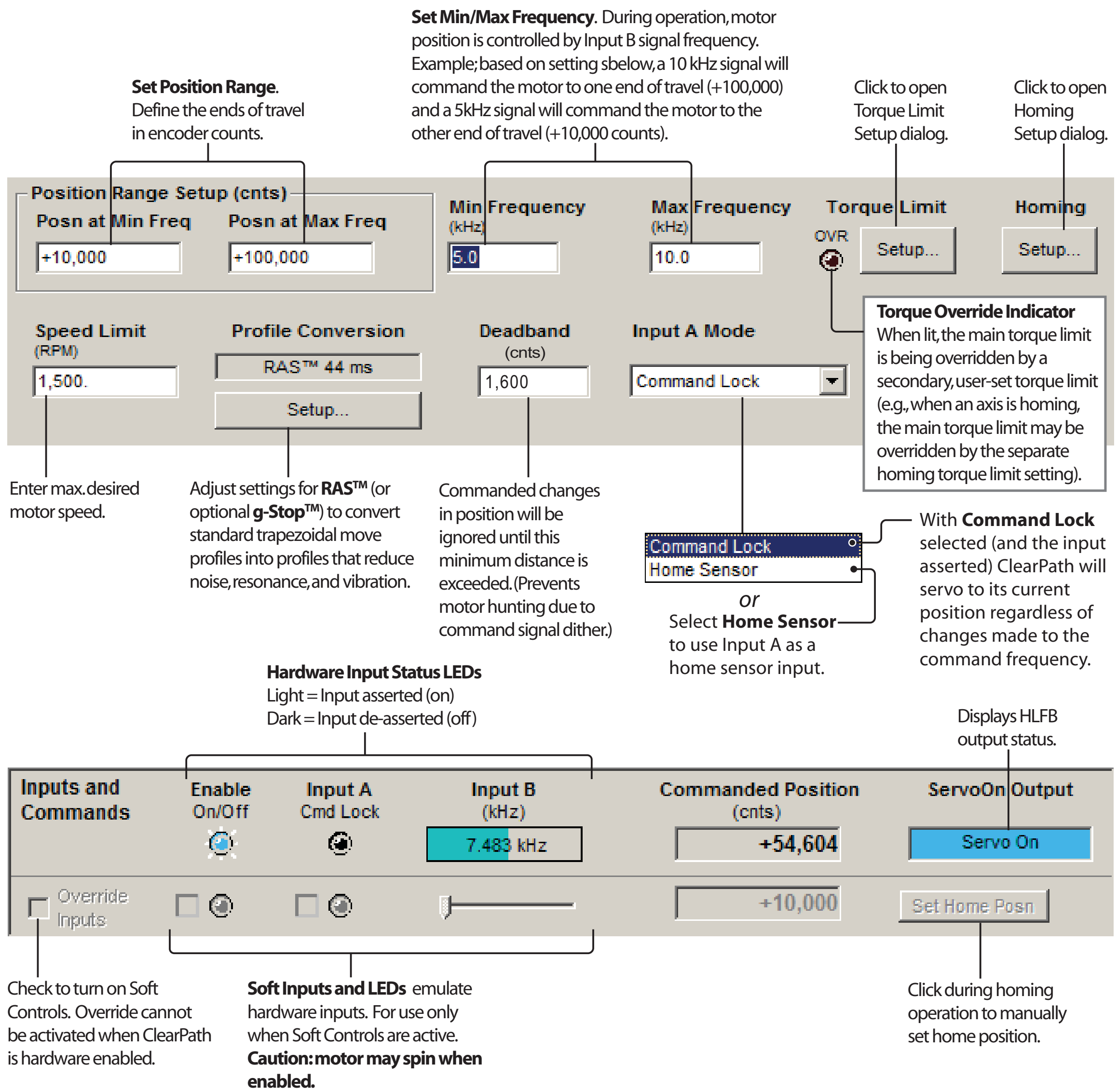
**Input B -** This input is connected to a digital signal whose frequency represents the desired position.

**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.
- Input frequency range: 20 Hz to 700 kHz.
- Frequencies between the minimum and maximum will command positions (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



# OPERATIONAL MODES: SDSK AND SDHP

The ClearPath SD (Step & Direction) family was designed to replace stepper motor/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

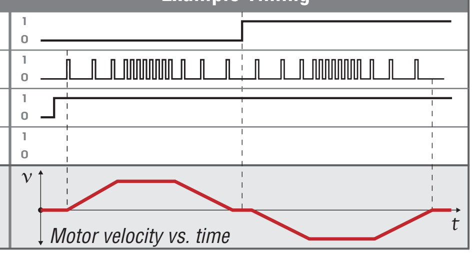
### MODE DESCRIPTION

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: Absolute Minimum Pulse Width = 750nS. | | | |




*Step and Direction Inputs and Timing*

### I/O FUNCTIONS

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

**Input A -** Direction input.

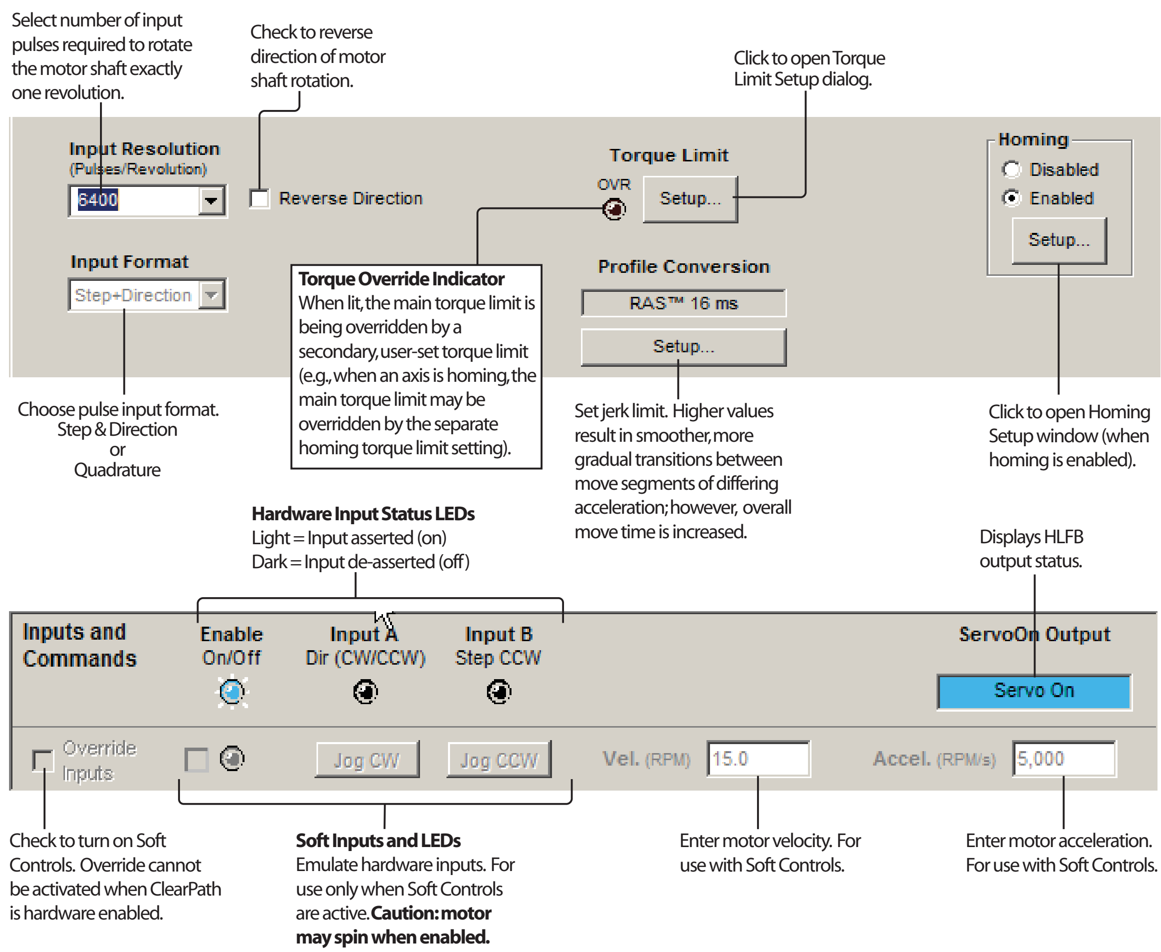
**Input B -** Step input.

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

**Notes:**

- Minimum pulse width (for high and low states) = 750 nS. See Step & Direction Pulse Timing Information (later in this section) for details.
- Maximum pulse input frequency = 667 kHz **at 50% duty cycle.**
- Motion occurs on the falling edge of each step input pulse.
- Time before Disable = 10 mS.

## Mode Controls

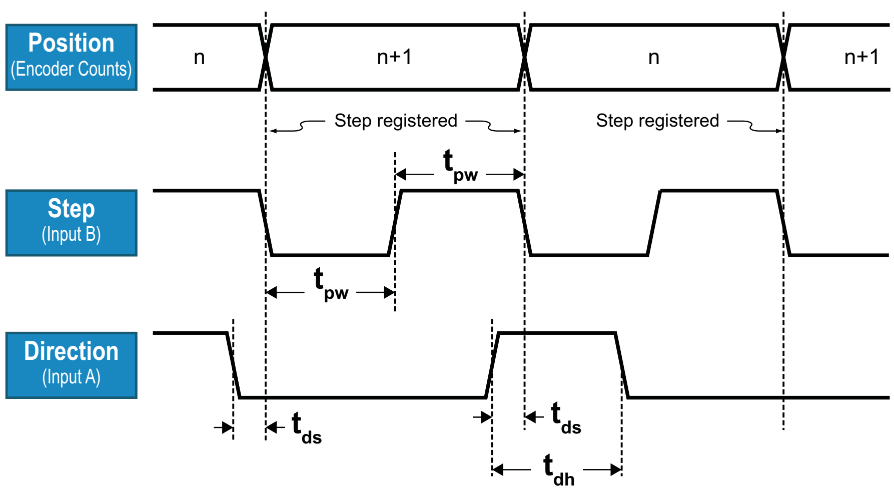


## Step & Direction Pulse Timing Information

This section contains:

- A step timing diagram applicable to ClearPath **Step and Direction mode** (SD models) and **Pulse Burst Positioning mode** (MCPV models).
- A table listing minimum step (pulse) timing requirements based on typical interface circuits and controller cable lengths.
- A section discussing **Step Timing Errors**, including common causes and fixes. This type of alert occurs when ClearPath identifies a problem with the timing and/or quality of the incoming controller pulses.

### Step/Pulse Timing Diagram




***ClearPath Minimum Step/Direction Timing***

- $\mathbf{t_{pw}}$ – Absolute minimum step pulse width: **750 nS** (applies to high and low states)
- $\mathbf{t_{ds}}$ – Absolute minimum time between direction change and step input change: **25 nS**
- $\mathbf{t_{dh}}$ – Absolute minimum direction hold time: **1 uS**

The timing diagram above shows *absolute minimum* step and direction timing values as measured directly at the ClearPath motor inputs. For recommended pulse width settings at the controller, see table ***Minimum Pulse Width Settings for Step/Dir and Pulse Burst Positioning*** (next page).

### MINIMUM STEP PULSE WIDTH SETTINGS

The table below shows minimum step and direction pulse width requirements for actively driven vs. open collector pulse output architectures at different controller cable lengths (10 ft. and 55 ft. Teknic cables). This data applies to Step and Direction (SD models) and Pulse Burst Positioning modes (MCPV models).

**Minimum Pulse Width Settings for Step/Dir and Pulse Burst Positioning**

| | **Cable Length** *(Teknic Cable Part Number)* | | | |
|---|---|---|---|---|
| | **10 ft.** (*CPM-CABLE-CTRL-MU120*) | | **55 ft.** (*CPM-CABLE-CTRL-MU660*) | |
| **Output Type** | Minimum pulse width (time high) | Minimum pulse width (time low) | Minimum pulse width (time high) | Minimum pulse width (time low) |
| Totem-pole[1], 5V (actively driven) | 750nS | 750nS | 750nS | 750nS |
| Open collector, 249Ω pull-up to 5V | 750nS | 750nS | 1,000nS | 1,000nS |
| Open collector, 1kΩ pull-up to 5V | 750nS | 750nS | 1,200nS | 1,200nS |
| Open collector, 5V, no pull-up[2] | 900nS | 900nS | 1,700nS | 1,700nS |

*1. Values based on driver chip P/N U74HC14.*
*2. This is not recommended. Always use a pull-up resistor for open collector outputs.*
*3. Open collector signals >5VDC should be evaluated for minimum stable pulse width settings.*

## STEP INPUT TIMING PROBLEMS

If ClearPath detects a problem with the incoming step/pulse stream (e.g. electrical noise, narrow pulses, pulses sent at excessively high frequency, etc.), it will execute a safety shutdown and alert the user with 1) an LED blink code at the motor, and 2) an exception/alert message viewable in MSP software as a **Step Timing Error**.

