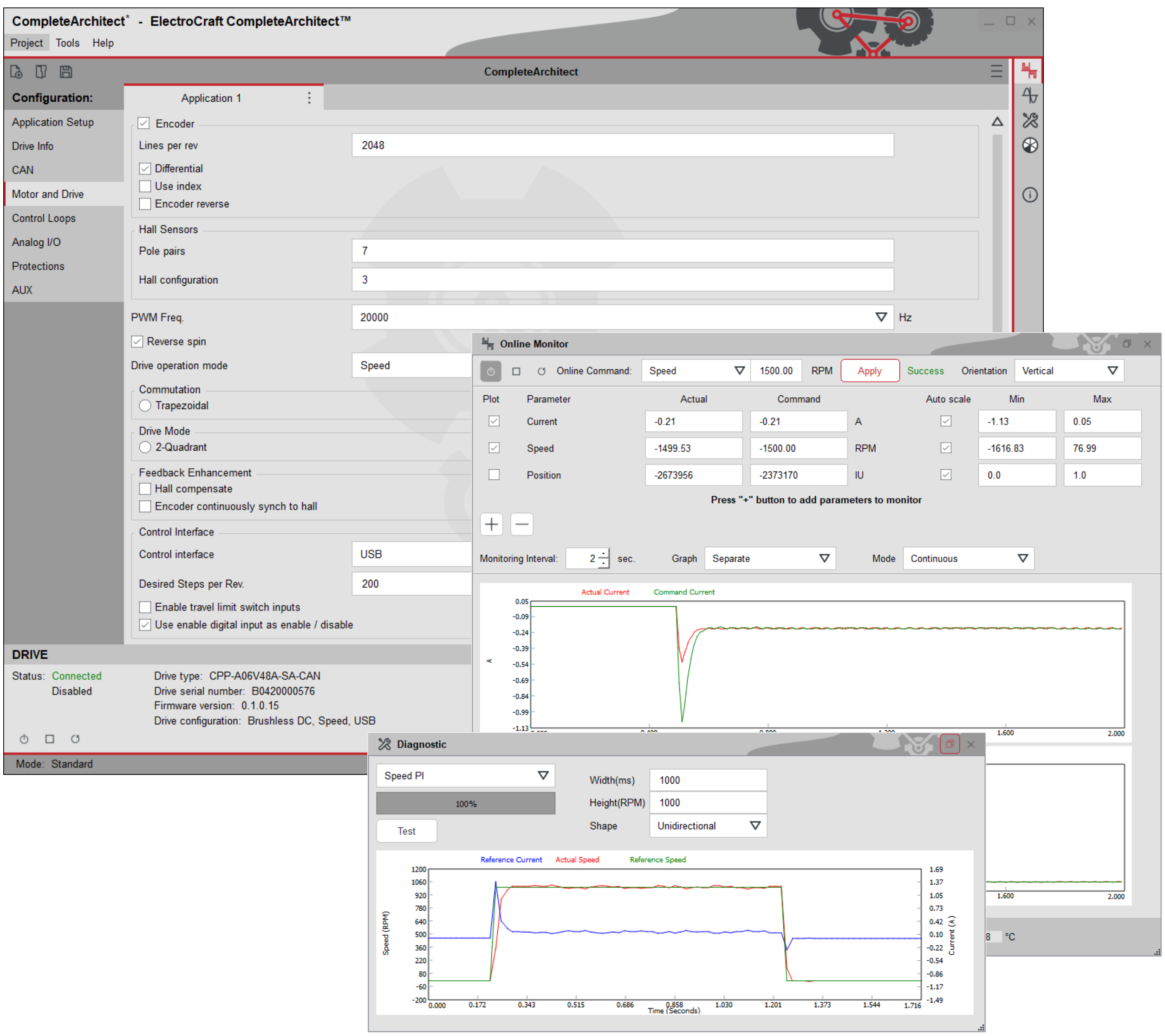
ElectroCraft®

# CompleteArchitect™

CompletePower™ Plus – Universal Drive Configuration Software

# Software User Manual




CompleteArchitect™ Software User Manual
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| 004 | 07/12/2022 | Update for CAN release |
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## Read This First

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## About This Manual

This document is a software manual for ElectroCraft CompletePower™ Plus Universal servo drives. This document covers the download, installation, and operation of the CompleteArchitect™ software needed for configuring all ElectroCraft CompletePower™ Plus Universal servo drives.

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# 1 Software Overview

This manual covers the download, installation, and operation of the ElectroCraft CompleteArchitect™ software to configure ElectroCraft CompletePower™ Plus Universal servo drives.

## 1.1 Key Features

ElectroCraft CompleteArchitect™ is a Windows®-based software tool that includes the following key features:

- Easy installation
- An Interactive graphical user interface
- A user configurable motor database
- Detailed video tutorials
- An online monitor for visualizing application parameters such as bus voltage and motor speed
- An oscilloscope for measuring high speed waveforms such as motor phase currents
- Diagnostic test scripts for verifying control loop parameters
- I/O monitor to display the physical state of all the digital and analog inputs and outputs
- Configurable application protection
- Selectable measurement units

## 1.2 Simplified Process Flow

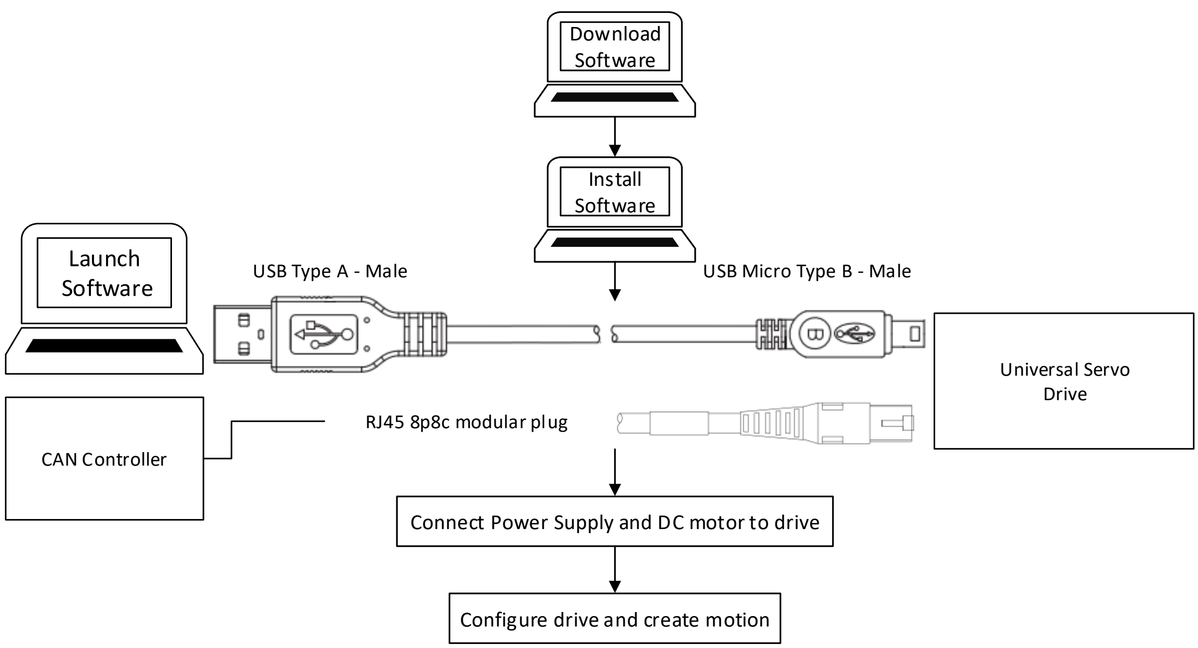



**Figure 1: Simplified Block Diagram**

*Note: The supply input voltage must be applied to the drive before operating a motor, however, our CompletePower™ Plus Universal Drives can be configured using CompleteArchitect™ software through the USB when no supply power is supplied to the drive.*

## 1.3 Software Setup

### 1.3.1 Software Download

Launch your preferred internet browser and go to the ElectroCraft website. Navigate to the Resource Center and download ElectroCraft CompleteArchitect™ Configuration Software.

### 1.3.2 Software Installation

Once the download is complete, launch the software installer (ElectroCraft CompleteArchitect Setup vxxx.exe). The window shown in Figure 2 will appear.


**Figure 2: Initial Installation Window**

Follow the instructions in the installation window. Once the installation is successfully complete, the CompleteArchitect™ software icon  will be accessible from your desktop and Windows Start menu.

### 1.3.3 Software Launch

Open CompleteArchitect™. The window shown in Figure 3 will appear.