**Application Note**

All three ClearPath digital inputs are optically isolated and highly noise immune when used as recommended. ClearPath firmware was designed to detect, and alert the user to problems related to step and direction signaling.

### COMMON CAUSES OF STEP TIMING ERRORS

**Low voltage and/or low current from the controller.** If the controller is outputting less than 4VDC and/or less than 8mA, it may be unable to reliably switch the ClearPath motor's inputs.

**Pull-up resistor not installed or installed incorrectly.** If your controller has open collector outputs, be sure to install the recommended pull-up resistors (at the controller end) as specified in the ClearPath Inputs section.

**Step pulses from the controller are out of spec.** Problems can occur if the controller's step pulse frequency is higher than the ClearPath specification, or if the minimum step pulse time is less than 750 nS. **Note:** Pulse width and frequency settings are often configurable in the controller.

**Signal pairs were not run from motor to controller.** Always run two wires for each ClearPath I/O signal (e.g. Step+ & Step-) all the way from the ClearPath motor to the controller's outputs. *Avoid jumping or otherwise combining wires at the motor connector. For example, do not combine all of the return wires (i.e. Step-, Dir-, Enable-) together at the motor and run a single wire from the motor to the controller.* If your controller doesn't have enough connection points, always opt to *combine connections at the controller side.*

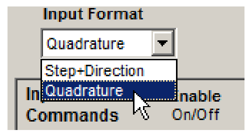
## Quadrature Input

Available on
SDSK + SDHP

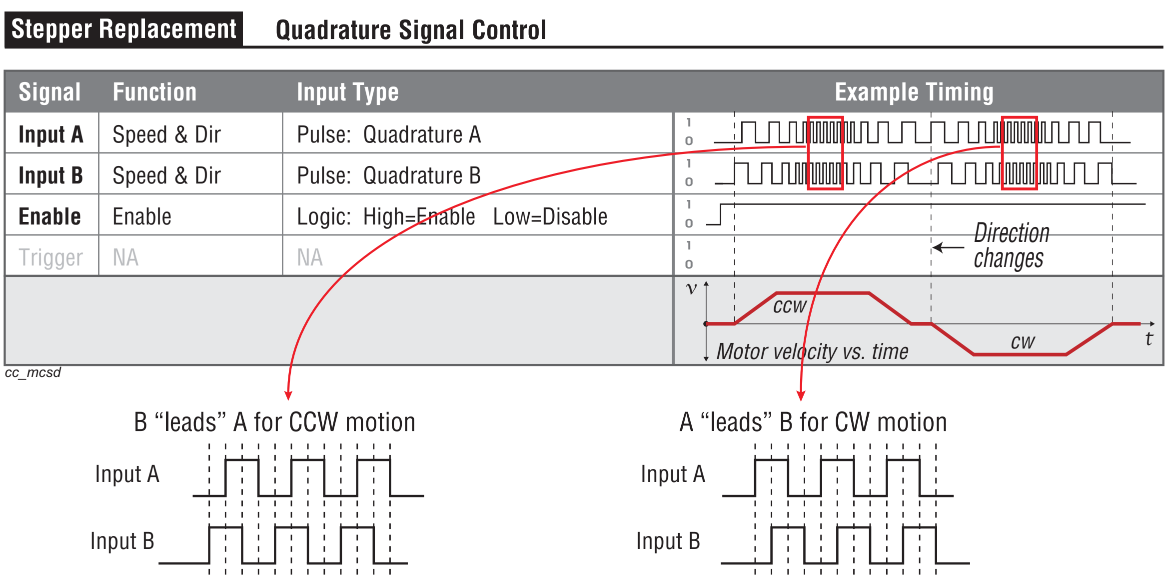
### Mode Description

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.




***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.

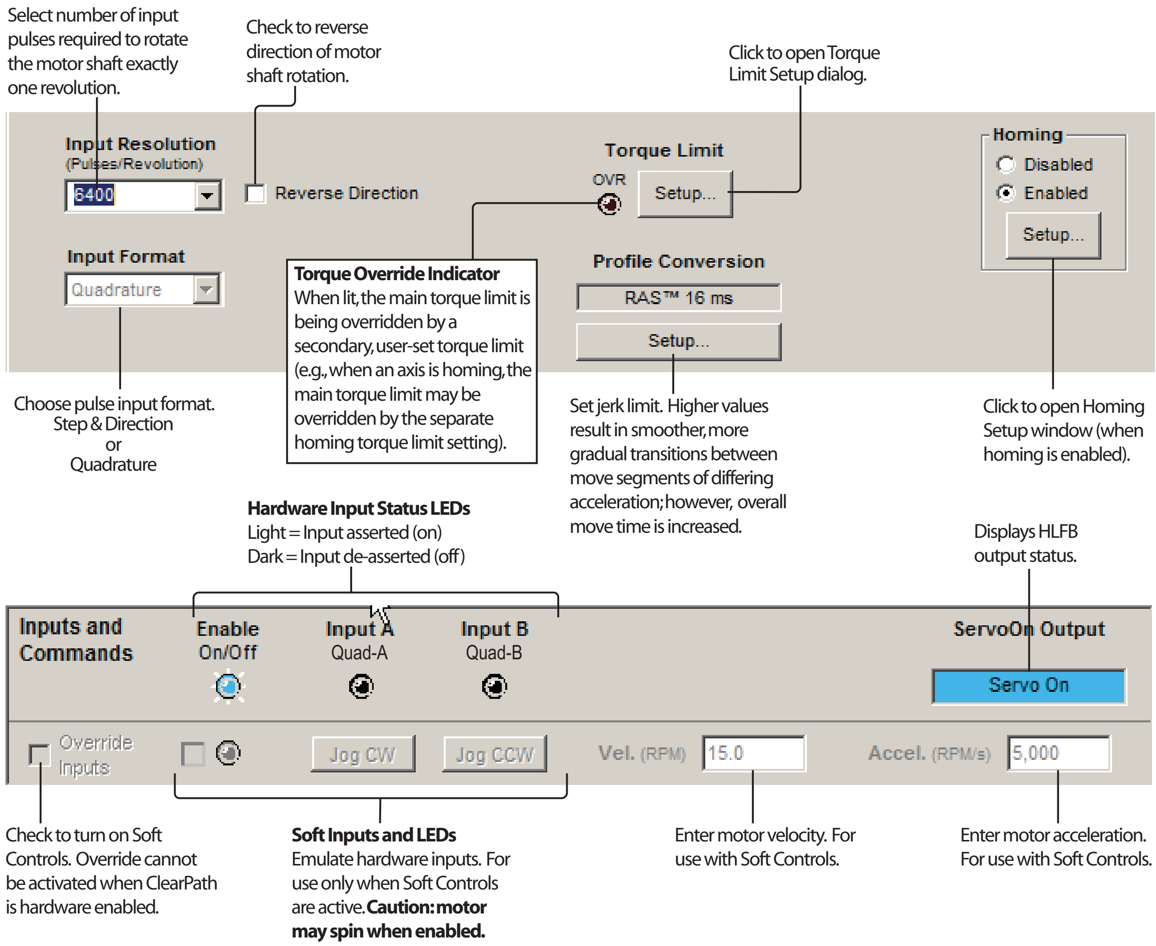
**Output (HLFB) -** See HLFB section for available modes.

**Notes:**

- Input B must lead Input A for CCW motion; Input A must lead Input B for CW motion.
- Maximum pulse input frequency = 667 kHz *per channel* **at 50% duty cycle.**

- Minimum pulse width (for high and low states) = 750 nS.
- Minimum time between adjacent channel transitions = 25 nS.
- Time before Disable = 10 mS.

## MODE CONTROLS




### INPUT RESOLUTION SETTING

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

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

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

#### Available Input Resolution Settings

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

# Appendix A: Troubleshooting

## LED Blink Codes

Note: In cases where the same blink code is used for multiple different exceptions, connect your ClearPath to a PC running MSP to view the specific exception/shutdown information.

| LED Code | 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: large regenerated voltage upon deceleration or high AC line voltage. Possible remedy: Enable the Vector Regen Shunt (VRS) feature (MSP Advanced Menu) |
| Yellow - 3 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **AC Loss**<br>Probable cause: Dropped AC phase, breaker tripped, power outage. |
| Yellow - 3 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **AC Wiring Error**<br>Possible causes: Set for 3-phase AC but wired for single phase, or set for single phase AC but wired for 3-ph. |
| Yellow - 3 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Bus Under Operating Voltage**<br>Possible causes: Brown out, power supply too small, Minimum Operating Bus Voltage set too high (this setting is in MSP under Advanced > Power and Temperature.) |
| 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. |

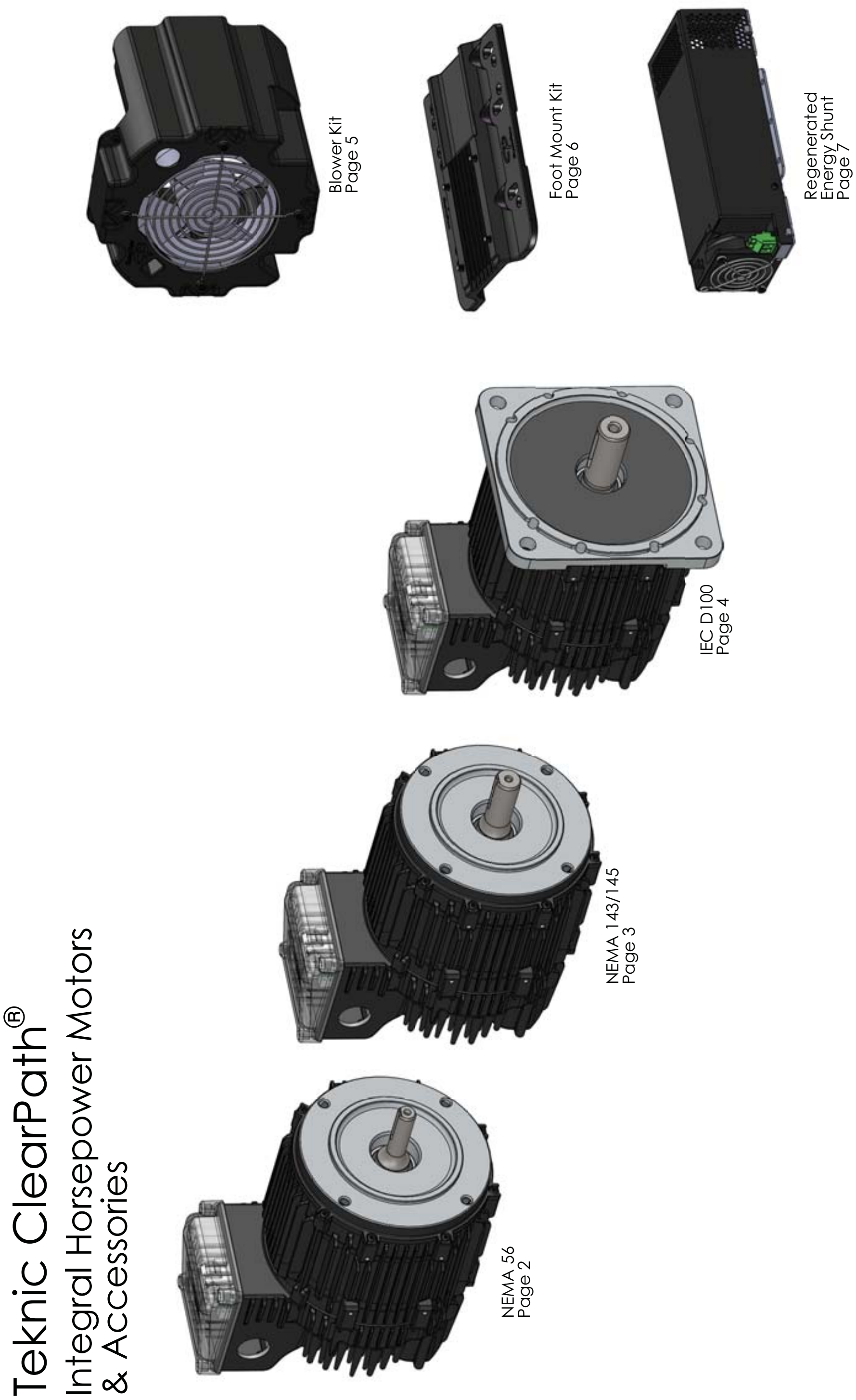
| | | | | | |
|---|---|---|---|---|---|
| Yellow - 4 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Tracking Error Limit Exceeded**<br><br>Possible causes: excessive friction, mechanical misalignment, vel/accel too high, low DC bus voltage. |
| Yellow - 4 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **RMS Torque Limit Exceeded**<br><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><br>Probable causes: bad tuning, low bus voltage, excessive loading for the power source. Try increasing AC voltage (if possible) or using three phase/ 5-wire AC instead of single phase. Lower speed/acceleration/loading if issue persists. |
| Yellow - 5 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Excessive Motor Temp**<br><br>Possible causes: ambient temperature too high for motor load, poor cooling, fan not running (if used), or maximum temperature setting too low (this setting can be found under Advanced > Power and Temperature. |
| Yellow – 6 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Momentary Low Bus Voltage**<br><br>DC bus drooped below 90V, insufficient current capabilities, and/or impedance too high. |
| Yellow - 7 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Old Config File Version**<br><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><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><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><br>Probable cause: bad tuning, low bus voltage. |
| Yellow - 7 blinks | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Commutation Startup Error**<br><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 - strobe | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Velocity Set Too High**<br><br>Velocity/speed limit exceeds motor's factory-set maximum speed. |

| | | | | | |
|---|---|---|---|---|---|
| Yellow - strobe | Shutdown | Disallows motion | Servo off | Toggle Enable input | **Step Input Timing Error**<br>Possible causes: Step input pulse width too short, electrical noise, loose or shorted wires. A pull-up resistor may be required. Read Step Timing section of user manual for details.. |
| 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. |
| 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. |

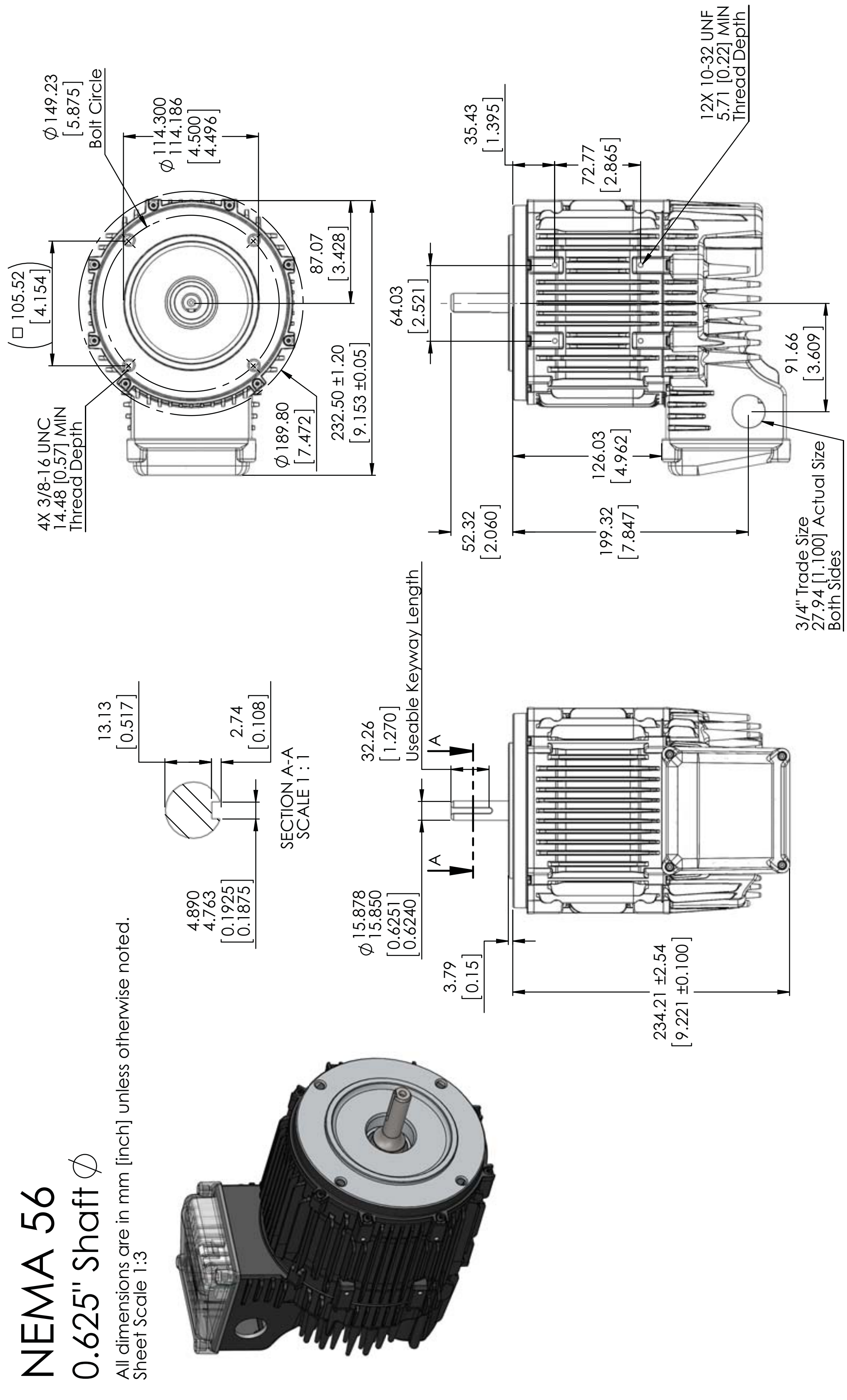
| | | | | | |
|---|---|---|---|---|---|
| Green - 3 blinks | Alert | Allows motion | Servo on | Auto-clears when cause is no longer present | **Torque Saturation**<br>Power supply may be insufficient for application, torque Limit may be set too low for command. Try lowering acceleration. |
| Green - 3 blinks | Alert | Allows motion | Servo on | Auto-clears when cause is no longer present | **Voltage Saturation**<br>Available torque is limited by DC bus voltage. Commanded speed may exceed motor spec. Try lowering speed or using a higher voltage power source (if possible). |
| Green - 3 blinks | Alert | Allows motion | Servo on | Auto-clears when cause is no longer present | **Over Speed**<br>Commanded speed exceeds motor max speed limit. Try lowering speed. |
| Green - 3 blinks | Alert | Allows motion | Servo on | Auto-clears when cause is no longer present | **Over Temp**<br>temperature of Internal electronics above shutdown threshold. Add fan. |
| Green - 3 blinks | Warning | Allows motion | Servo on | Toggle Enable input | **AC Loss**<br>Possible cause: Dropped AC phase, breaker tripped, power outage. |
| Green - 3 blinks | Warning | Allows motion | Servo on | Toggle Enable input | **AC Wiring Error**<br>Possible causes: Set for 3-phase AC but wired for single phase, or set for single phase AC but wired for 3-phase. |
| Green - 3 blinks | Warning | Allows motion | Servo on | Toggle Enable input | **Bus Under Operating Voltage**<br>Possible causes: Brown out, power supply undersized, Minimum Operating Bus Voltage set too high (this setting is in MSP under Advanced > Power and Temperature. |
| **Red Toggle** | Motor Failure | Disallows Motion | Servo off | Not clearable | **Motor Has Failed**<br>Return to Teknic for repair or replacement. |