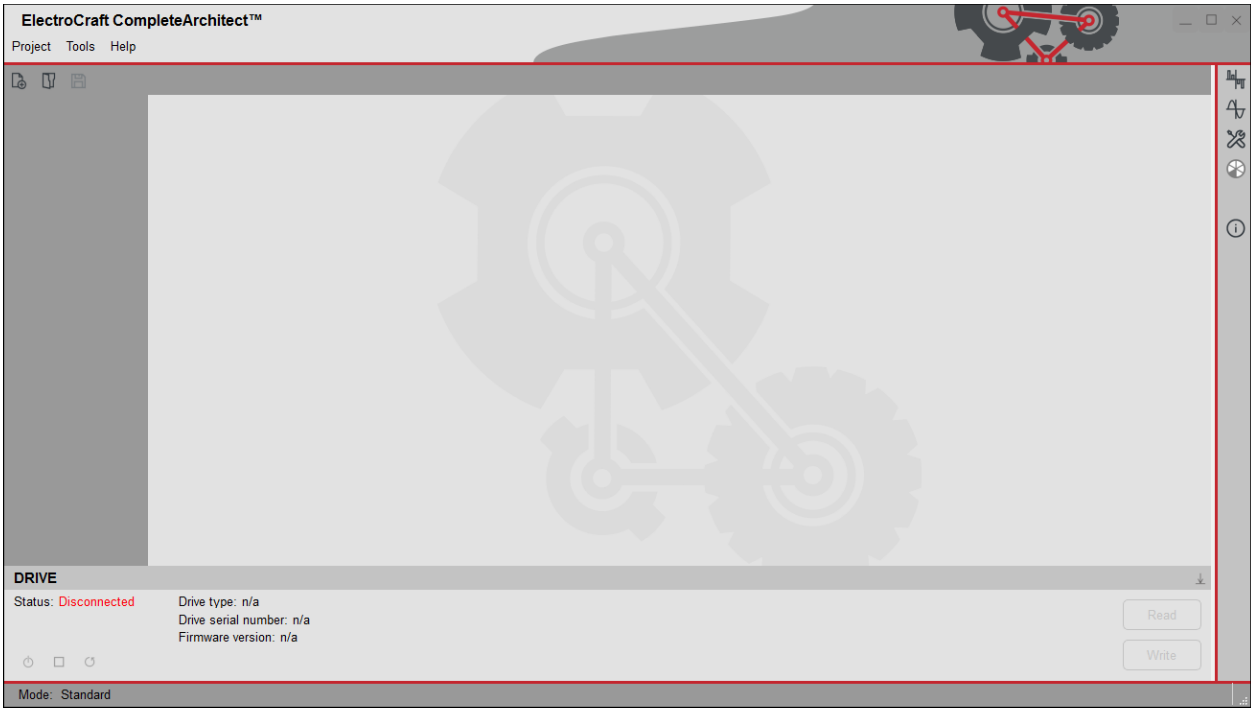



**Figure 3: CompleteArchitect™ Software Initial Window**

Connect a drive to a PC using a USB interface cable and supply power to the drive. Status will change to *Connected* and the Drive type, Drive serial number, Firmware version and Drive configuration will change to reflect the characteristics of the connected drive. An example of a connected drive is shown in Figure 4.


**Figure 4: Drive Information**

## 1.4 Software Window Overview

The fundamental symbols and sections of the program are labelled in the example window shown in Figure 5. A description of the function of each fundamental symbol is provided in the accompanying table. The image also highlights the locations and teminology used to describe the different functional groups in this document.

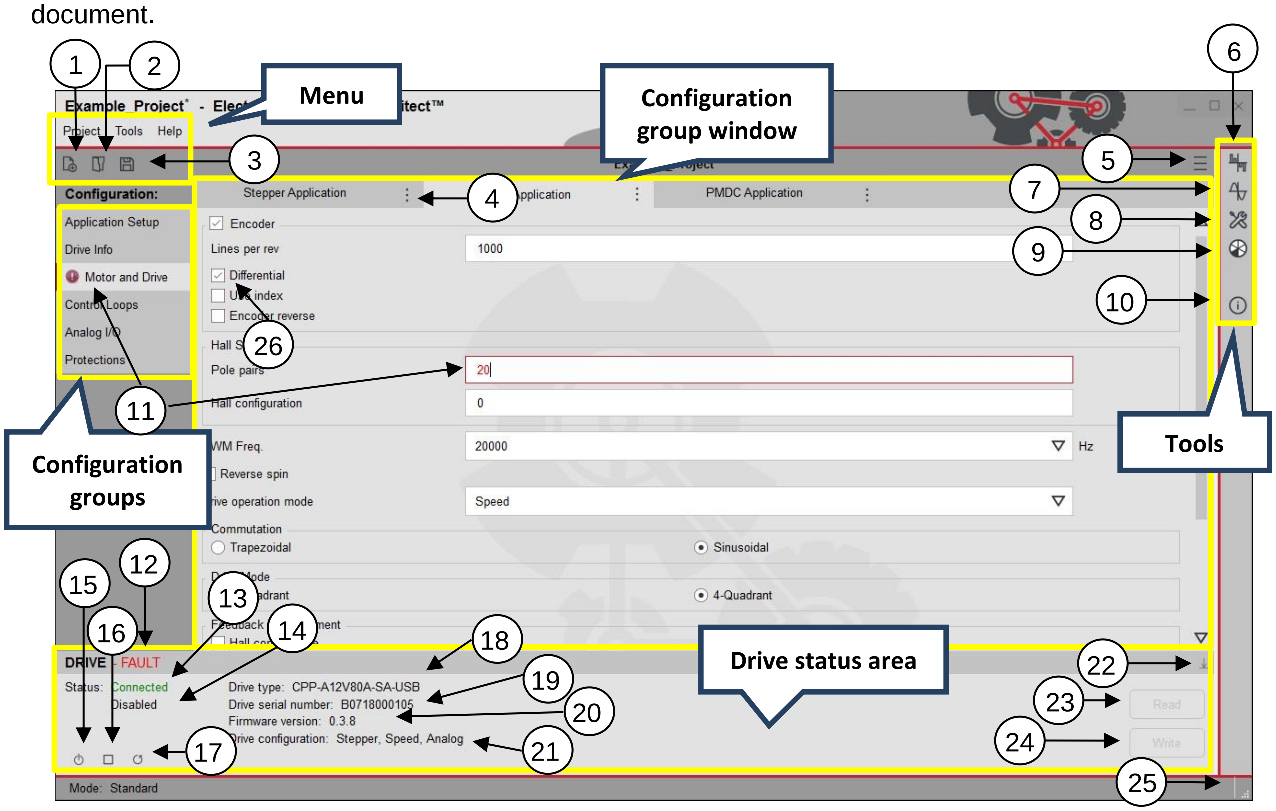



**Figure 5: Fundamental Symbols**

1. New project – Create a new project.
2. Open project – Open an existing project.
3. Save project – Save the current project.
4. Rename application - Modify the application name.
5. Edit project description – Modify the project description.
6. Online monitor – Open the Online monitor tool.
7. Oscilloscope – Open the Oscilloscope tool.
8. Diagnostic – Open the Diagnostic tool.
9. I/O Monitor – Open the I/O Monitor tool.
10. Help – Open the most recently viewed help notes. Right click any of the drive or motor parameters and select *Help* to open the help window which has a concise explanation about the selected parameter.
11. Attention – This indicates an issue with a drive setting or parameter value.
    Red Text – Entered value is outside the defined limit of the parameter.
12. FAULT – This status will be displayed when a fault is triggered. Click on the status to see which protection caused the fault.
13. Connected– Indicates that the drive is connected to the software successfully. The status changes to Disconnected when the drive is not connected to the software.
14. Disabled – Indicates that the drive is disabled. The status changes to Enabled when the drive is enabled.
15. Enable drive – Enable the drive. When the control interface is set to “Analog,” this symbol will function as an indicator and cannot be toggled.
16. Brake/Release drive – Apply Brake. When the control interface is set to “Analog,” this symbol will function as an indicator and cannot be toggled.
17. Reset drive – Reset drive.
18. Drive type – Displays drive model.
19. Drive serial number – Displays serial number.
20. Firmware version – Displays the current firmware version of the drive.
21. Drive configuration – Displays a summary of the configuration of the drive.
22. Minimize – Minimize the drive status area.
23. Read Read – Read the parameters saved in the drive.
24. Write Write – Write parameters into the drive. In case any error, this button will be disabled.
25. Resize – Click and drag on this symbol to change software window size.
26. Checkbox – click a checkbox to enable / disable the function.

## 1.5 Database Updates

ElectroCraft makes routine updates to our CompleteArchitect™ motor database as new motors become available. The database (DB) and software (SW) can be updated at any time from the tools menu.

Check for updates by clicking *Tools -> Check for Updates*. The *Updates* window will search for available updates and will offer an option to download the latest database and software versions when new versions are available. After downloading, click *Update* to update the software and to download the current version.

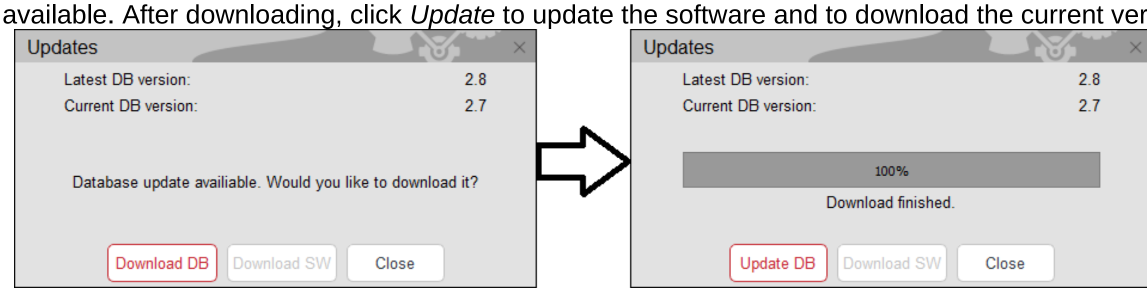



**Figure 6: Database Update Window**

(*Pictures may not represent current version*)

Click *Yes* when prompted to close the program as shown in Figure 7.