# APPENDIX B: MECHANICAL INDEX

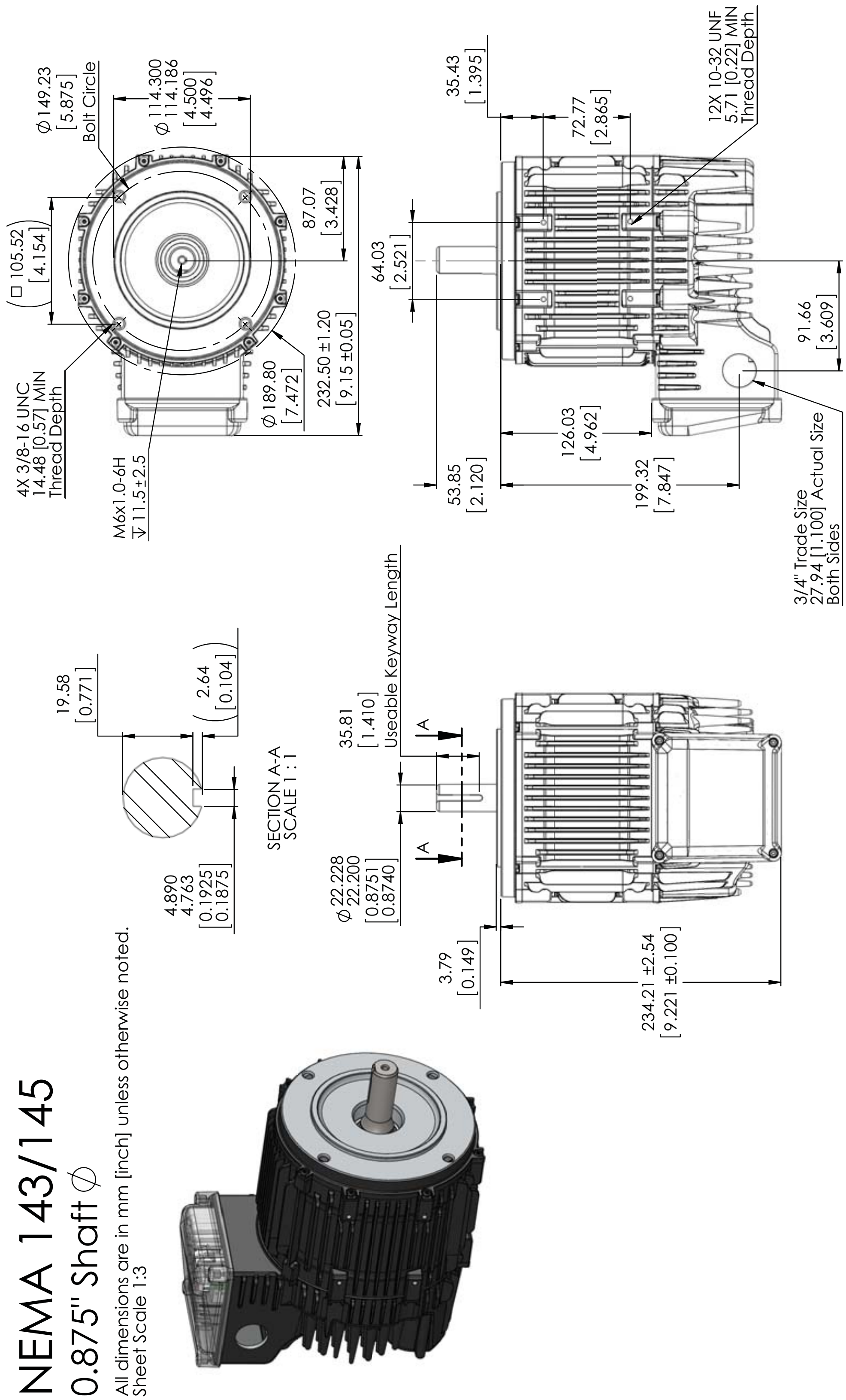
## DIMENSIONAL DRAWINGS



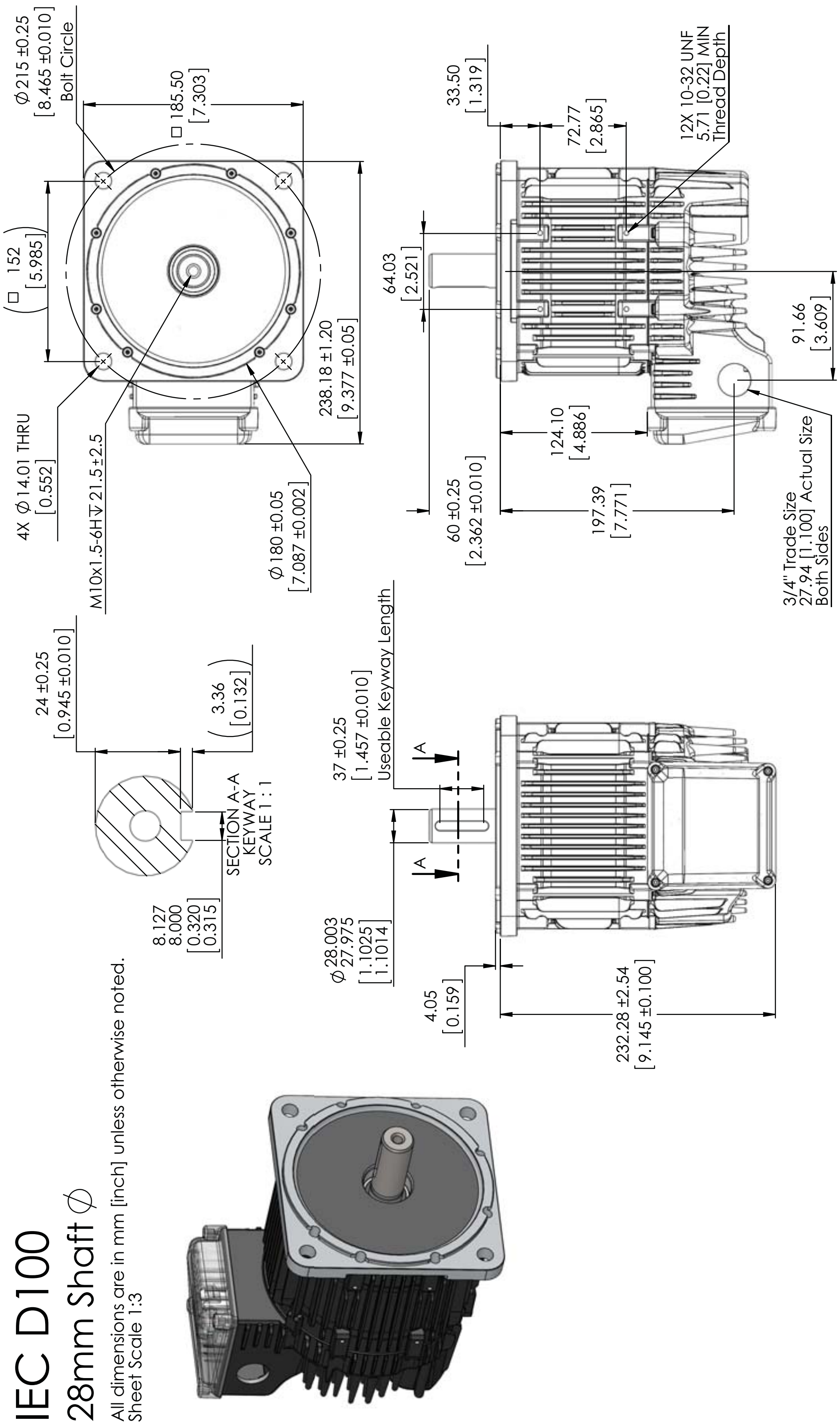
## NEMA 56 FRAME MOTORS



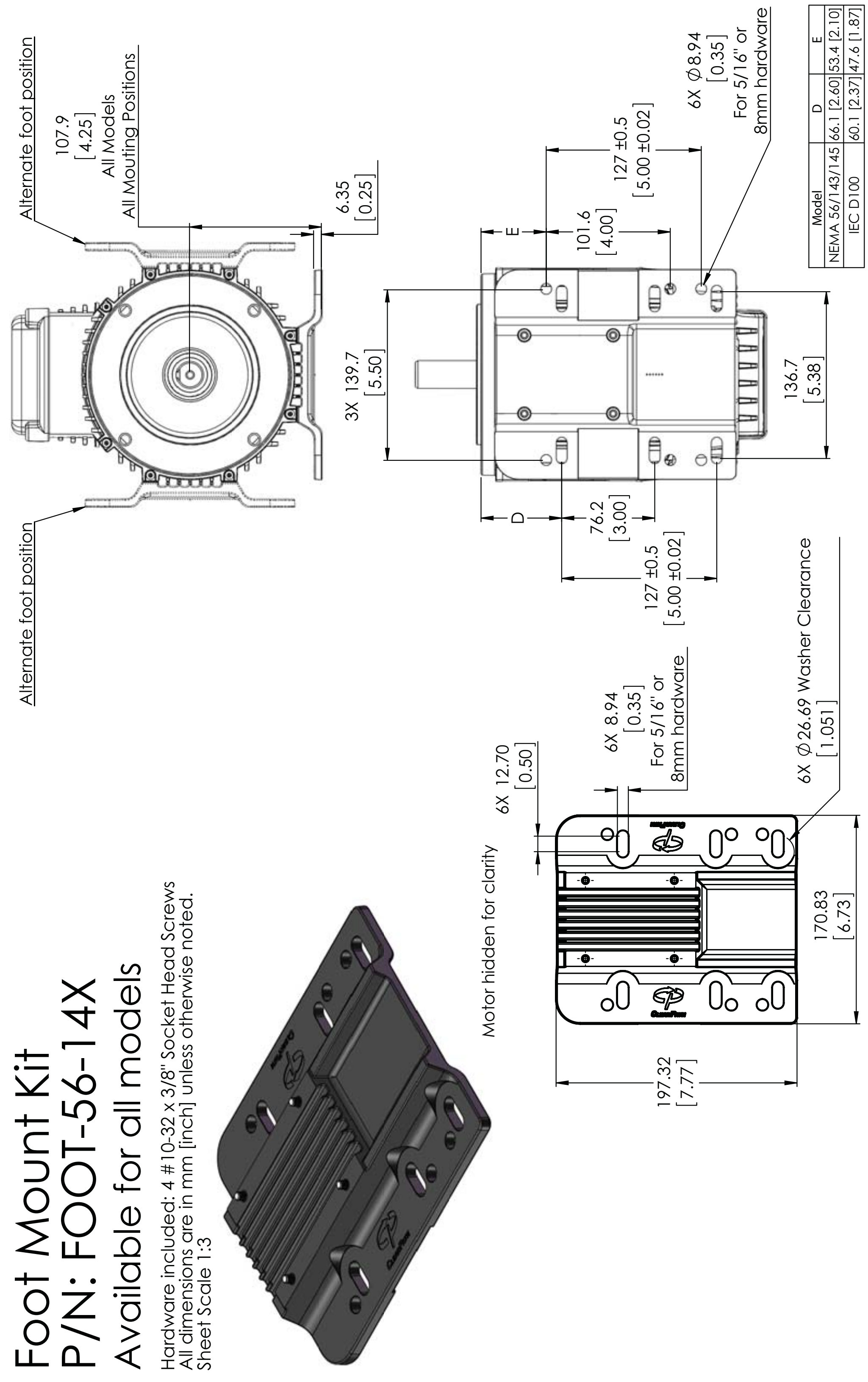
## NEMA 143/145 FRAME MOTORS



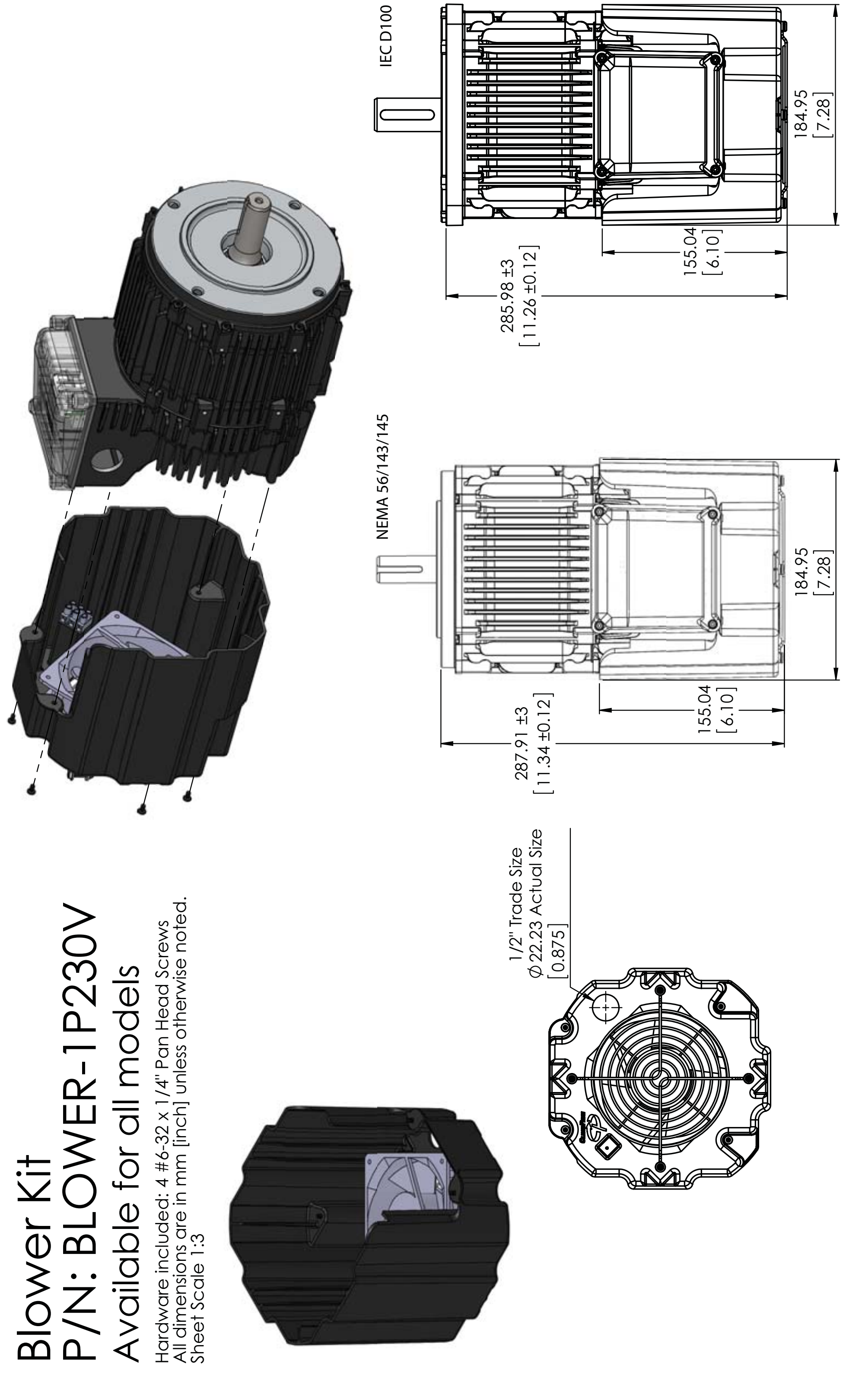
## IEC D100 FRAME MOTORS



### Foot (Accessory Mounting Plate)



### Motor Dimensions With Blower Kit



## CORD GRIPS AND CABLE CLAMPS

Below is a short list of cord grips, clamps, and conduit connectors that will fit the ClearPath motor junction box knockout holes. There are many more options for cord grips, cable clamps, and plugs on the market[6].

**Available from McMaster-Carr**

- Screw-down cord grip (Romex connector): M-C Part# 7798K42
- Liquid-tight Conduit (Sealtite): M-C Part# 9082K53 (9082K63 is the 90 degree elbow version)
- EMT connectors (water-tight versions are also available): M-C Part# 7150K12 (Part# 8081K32 is the 90 degree elbow version)
- Metal-Armored cable: M-C Part# 7267K35 (90 degree elbow version)
- Liquid-tight cord grips: M-C Part# 7529K566 (many cord diameters are available, as well as 90 degree angle versions)
- Screw-down cord grip (Romex connector): M-C Part# 7798K41

**Available from Mouser.com**

- Liquid tight, 3-cable cord grip with skinned over opening: Mouser Part# 836-M3234GBS-SM (Heyco Part# M3234GBS-SM). *This cord grip is compatible with Teknic' s controller cables and 24VDC logic power backup cable.*

[6] Disclaimer: It is the user's responsibility to evaluate the safety and suitability of third-party accessory items for their application. Part numbers, pricing, and availability of items listed in this section are subject to change without notice.

## CLEARPATH MOUNTING CONSIDERATIONS

**Tip:** For greater ease of use, consider mounting your 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.
- **Note:** ClearPath can be fitted with an external accessory fan if desired See ***How to Mount the Blower kit,*** later in this section.

## CONNECTING CLEARPATH TO A MECHANICAL SYSTEM

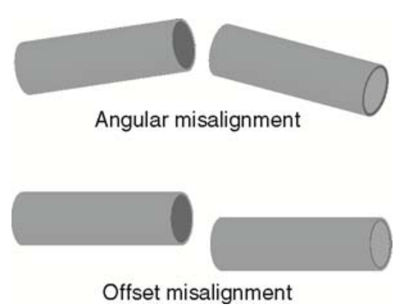
While it's obvious that ClearPath must be connected to a mechanical system to do useful work, it's not always clear just how to connect the motor to the mechanics.

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.