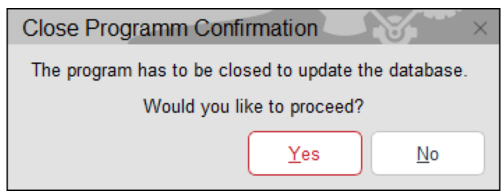



**Figure 7: Close Program Confirmation Window**

Click Update and Close the *Updater* window as shown in Figure 8. The program will then close.

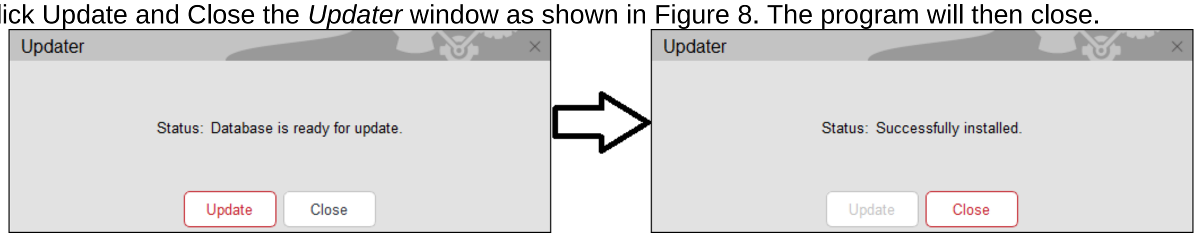



**Figure 8: Updater Window**

Follow similar steps by clicking “Download SW” to download and install the latest software version.
To confirm that the latest database (DB) has been successfully updated, reopen CompleteArchitect™ and click *Tools -> Check for DB Updates* from the menu. Confirm that the DB update window indicates that *No updates available* as shown in Figure 9.

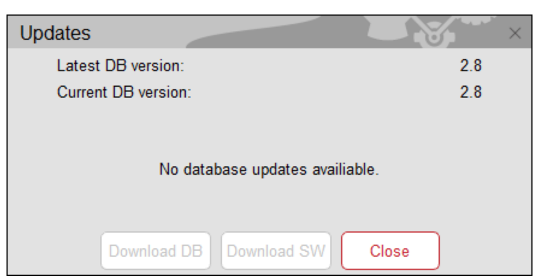



**Figure 9: Database Update Window after Update**

# 2 Help Menu

## 2.1 About

To view the product version, end user license agreement and open source license list, click *Help -> About* from the menu. The window shown in Figure 10 will appear.


**Figure 10: About Window**

## 2.2 Tutorial

The software contains video tutorials to demonstrate commonly used software features. Select *Help -> Tutorials* from the menu and the window shown in Figure 11 will appear. Select *New Project* and click *Start* to learn about new project creation. Select *Read/Write Configuration* and click *Start* to learn about reading, modifying, and writing drive parameters. Select *New User Motor* and click *Start* to learn about creating and storing a custom motor model in the software motor database.

The tutorial will open in the user's default web browser.

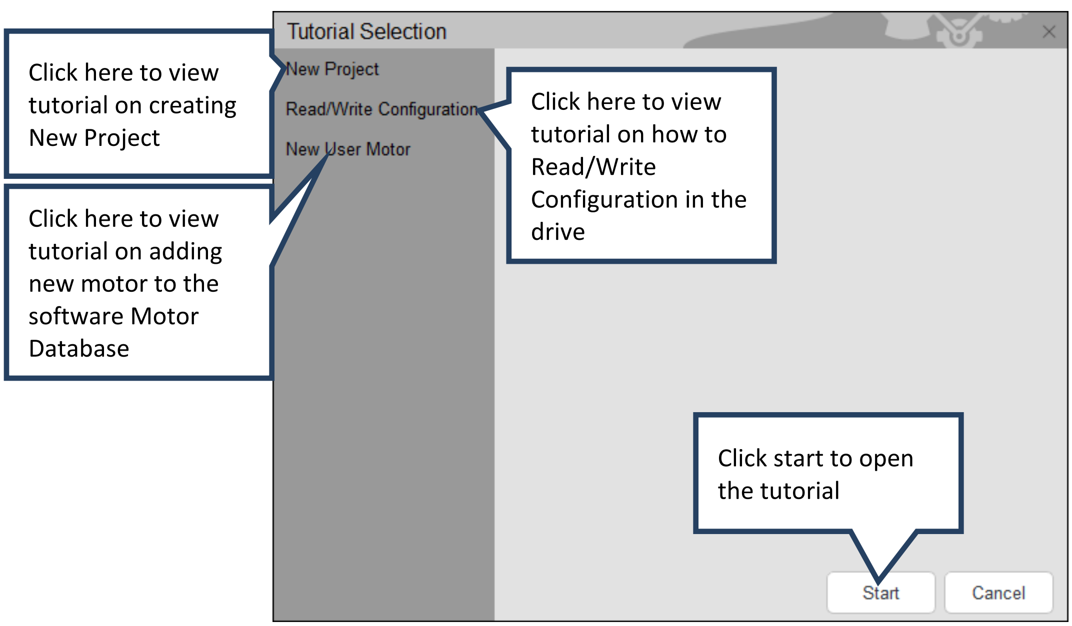


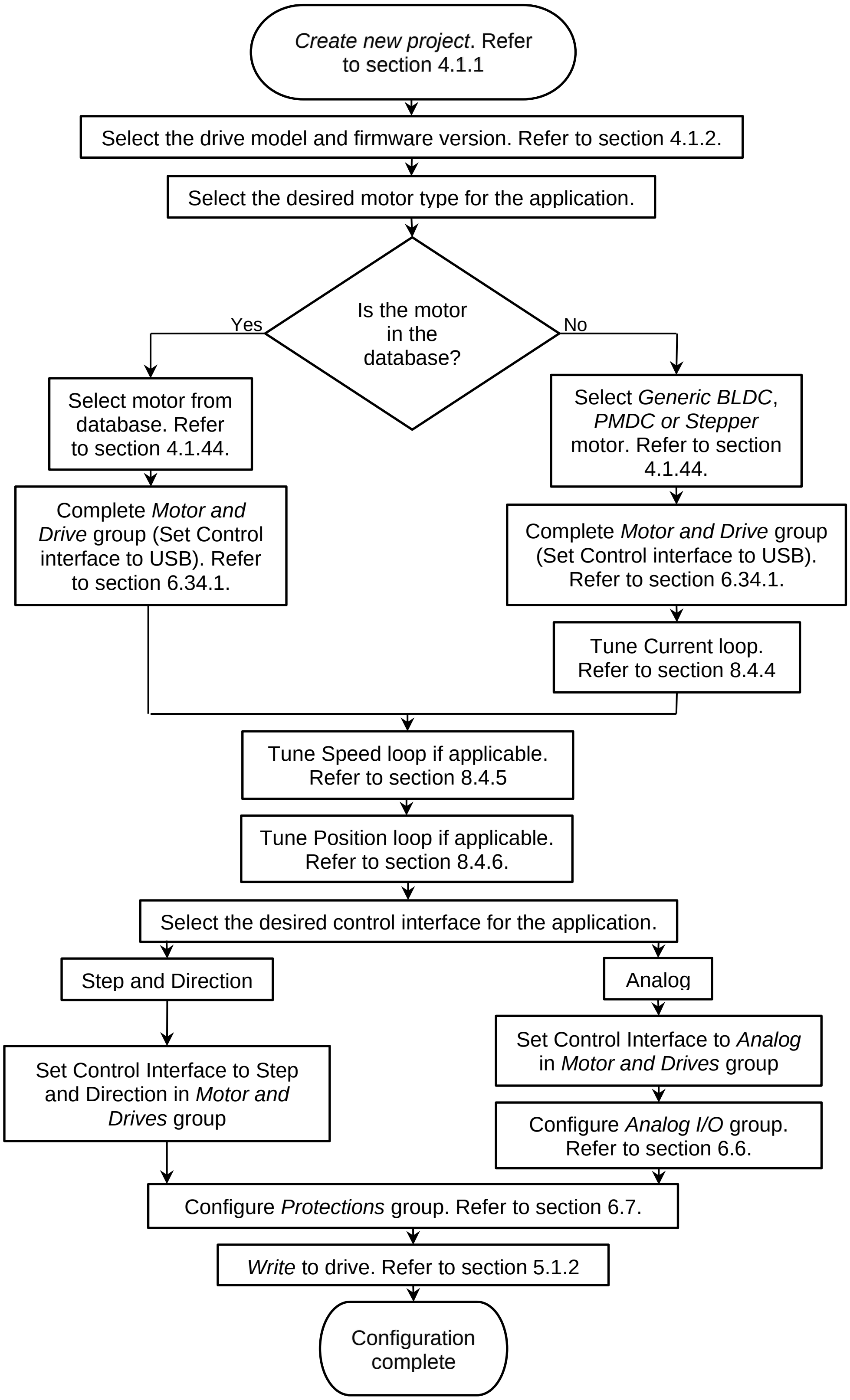

**Figure 11: Tutorial Select Window**

# 3 Drive Configuration Process Flowchart

## 3.1 Flowchart to Configure a Blank Drive or Reconfigure a Drive

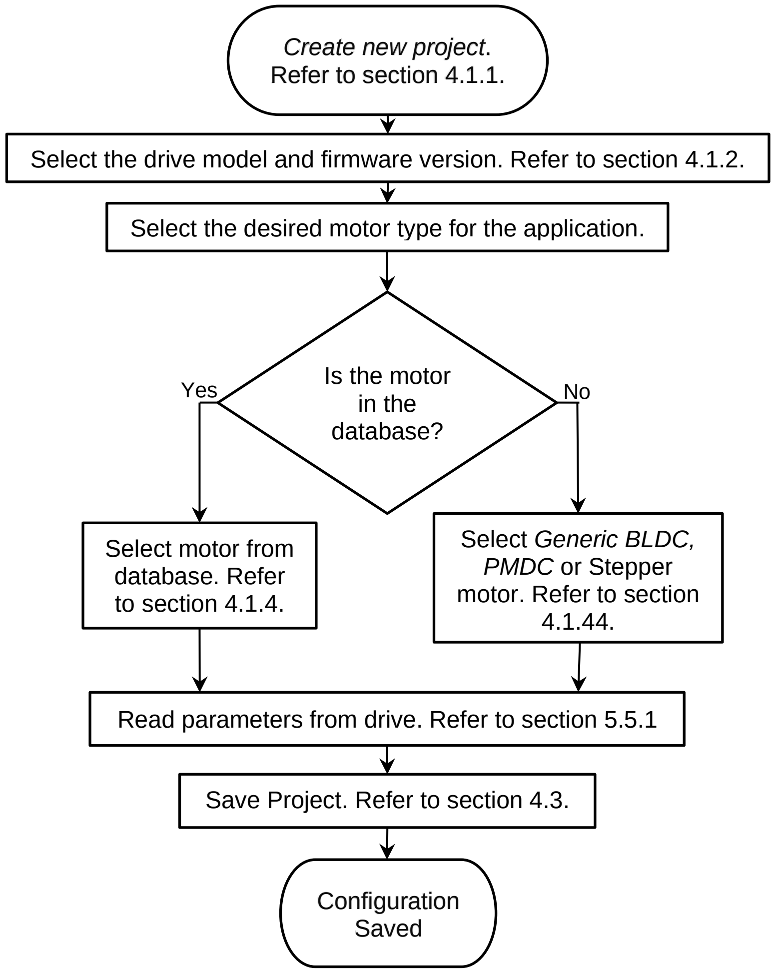
Follow the flow chart below to configure the drive for a BLDC, PMDC or Stepper motor application using CompleteArchitect™. Launch the software on a PC and connect the drive to the PC via USB or CAN cable. Connect the motor and power supply to the drive as described in the Drive User manual.

Note: Following the steps in the flowchart in this section will overwrite the configuration present in the drive.



## 3.2 Flowchart to Read and Save Configuration from Drive

Follow the flow chart below to save the configuration in the drive into a project for a BLDC, PMDC or Stepper motor application using CompleteArchitect™. Launch the software on a PC and connect the drive to the PC via USB or CAN cable. Connect the motor and power supply to the drive as described in the Drive User manual.



# 4 Project Menu

## 4.1 New

Refer to Section 2.2 to access a video tutorial on creating new project. In this section a new project is created which contains one application (refer section 4.6 to add more applications to the same project) using a CPP-A12V80A-SA-USB servo drive and a RP17M-8V24-100-D motor as an example.

### 4.1.1 Name a New Project

Follow the steps in the Figure 12 to create and name a new project.

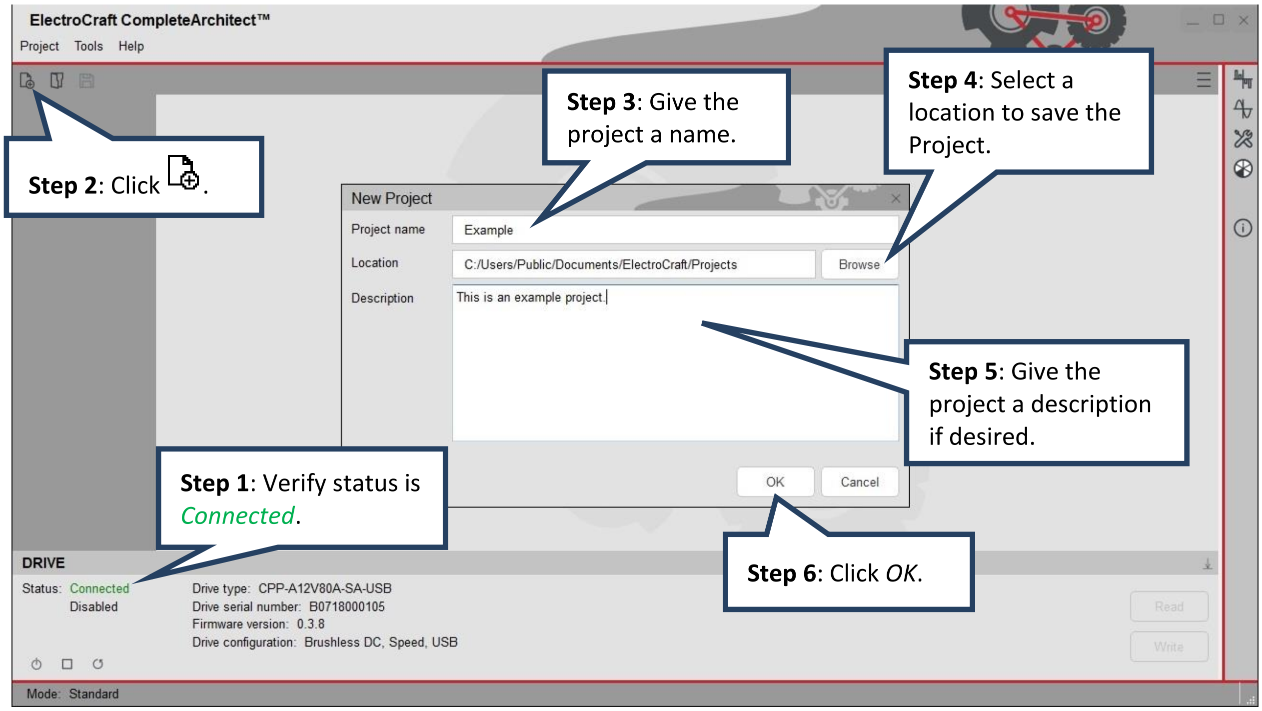



**Figure 12: Creating and Naming New Project**

### 4.1.2 Select the Product Family

Follow the steps in the Figure 13 to select the Product family.


**Figure 13: Selecting the Product Family**

### 4.1.3 Select the Drive and Firmware version

Follow the steps in Figure 14 to select the drive model and firmware version. The drive model and firmware version can be found in drive status area as shown in section 1.4.

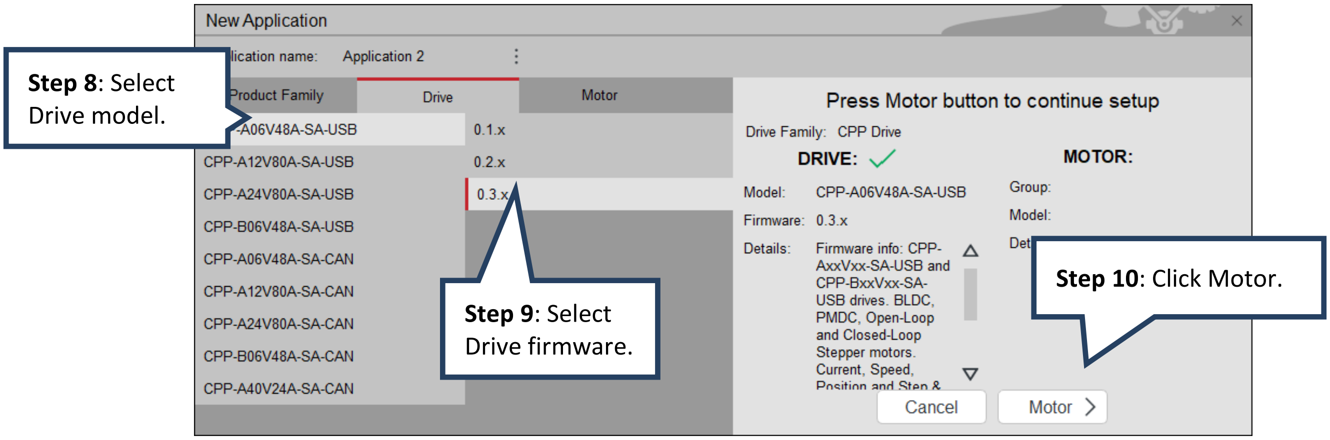



Figure 14: Selecting the Drive and Firmware version

### 4.1.4 Select the Motor

Follow the steps in the Figure 15 to select the motor model from the ElectroCraft motor database. If the specific motor used is not available in the database, a minimally populated project can be created by selecting the *Generic BLDC motor* model. Selecting this model will require the user to gather additional information regarding the operating characteristics of the motor before completing the configuration.