## NOTES ON COUPLING SELECTION

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

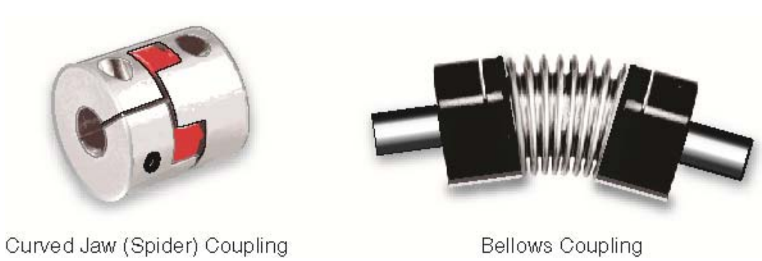
**General Guidelines for Coupling Selection**

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

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

**Coupling Recommendation**

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




***Couplings for servo applications***

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

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

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

#### Coupling Information on the Web

Ruland's website has a good collection of technical information on coupling types and coupling selection for servo systems. See links below.

https://www.ruland.com/technical-resources/technical-articles

https://www.ruland.com/technical-resources/technical-articles/5-reasons-to-consider-using-jaw-couplings

## 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.

## How to Mount Optional Blower Kit (BLOWER-1P230V)

This section describes how to wire and mount Teknic Part#: ***BLOWER-1P230V*** to UL Recognized AC ClearPath models.

**Please read these important notes before proceeding!**

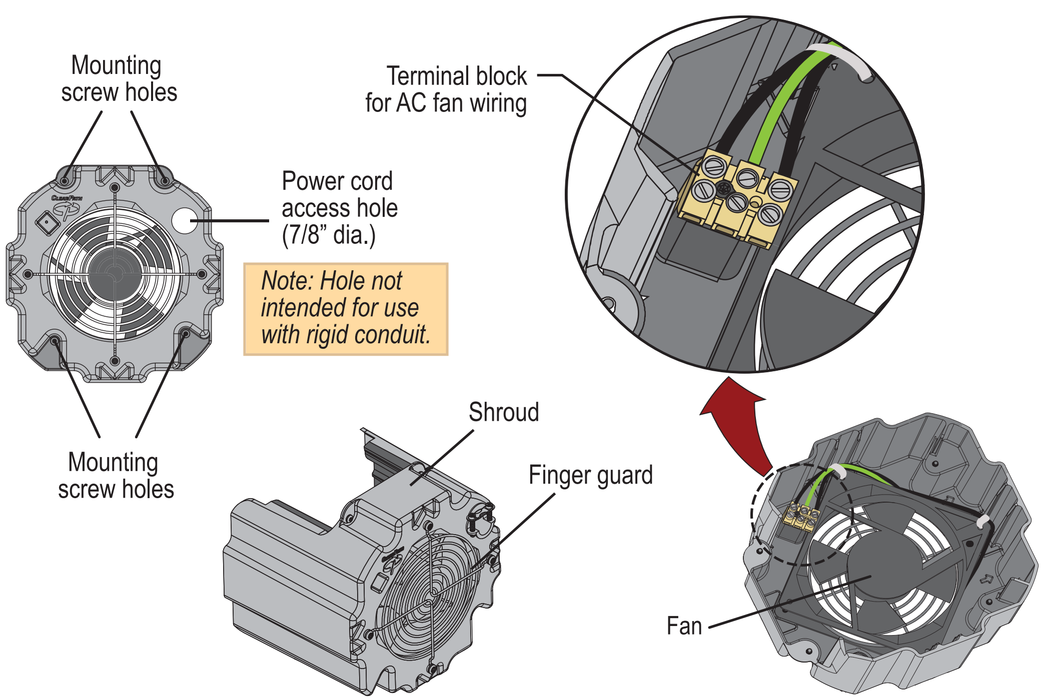
- The fan supplied with this blower kit requires single phase 230VAC nominal mains power with a max. rating of 250 VAC. The fan will not work properly with 120VAC power.
- Important: Bond Protective Earth of the blower kit and Protective Earth of the AC ClearPath Motor to the same electrical system in the final installation.
- This device is not intended for connection to rigid metal conduit.

**Items included in this kit**

- Shroud (heavy-duty plastic)
- Fan (230VAC nominal)
- Finger guard
- AC wiring terminal block, 3 position
- Mounting screws, (qty.4), #6-32, T-10, pre-treated with thread locker

**Items *not included* in this kit**

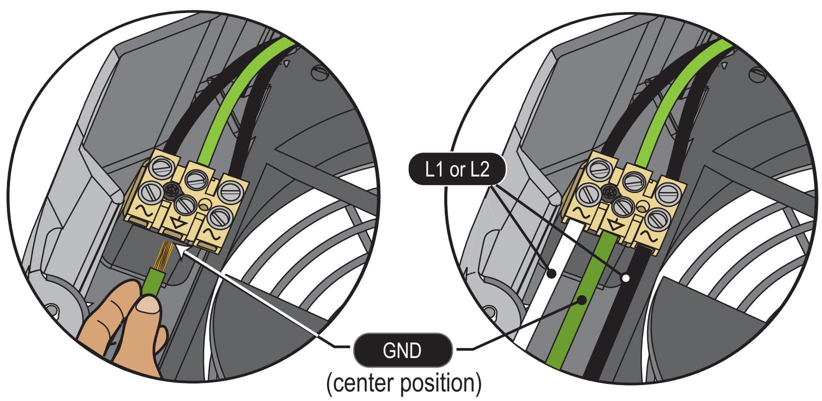
- Screwdriver, Torx, T-10
- Screwdriver, slotted, small
- Suitably Listed line cord with 3 flying leads (L1, L2, and GND) and appropriate (230VAC) Listed plug
- Suitably Listed cord grip or strain relief sized to fit a 1/2" Trade Size knockout. (7/8" hole diameter)
- Tie wrap (1), Panduit PLT1.5i-c (or equivalent)



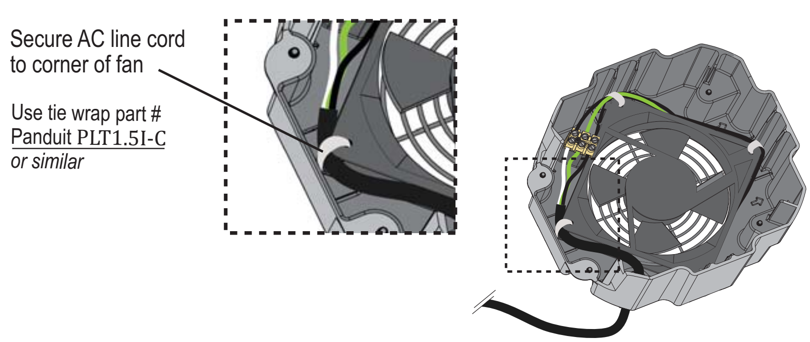

***BLOWER-1P230V***

### Procedure

1. Strip 50-75mm (approximately 2-3 inches) of the line cord's outer jacket to expose the 3 inner wires. Be careful not to nick the insulation on any wires.
2. Strip 6-7 mm (approximately 0.25 inches) from each of the 3 inner wires.
3. Attach strain relief or cord grip to the shroud.
4. Feed the line cord through the strain relief and into the blower housing.
5. Insert the line cord wires into the 3 position terminal block as shown below. Connect ground (typically green) to the center terminal. Important: Ensure that GND wire connects to Protective Earth. Connect the AC phase wires (labeled L1 and L2 below) to either of the outer terminals.

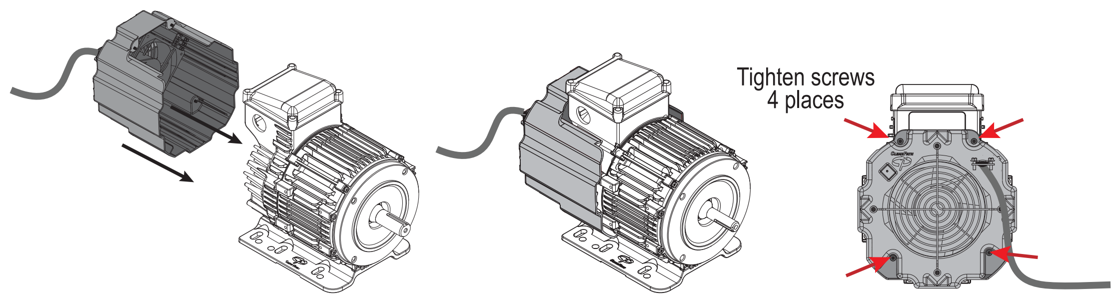



6. Tighten screws. Verify that no stray wire strands are protruding from terminal housing.
7. Tighten strain relief or cord grip. Verify that all wires are properly captured and strain relieved.
8. Important: Secure AC line cord to the corner of fan with a tie wrap (see figure below). This is necessary to prevent the line cord from interfering with the fan during operation.




9. Test fan operation by applying AC mains power. Remove power after test.

10. Slide the blower onto the ClearPath motor as shown below.
11. Secure blower to the motor by tightening 4 screws as shown below. Use Torx (T-10) screwdriver.




***Connecting the BLOWER-1P230V to an AC ClearPath Motor***

## 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.

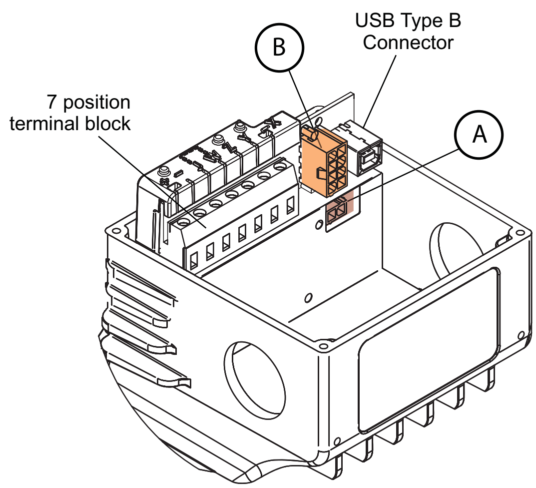
### END STOPS AND HARD STOP HOMING

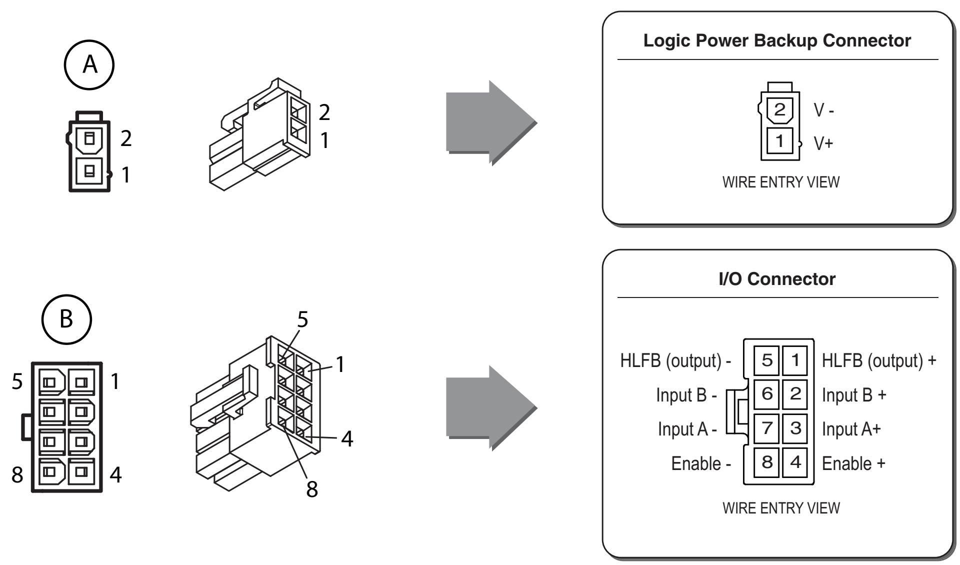
End stops from medium durometer rubber to steel can be used successfully with Hard Stop Homing. When selecting end stops for a Hard Stop Homing application consider the following:

- 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.