When a user's motor is used the operating characteristics of that motor must be added to the database. Refer to section 8.6. User Motor Database Manager for this process.

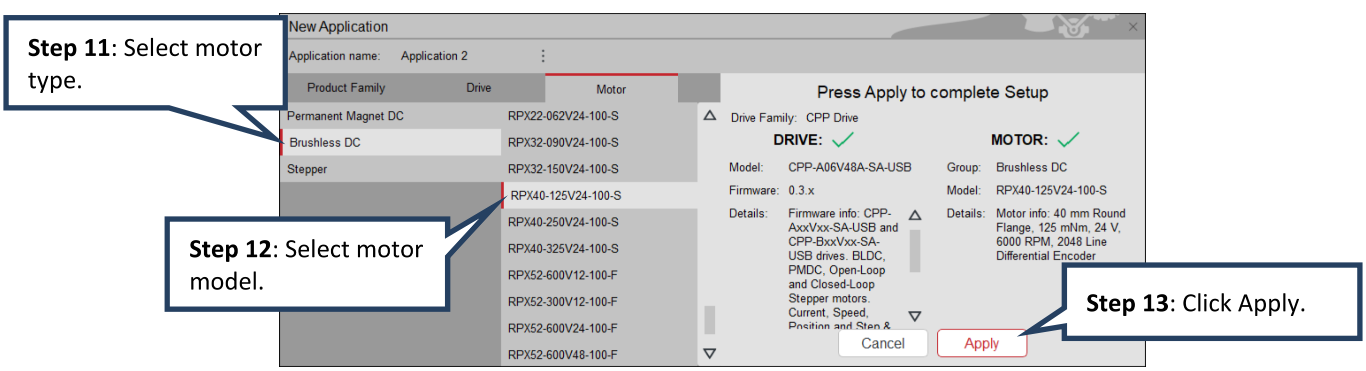



Figure 15: Selecting the Motor

## 4.2 Open

To open a project previously created, select *Project -> Open* or click the icon from the menu and the window shown in Figure 16 will appear. Select the project folder and click *Open.*

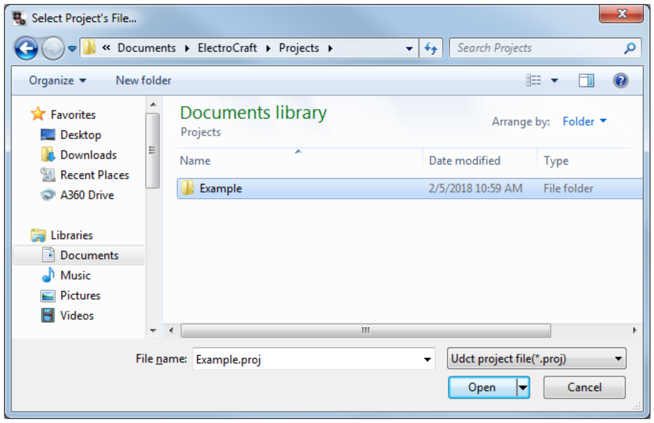



**Figure 16: Select Project File Window**

Select the project file and click open as shown in Figure 17.

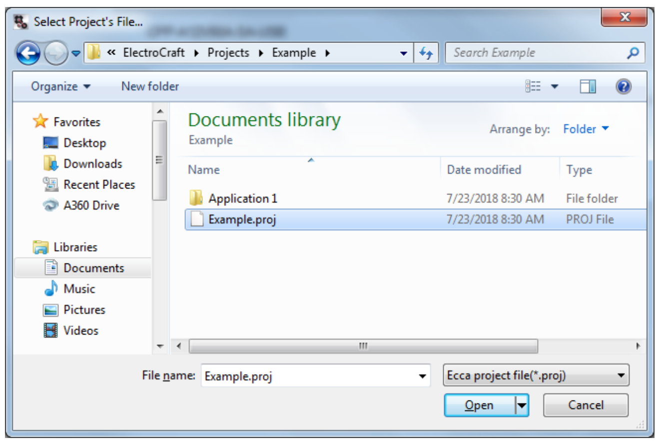



**Figure 17: Select ".proj" File**

### 4.3 Save

To save a project, select Project -> Save or click the icon from the menu.

### 4.4 Save as

To save a project with a different name or in a different location in the computer, select *Project -> Save as* from the menu and the window shown in Figure 18 will appear. Make the necessary changes to the project file name, location and description and click *OK.*

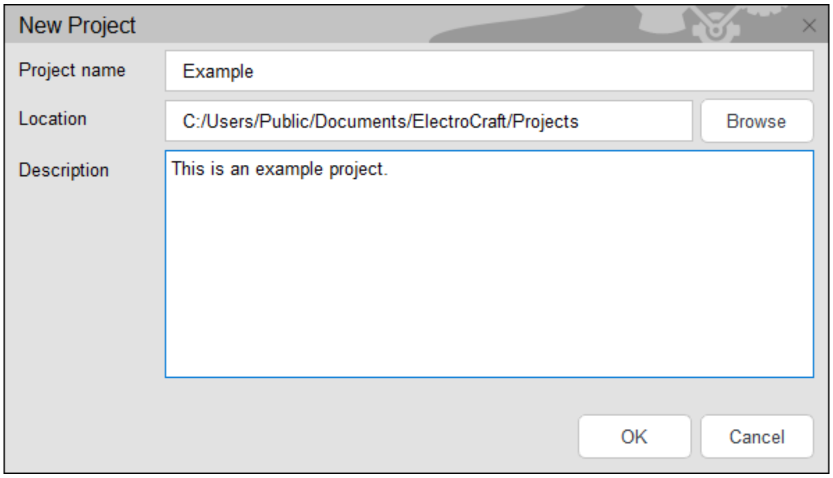



**Figure 18: Save as Window**

### 4.5 Close

To close a project, select *Project -> Close Project* from the menu. The window shown in Figure 19 will appear if the project was not saved prior to closing. Selecting *Save* will save any changes made to the project. Selecting *Discard* will close the project without saving any changes.

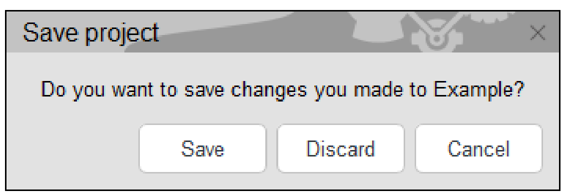



**Figure 19: Save Project Prompt**

### 4.6 New Application

To create a new application within the same project, select Project -> New Application from the menu. The window shown in Figure 20 will appear. Select the drive & motor and click *Apply* to create the new application.

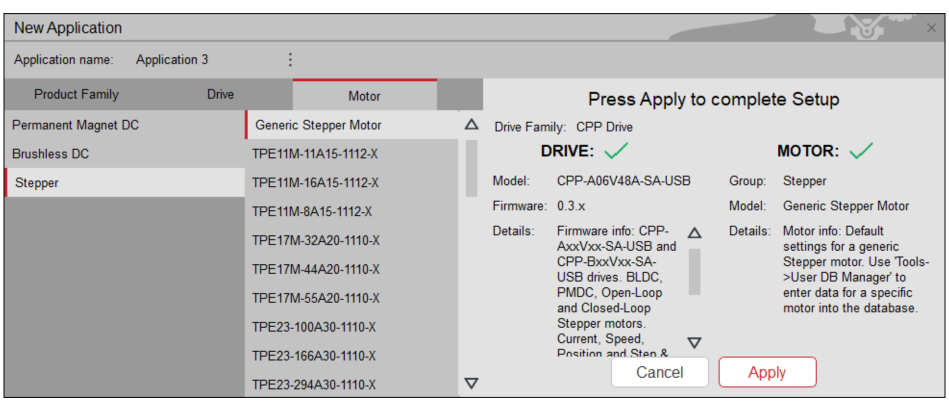



**Figure 20: Creating New Application**

## 4.7 Import Application

To import an application into the current project from another project, select Project -> Import Application from the menu. The window shown in Figure 21 will appear. Open the project file, select the specific application, and click *OK* to add the application to the existing project.

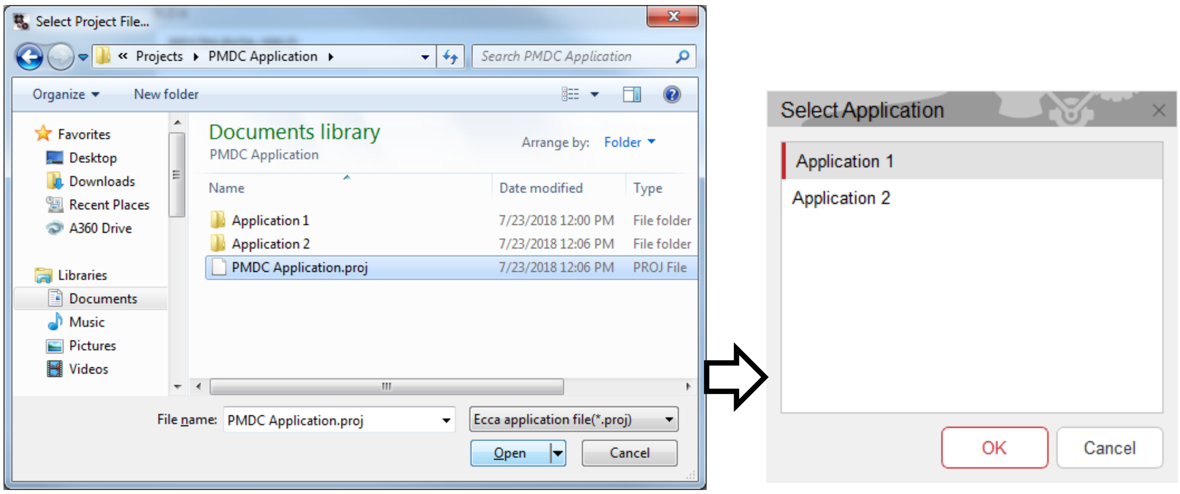



**Figure 21: Importing application from another Project**

To import an application into the current project from another Drive, select Project -> Import Application from Drive. The window shown in Figure 22 will appear. Enter an Application name and click *OK* to get the drive parameters. When complete click *OK.*

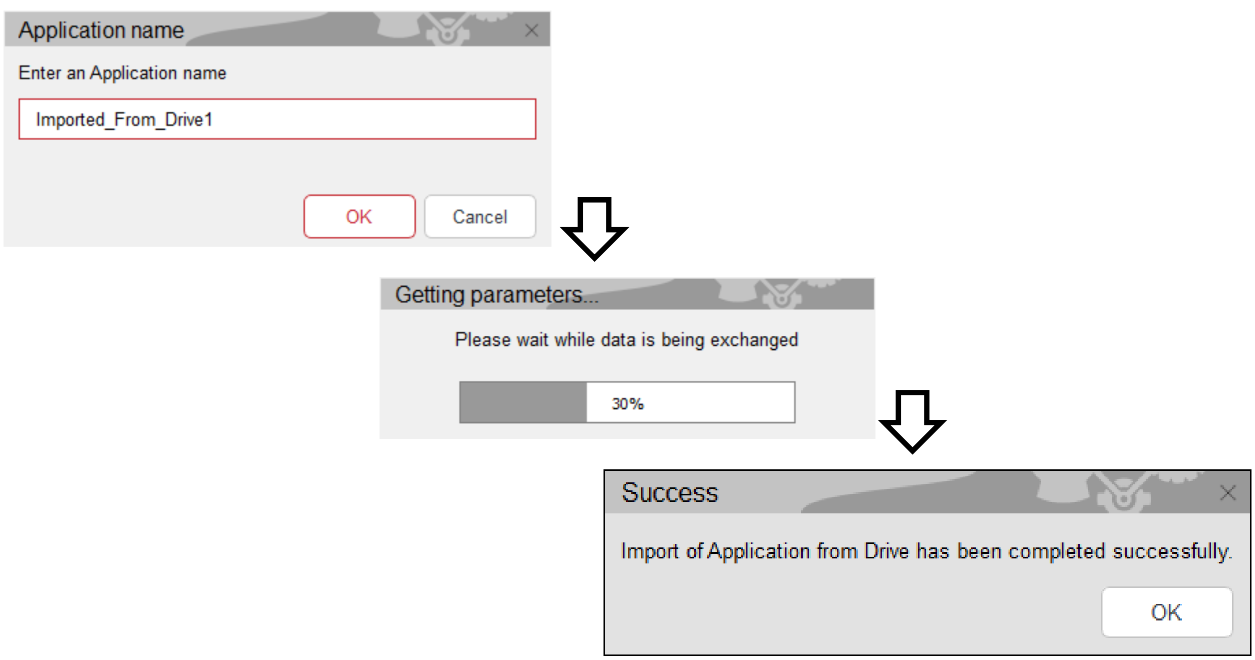



**Figure 22: Importing application from Drive**

## 4.8 Upgrade Application

ElectroCraft makes routine updates to the product firmware as new firmware is released. The firmware is populated from the database and CompleteArchitect™ project can be upgraded. Application Setup group shows the drive firmware.

The drive is not at the latest version when in the Application Setup window, the firmware shows in red text as shown if Figure 23. Check for updates by selecting Project -> Upgrade Application.

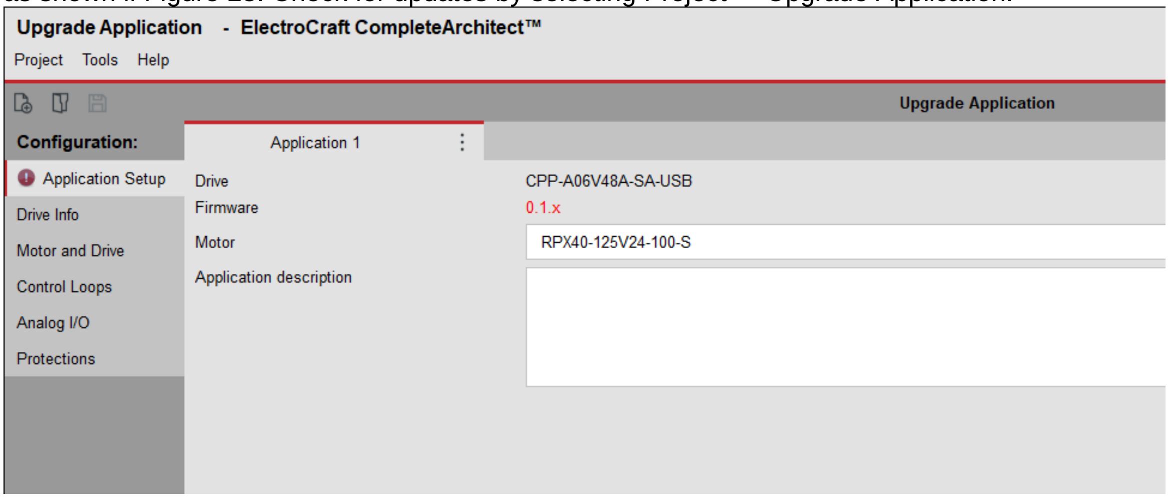
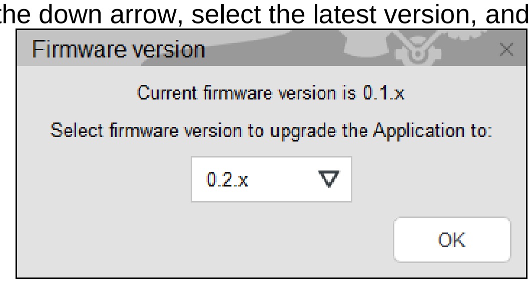
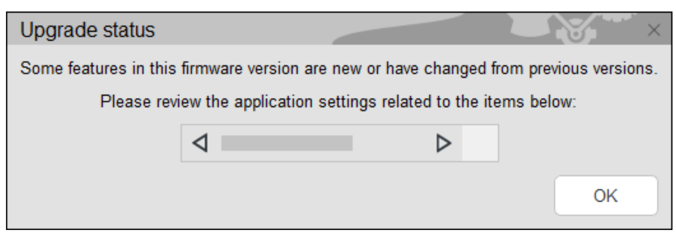



**Figure 23: Application Setup**

CompleteArchitect™ will search for available firmware releases and offer the option to download the latest firmware version. Click the down arrow, select the latest version, and click *OK*.




Enter new Application name and click *OK*. After downloading firmware an Upgrade Status dialog will appear with a status message, click *OK*.




When the firmware is at the latest version you will receive conformation that the current firmware version is at the most recent as shown in Figure 24, click *OK*. In the Application Setup window, now the firmware will show in black text.

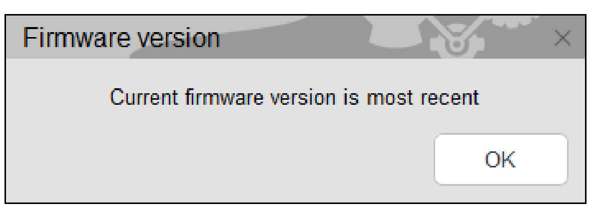



**Figure 24: Firmware Status message**

## 4.9 Archive

Archiving a project will bundle all files associated with the project and store them as a single *.zip* file for future use at any location in the computer. The default archive location in the computer is "C:\Users\Public\Documents\ElectroCraft\Archives."

To archive a project, select *Project -> Archive* from the menu. The window shown in Figure 25 will appear. Select the location to archive the project, then click *OK* and then in the progress window click *OK* after the status changes to completed.