# APPENDIX C: CONNECTOR MATING PARTS AND CABLE PINOUTS

## CONNECTOR MATING PARTS




Mating Parts List

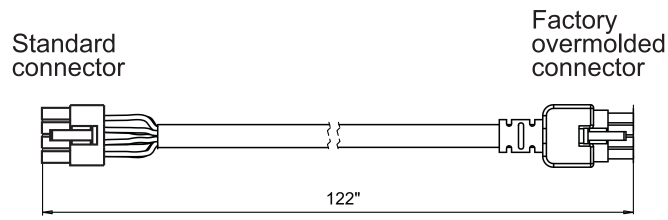
| Ref. | Description | Mating Connector PN | Terminal PN | Terminal Desc. | Crimp Tool | Extraction Tool | Recommended Wire Gauge** |
|---|---|---|---|---|---|---|---|
| A | Molex MiniFit-Jr, Receptacle, 2 circuits | 39-01-2020 (natural, UL 94V-2)<br>39-01-3025 (black, UL 94V-2)<br>39-01-3028 (natural, 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 |
| B | 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 |

** AWG values listed are the actual wire gauges used in Teknic-manufactured cables.

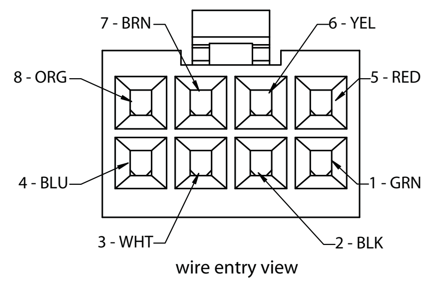
# Cable Pinouts

## Control Cable: CPM-CABLE-CTRL-MU120

**Cable description:** ClearPath I/O connector cable, ~122 inches end-to-end. Overmolded Molex MiniFit Jr. 8-position connector to standard MiniFit Jr. 8-position connector (no overmolding on one end for easy access to wires).

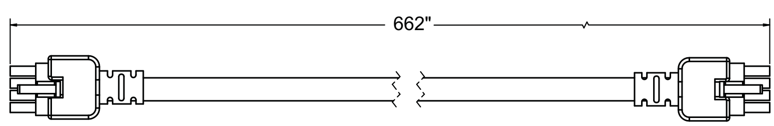



| Pin Assignments | | |
|---|---|---|
| **Pin** | **Color** | **Name** |
| 1 | GRN | HLFB + |
| 2 | BLK | Input B + |
| 3 | WHT | Input A + |
| 4 | BLU | Enable + |
| 5 | RED | HLFB - |
| 6 | YEL | Input B - |
| 7 | BRN | Input A - |
| 8 | ORN | Enable - |

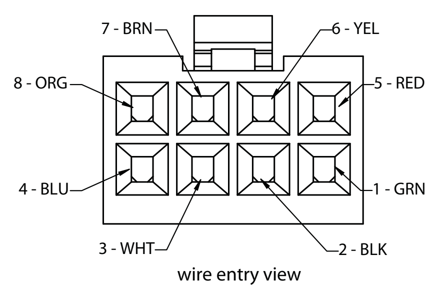



## Control Cable: CPM-CABLE-CTRL-MM660

**Cable description:** ClearPath I/O connector cable (double-ended), ~662" end-to-end. Overmolded 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 - |



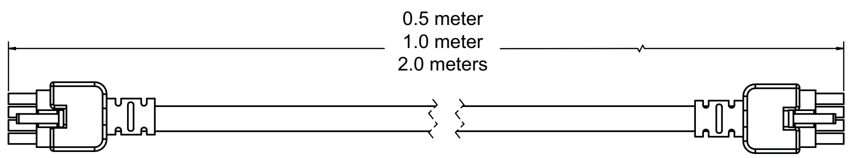
## Control Cable: Molex Brand (2 meters and shorter)

Molex stocks a few shorter, ClearPath-compatible control cables through their website (see URLs below).

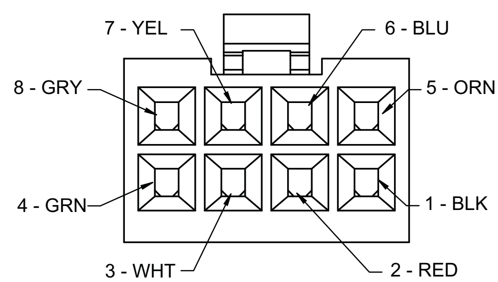
**Cable description:** These cables are overmolded Molex MiniFit Jr. 8-position connector to same, with 18AWG wires. Available lengths include 0.5 meter, 1 meter, and 2 meters.

**Note:** The wire colors for the Molex brand cables are not identical to the wire colors used in the Teknic brand cables (listed on the previous page). This will not affect cable operation.

| Length | Molex PN | Link |
|---|---|---|
| 0.5 m | 2451350805 | https://www.molex.com/molex/products/part-detail/cable_assemblies/2451350805 |
| 1.0 m | 2451350810 | https://www.molex.com/molex/products/part-detail/cable_assemblies/2451350810 |
| 2.0 m | 2451350820 | https://www.molex.com/molex/products/part-detail/cable_assemblies/2451350820 |




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




wire entry view

# APPENDIX D: SPECIFICATIONS

## COMMON MOTOR SPECIFICATIONS (ALL MODELS)

| **Motor Common Specifications (All Models)** | |
|---|---|
| **Input Power** | |
| Input voltage range, AC, single and 3 phase | 100-240VAC |
| Input voltage range, AC, 3-phase, 5-wire source | 300-415VAC |
| Typical / Max. quiescent AC input power, enabled | 27W / 30W |
| LVDC Backup power input range | 20-28VDC |
| LVDC Backup power watts, maximum | 4.0 W |
| **Environmental** | |
| Ambient temperature | -40°C to +70°C* |
| Ambient humidity, junction box open (during commissioning) | 10%-85%, non condensing |
| Environmental Sealing with optional shaft seal | IP66K/IP67** |
| Environmental Sealing without shaft seal | IP53** |
| **Electrical Control I/O** | |
| Logic Input Voltage Range | 4.0VDC to 28VDC |
| Input Current @ 5V | 7.5mA (typical) |
| Input Current @ 28V | 12.0mA (typical) |
| 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) |
| **Bearing/Shaft Ratings:** | |
| Rated Radial Load, NEMA56 (lbs./N) | 170 lbs (756 N) applied 1.18" (30mm) from user mounting face |
| Rated Radial Load, NEMA143/145 (lbs./N) | 170 lbs (756 N) applied 1.18" (30mm) from user mounting face |
| Rated Radial Load, IEC D100 (lbs./N) | 170 lbs (756 N) applied 1.18" (30mm) from user mounting face |
| Maximum Axial (Inward-Thrust) Load, all models, all shaft orientations | 70 lb (311 N) |
| Maximum Axial (Outward-Tensile) Load, all models, all shaft orientations | 40 lb (178 N) |
| Bearing Life | 2.1 x$10^{10}$ to 4.4 x$10^{10}$ revs (typ., load dependent.) |
| **Shock and Vibration** | |
| Maximum Shock during transport/storage | 10G (applied no more than twice) |
| Maximum Shock during operation | 2G |
| Maximum Vibration (2-200Hz) | 1G or 0.5mm (whichever is less) |
| Maximum externally applied shaft acceleration (rev/sec2) | 250,000 radians/sec2 |
| **Compliance** | |
| Electrical Safety | EN61010, UL61010, UL61800-5-1 |
| EMI (RF emissions and immunity) | EN 61326-1 |
| Conformance Marking | UL recognized for use up to 240VAC<br>CE certified for use up to 415 VAC<br>RoHS |
| **General** | |
| Frame sizes available | NEMA 56, NEMA 143/145, IEC D100 |
| Mass | 11.5kg |
| Country of Origin | USA |
| Warranty | 3 Years |

** The RMS torque limit on certain motors is derated for operation in ambient temperatures above +40°C. Contact Teknic for derating assistance.*

*** To achieve the stated IP rating, user must install junction box cord grips or plugs that meet or exceed the specified IP ratings.*

# 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 junction box) to a point on the machine that is bonded to machine PE. **Use grounding wire with same AWG number (or heavier) as the ClearPath AC 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 AC 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 for all ClearPath power wiring. When in doubt, use heavier gauge wire.

# Appendix F: ClearPath Part Number Key

*Example Part Number*

**C P M - S C H P - N 1 4 3 1 P - E L N A**

1 (CPM) 2 (SCHP) 3 (N143) 4 (1) 5 (P) 6 (E) 7 (L) 8 (N) 9 (A)

| | | | |
|---|---|---|---|
| 1 | Product ID | CPM | ClearPath® Motor |
| 2 | Family/Model | SDSK | Step & Direction / "Stepper Killer" *(2-3x the power of similarly sized steppers)* |
| | | SDHP | Step & Direction / High Power model *(8-15x the power of similarly sized steppers)* |
| | | 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 | Frame/Shaft Diameter | N056 | NEMA 56 frame with 5/8" shaft diameter |
| | | N143/145 | NEMA 143/145 frame with 7/8" shaft diameter |
| | | D100 | IEC D100 frame with 28mm shaft diameter, endbell adapter plate |
| 4 | Torque-Speed Characteristic | 1<br>2<br>3<br>4<br>5 | Indicates specific winding design. See your motor's torque-speed curve for more information. |
| 5 | Cooling Options | P | Passive Cooling |
| | | A | Active Cooling (includes optional blower kit (Teknic Part #: ***BLOWER-1P230V***) |
| 6 | Enhanced Options | R | Positioning Resolution = 4000 counts per revolution |
| | | E | Positioning Resolution = 32000 counts per revolution. **Note: Encoder resolution is limited to 8000 counts per rev when using Step & Direction with Enhanced Option.** |
| 7 | Shaft Option | L | Standard |
| 8 | Shaft Seal | N | Standard dust sealing |
| | | S | Extra PTFE infused polyimide seal |
| 9 | Feature Set *(for 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 registers
- Warning and alert system
- Parameter memory
- Safety shutdowns
- Soft limits
- User defined data
- Automatic brake coil control
- Group shutdowns

**Advanced Features* (SC models only)**

- 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

* Includes all Basic Features

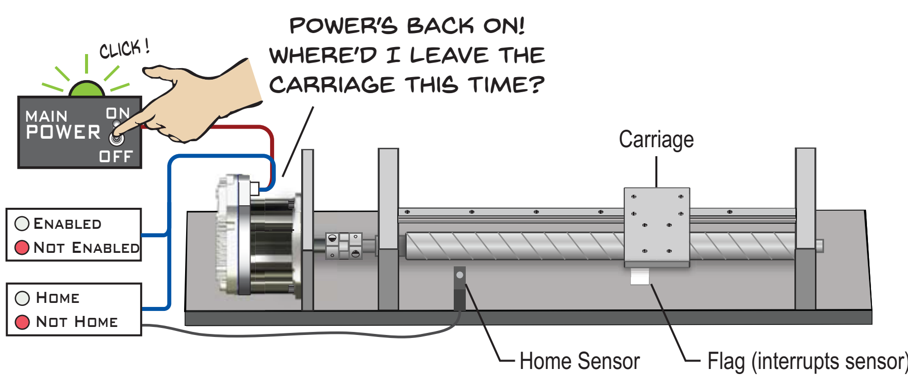
# Appendix G: Miscellaneous Topics

## 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)

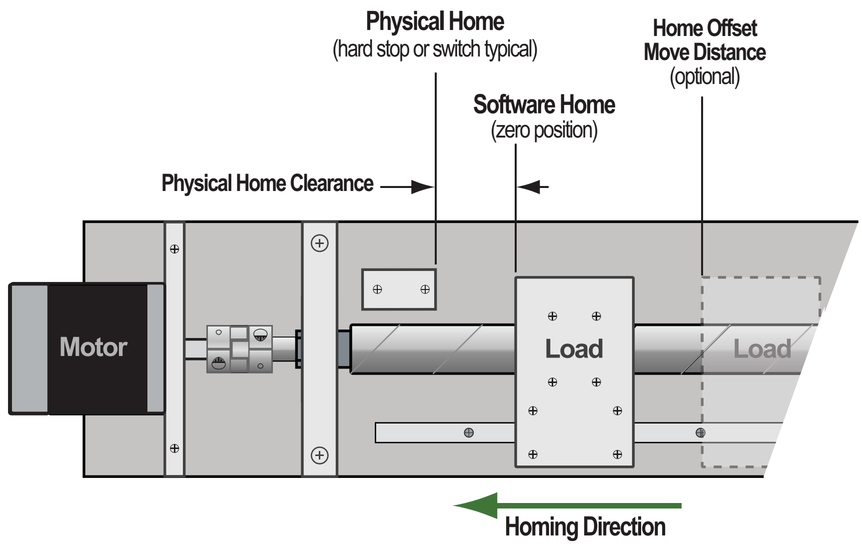
The homing process typically involves moving the motor in a predetermined direction towards a physical home location (typically a sensor or hardstop at the end of travel).

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.

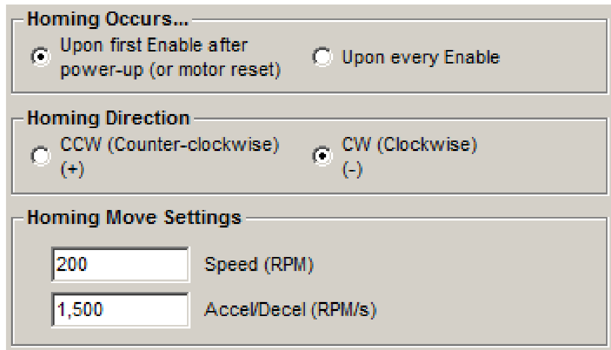
**Home Offset Move Distance (setting)** - This is an additional, user-defined parameter which determines the final offset location when homing is completed. At the end of homing the load will be the specified distance away from the Software Home.

## 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...**

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**

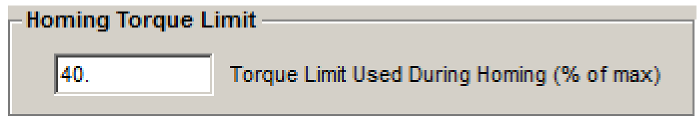
Lets you choose clockwise or counter-clockwise shaft rotation during homing. Select the direction of motor shaft rotation that will move the load toward the Physical Home (hard stop, switch, sensor).

**Homing Move Settings**

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

## Homing Settings: Other

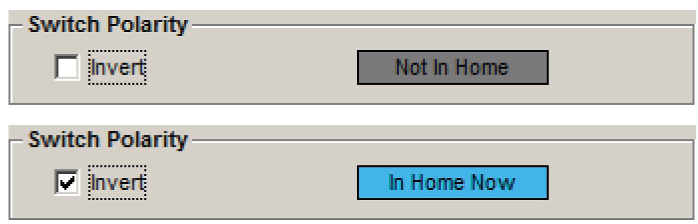
### Homing Torque Limit (Hard Stop Homing only)




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)

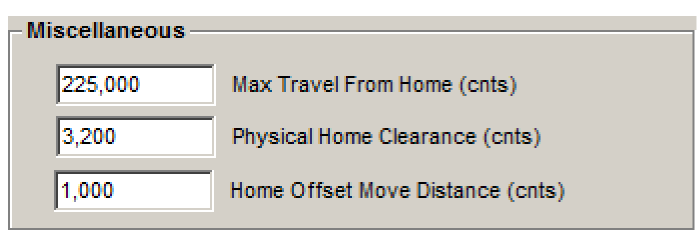
The Switch Polarity checkbox gives you the option of inverting how ClearPath interprets the home switch input state. This is helpful, for example, if you have a normally closed home switch and you really needed a normally open switch.




### 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



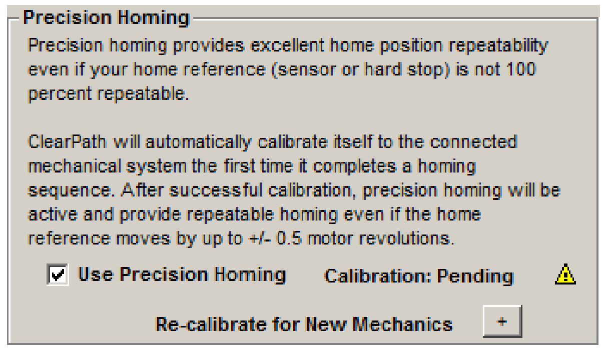

**Max Travel From Home (cnts) -** (Optional. Set to "0" to turn off.) This is a software enforced travel limit. It is the maximum distance that the motor is allowed to travel away from the Software Home position (i.e., the zero position). ClearPath will not execute any move that would violate this travel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

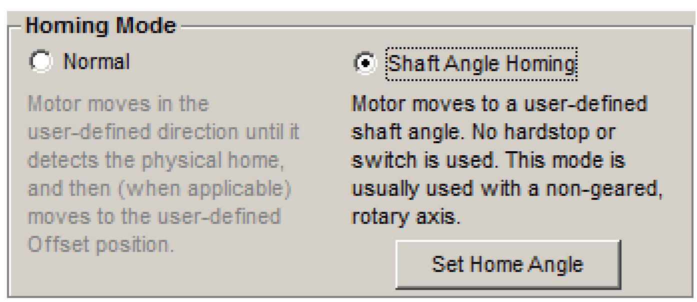
The Precision Homing feature was created to help ensure that ClearPath always finds the exact same Software Home (zero) position, even in cases where the hard stop or home switch has slipped, bent, or otherwise drifted in position. See the "Precision Homing" section later in this document for more information.




***Precision Homing 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.




### 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.

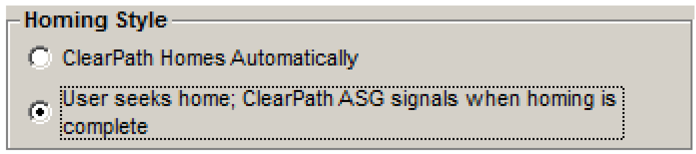
### Manual Homing aka "User Seeks Home"

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

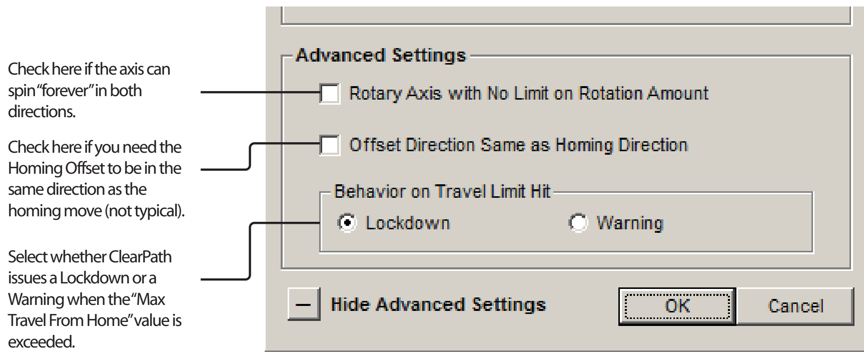
When using Manual Homing, the user is responsible for sending homing moves to ClearPath via step and direction or pulse burst signals.

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.



### Advanced Settings




***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

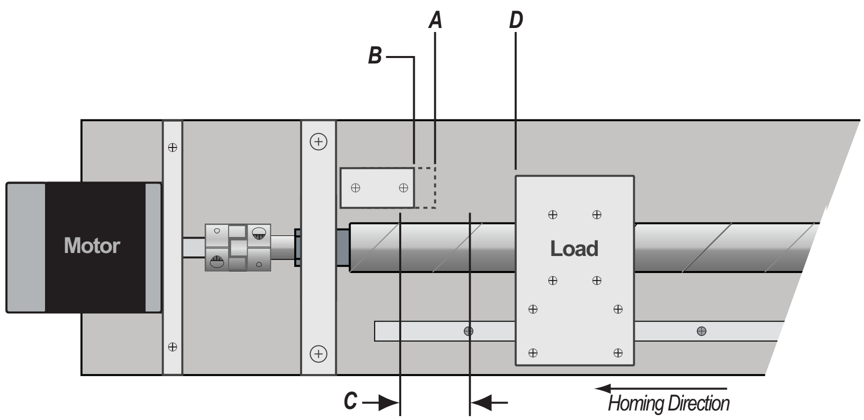
1. The user Enables ClearPath. (Enabling energizes the motor coils and puts ClearPath in Manual Homing mode.)
2. The motor remains stationary until the user's control system issues a move toward the Physical Home (hard stop) using Step & Direction or Pulse Burst signals. *Note: This initial move must 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 that your specified home position remains highly repeatable over time, even if the physical home mechanism (typically a switch, sensor or hard stop) takes a hit and shifts position, becomes bent, or experiences sensor drift over time. The physical home mechanism can move by as much as ± 1/2 of a motor revolution and not affect axis homing repeatability.

***Video Link:*** [Precision Homing Explained]

When a ClearPath motor is set up for Precision Homing, the motor automatically calibrates itself to the connected mechanical system the first time ClearPath completes a homing operation (note: homing can be recalibrated very easily at any time). After successful calibration, Precision Homing remains active unless the feature is turned off in MSP.




***Precision Homing Nomenclature***

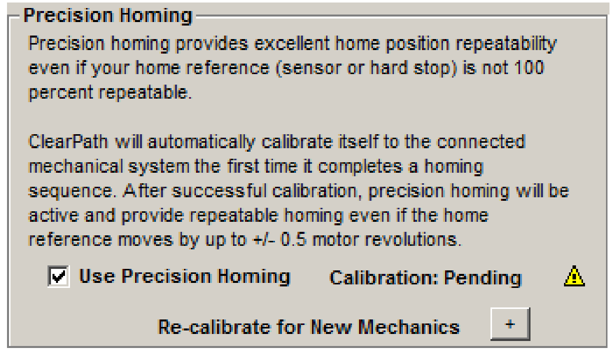
(a) **Original Physical Home -** This is the Physical Home reference point found during the initial homing/calibration operation. Note: This reference data is stored in the motor's nonvolatile memory. It is not reset when power is cycled.

(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 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

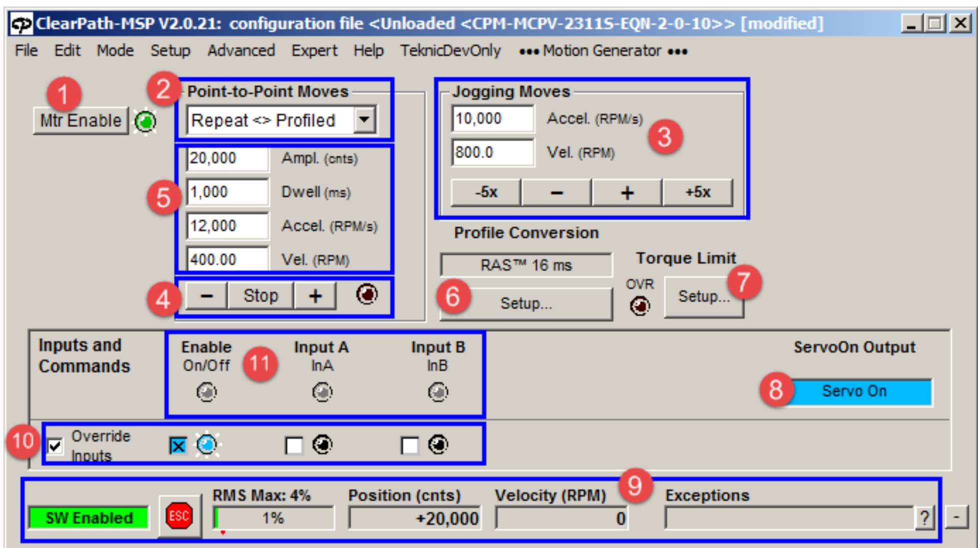
## Motion Generator

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*.




***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)*

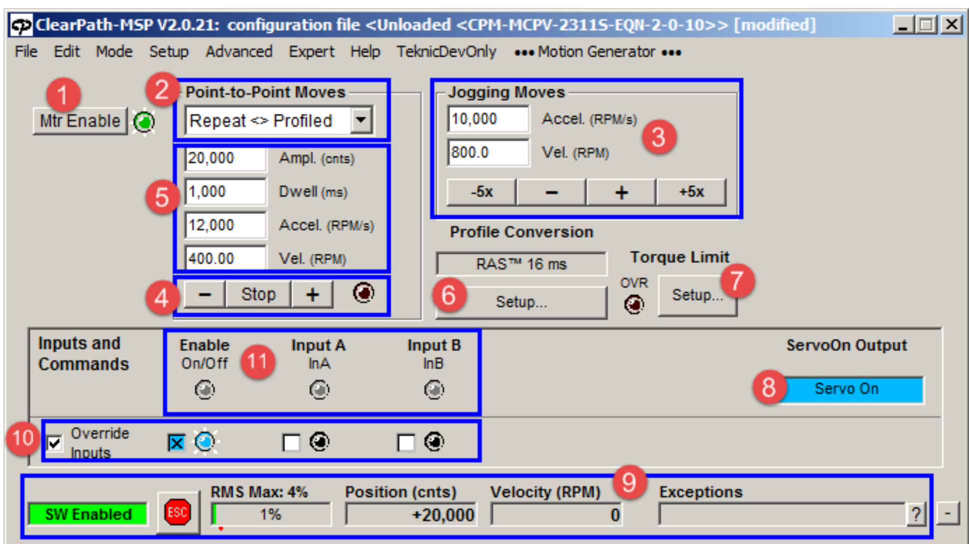
- **Single Profiled** - Move once and stop. Click + or - button to launch a single move in the specified direction.
- **Repeat <> Profiled** - Move back and forth repeatedly. Click + or - button to launch reciprocating (back and forth) moves. Moves will repeat indefinitely until the Stop button is clicked 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).