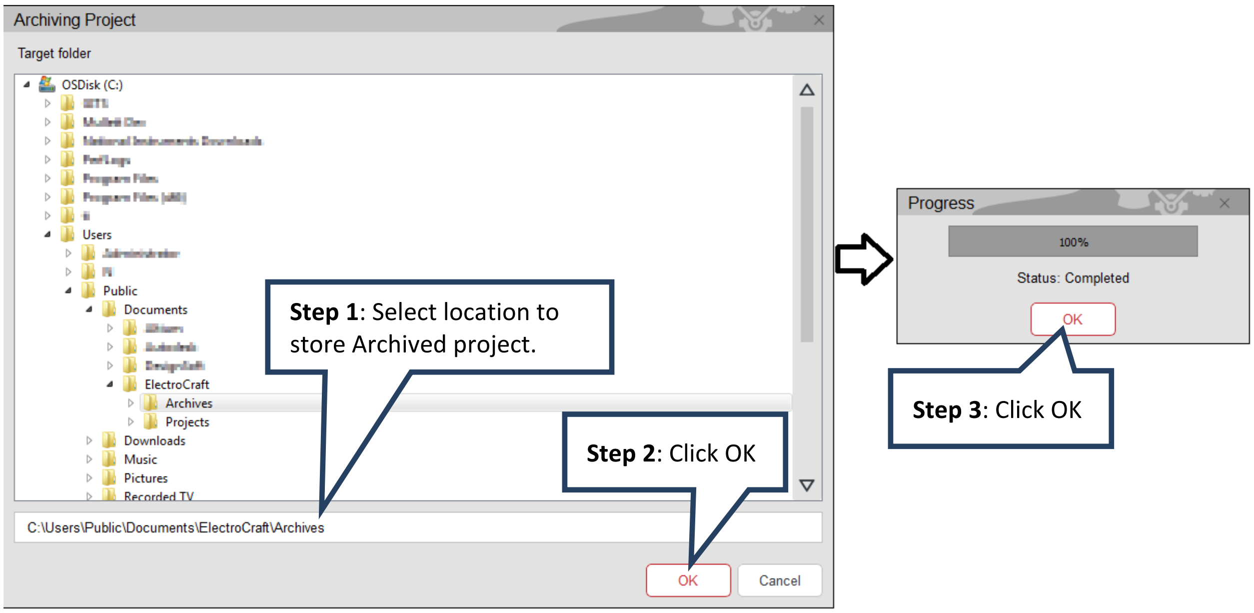



**Figure 25: Archive Project Folder Path and Progress Window**

## 4.10 Extract

An archived project can be unzipped and restored by extracting the project into any location in the computer. To extract a project, select *Project -> Extract* from the menu. The window shown in Figure 26 will appear. Select the source archive folder location and target folder for extracted project, then click *OK*. In the progress window click *OK* when the status changes to completed.

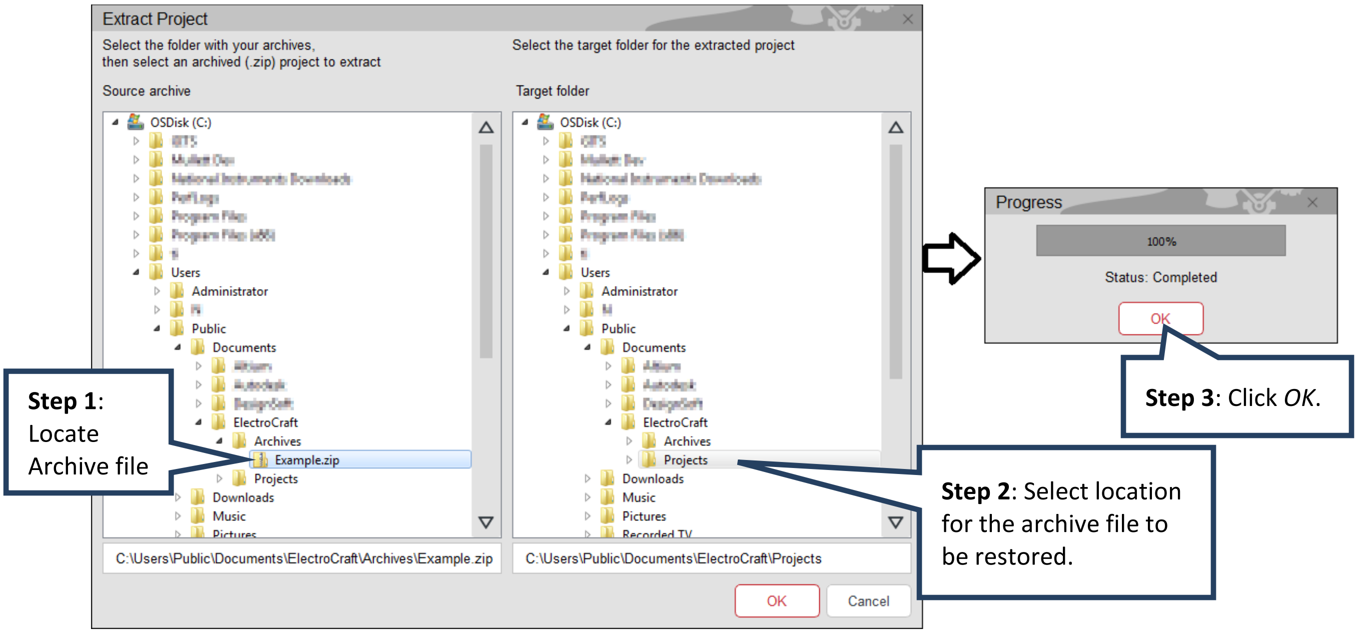



**Figure 26: Extract Project Folder path and Progress Window**

## 4.11 Settings

Select *Project -> Settings* from the menu to open the *Settings* window shown in Figure 27. The purpose of this window is to select different measuring units and languages in the software. Select the Measure or General menu and adjust the settings according to the user's preferences.

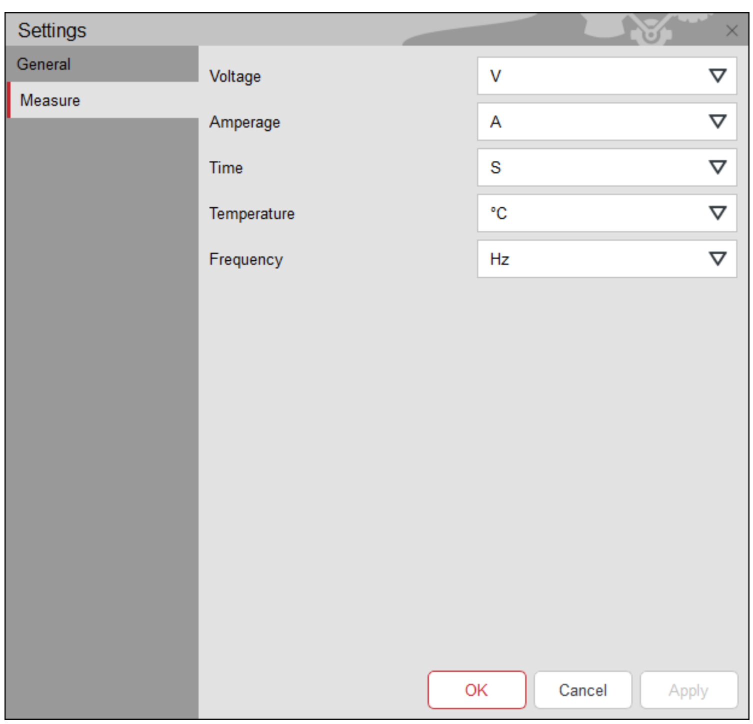



**Figure 27: Project Settings Window**

# 5 Read from and Write to the Drive

This section will describe the read and write features of the software.

### 5.1.1 Read

The read function will load all the parameters that exist in the connected drive into the software interface. In addition, the Serial number and Firmware version field will be populated in the Drive Information screen. Follow the steps shown in Figure 28 to load the drive parameters into the interface.

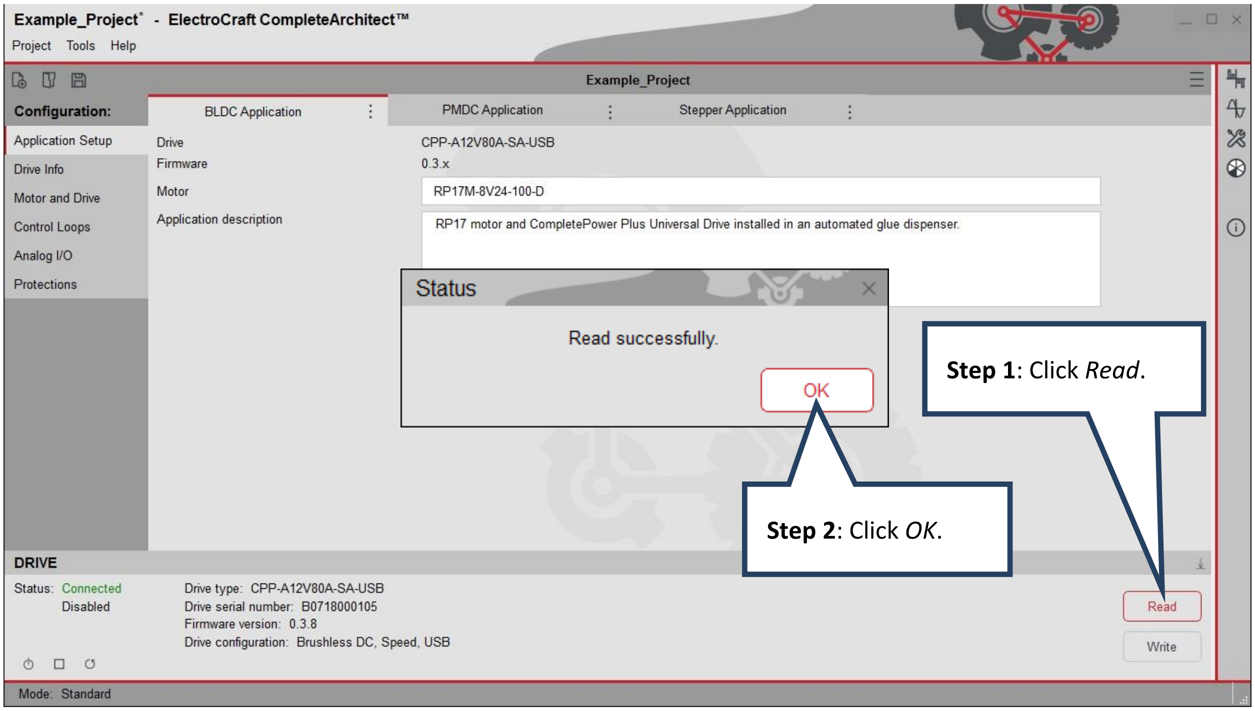



**Figure 28: Read Drive Parameters**

The error message shown in Figure 29 will be displayed when there is a problem reading the parameters from the drive.