***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 touches on 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 motion that can be commanded at a given encoder resolution. This family of ClearPath motors supports either 4000 or 32000 encoder 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 64,000 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 the AC ClearPath family are:

- **4000 counts per revolution** for motor part numbers ending in **-Rxx.**
- **32000 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.*

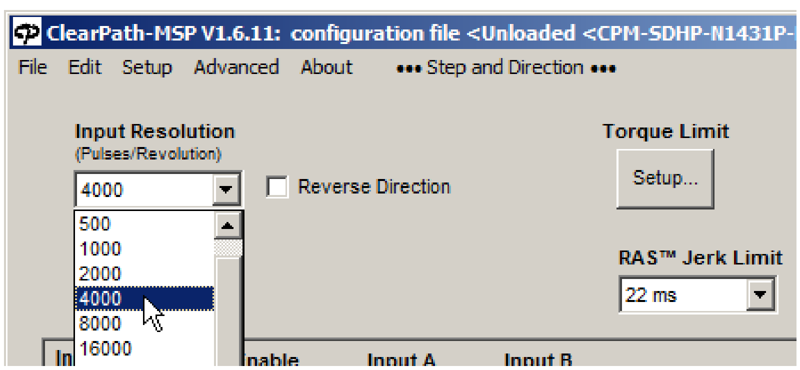
The **Input Resolution** setting lets you vary the ratio of step pulses to counts. It is set via a drop down menu in the mode settings of *Pulse Burst Positioning* and *Step and Direction* modes.

**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 a* ***4000 count per revolution*** *ClearPath motor.*

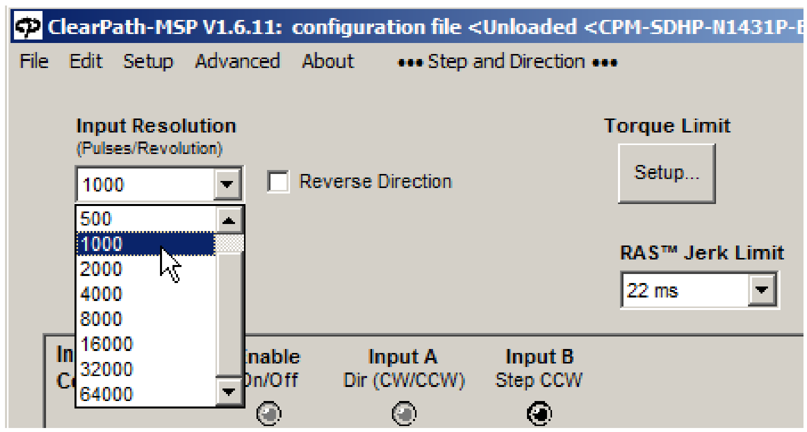
- **Case #1. You want one step pulse to command one count of motion (default).** One count per step is the most common Input Resolution setting. For a 4000 count per rev. motor, set Input Resolution to 4000.




**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 a 4000 count per revolution motor (as in the figure above) set Input Resolution to 4000 pulses per rev. For a 32000 count per rev motor, set it to 32000 pulses per revolution.

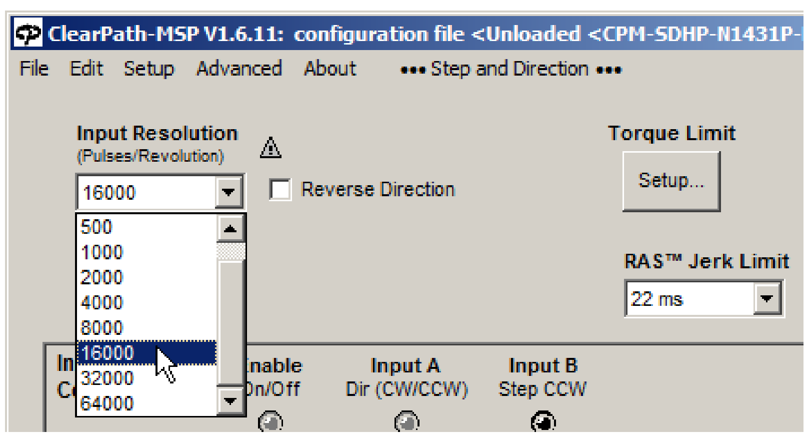
- **Case #2. You want one step pulse to command multiple counts of motion.** ClearPath can be configured such that a single step pulse commands 2, 4, 8, or more counts of motion. This strategy is most often used to compensate for a "slow" controller, i.e., a controller that can't put out step pulses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

  To do this, just set the Input Resolution to value lower than your motor's positioning resolution. For example, if you have a 4000 count encoder, and set the Input Resolution to 1000, each step pulse sent to the step input would cause the motor to rotate 4 counts. Thus it would only require 1000 pulses to rotate 4000 counts (one full revolution of the motor shaft).




- **Case #3. You want 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, and the motors have different positioning resolutions.

  To do this, set the Input Resolution to a multiple of your motor's positioning resolution. Example: Let's say you have a 4000 count motor. If you set the Input Resolution to 16000, it would take 16000 step pulses to rotate the motor one revolution. Thus, it would take 4 step pulses to move the motor 1 count.

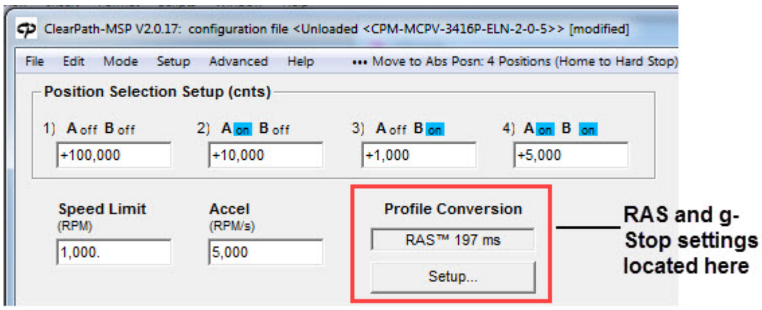



*With the above Input Resolution setting, it will take 16000 step pulses to make this [4000 count per rev.] motor rotate one full revolution.*

## 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.*



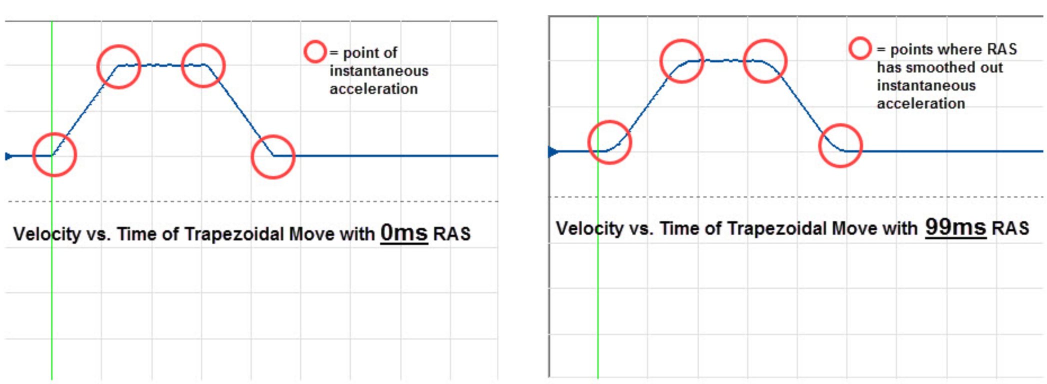

***Location of RAS and g-Stop settings***

### RAS (Regressive Auto-Spline)

RAS is a jerk limiting, and jerk-derivative limiting feature based on proprietary technology developed by Teknic.

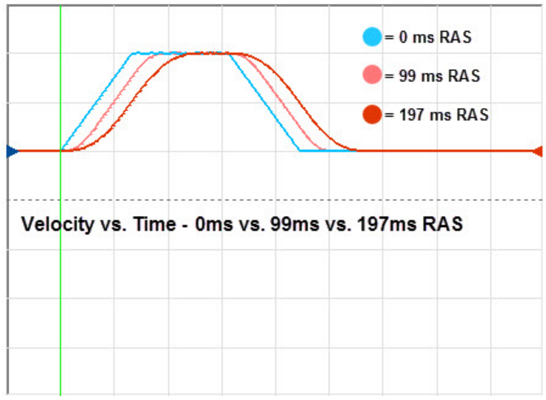
The RAS software uses advanced algorithms to analyze each commanded move and rapidly calculate and fit a forth-order polynomial spline to it. This converts the sharp cornered transitions between the constant velocity and acceleration segments of a move to more gradual, rounded corners.

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.

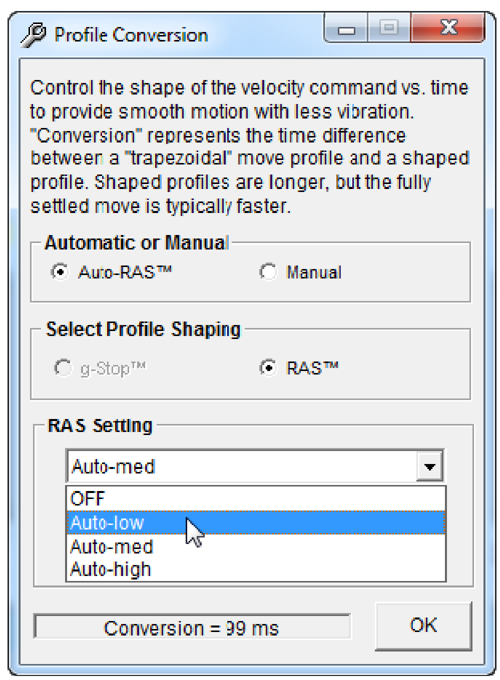



***RAS Motion Profile Comparisons***

### Auto-RAS (MC Series Motors)

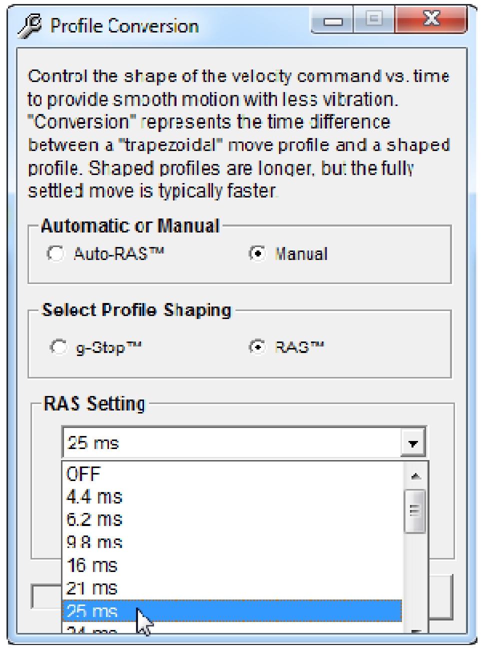
Auto-RAS simplifies RAS selection by offering three settings, "Auto-High", "Auto-Med", or "Auto-Low". "Auto-High" applies the most jerk/jerk-derivative limiting, but also adds the most conversion time.

Each Auto-RAS setting you choose, automatically adjusts to the motor's velocity and acceleration settings.



### 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.




### 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 a limited selection of Manual RAS settings.
- Auto-RAS is only available for ClearPath MC series motors.

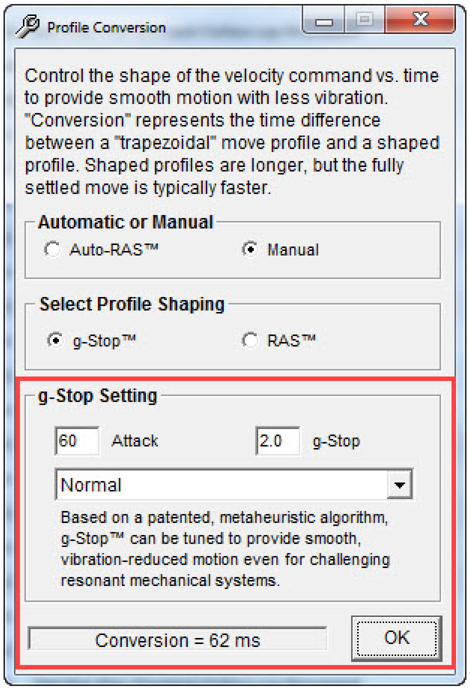
### g-Stop Tuning

g-Stop was designed primarily to help address machine resonances. A good g-Stop setting will reduce machine shake and vibration, and allow for the use of higher acceleration limits with less audible noise. This feature builds on patented technology developed by Teknic.

**G-Stop Video on the Web**

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.




***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 mode 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. If you continue to increment Attack and see worsening performance, you may have gone too far.

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 include 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 or may not include every component 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

**Teknic, Incorporated**
7650 Omnitech Pl
Victor, NY 14564