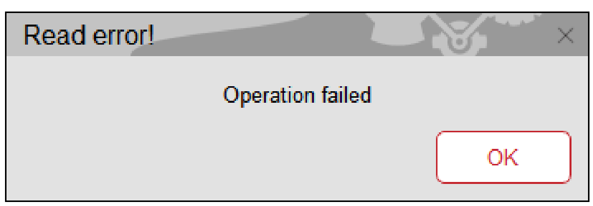



**Figure 29: Read Error Window**

Check your USB connection from computer USB port to the drive making sure you have a good connection. Drive Status will display "Connected" when the connection is made and communicating as shown in Figure 28.

### 5.1.2 Write

The Write function will transfer all the parameters of a project into the connected drive. CompleteArchitect™ will only allow the user to write to the drive when all of the required fields have been filled with values that are within allowable ranges.

When values fall outside of the allowable range, the value will turn red, an exclamation point appears next to the group that needs correction and the "Write" button is disabled. See example as shown in Figure 30. The user must correct all problematic entries before the "Write" button will allow the drive to be written to.

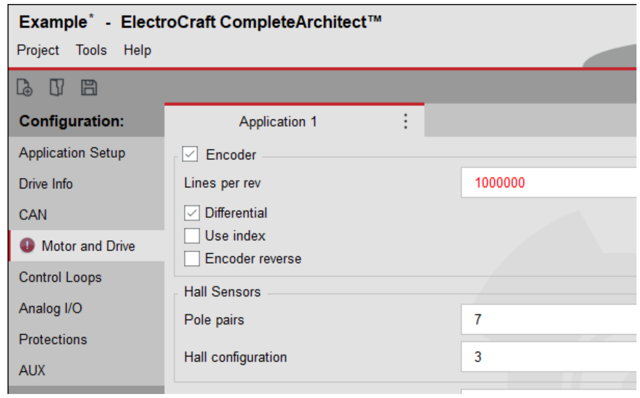



**Figure 30: Parameter Error Window**

After all errors have been corrected follow the steps shown in Figure 31 and Figure 32 to write all the parameters into drive.

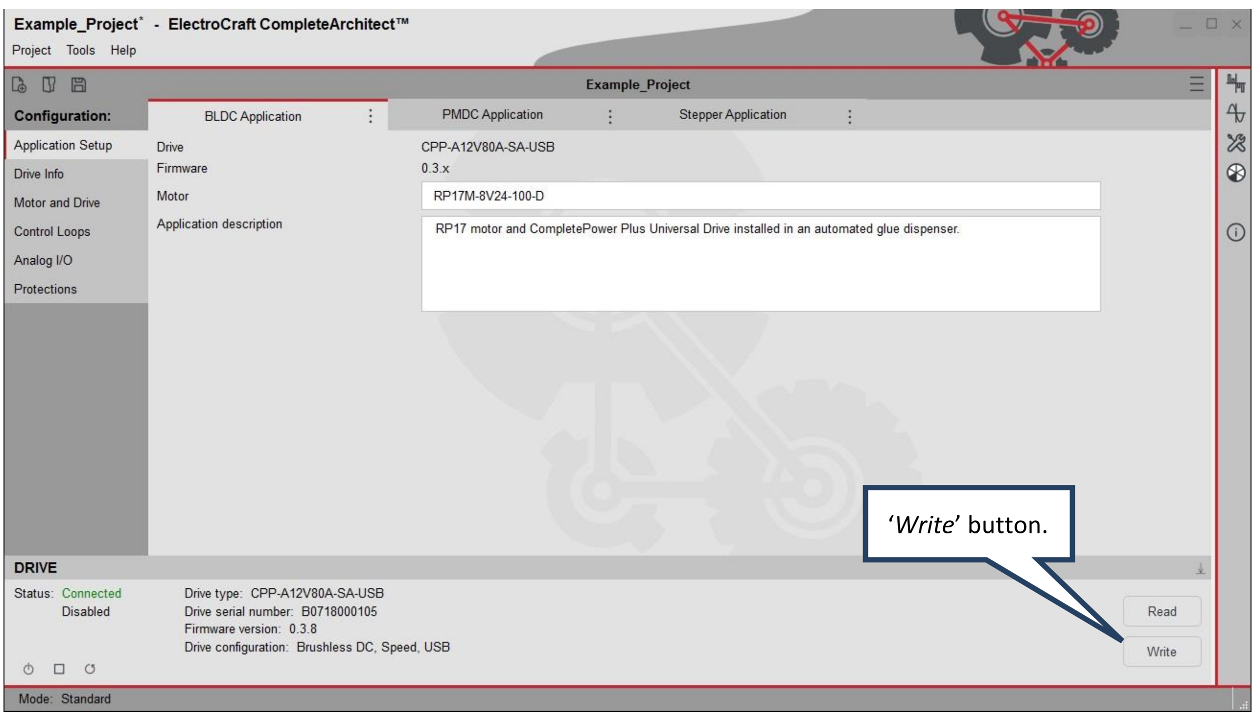



**Figure 31: Write Drive Parameters**

A prompt window as shown in Figure 32 will appear. When checking the 'Save to EEPROM' box, this function will permanently write the drive parameters into the drive's EEPROM. Leaving the box unchecked and clicking *OK* will only write the parameters into volatile memory and resetting the drive will return the parameters to the values saved in EEPROM.

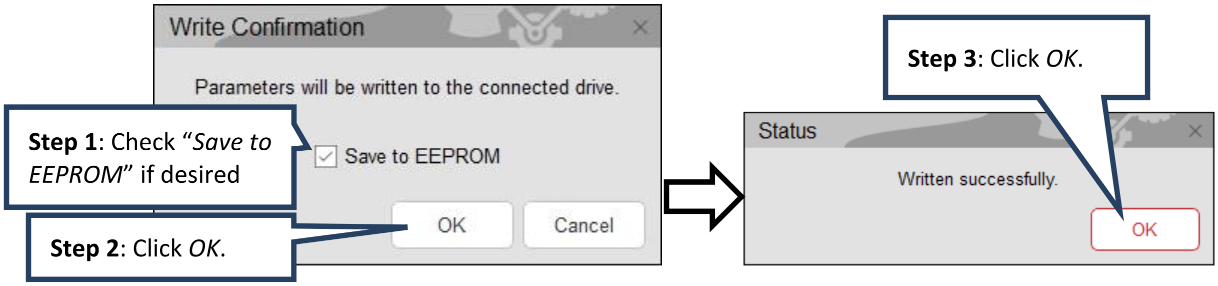
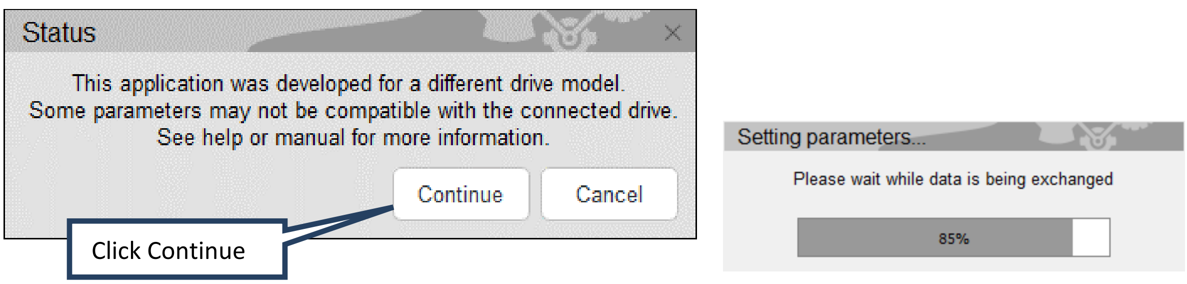



**Figure 32: Write Prompt Window**

Note in this example, the Save to EEPROM checkbox selection will retain the previous selection. If the box is checked, on the next write operation the box will be checked and vice-versa.

When Drive parameters that are being written to the the drive are not correct or out of range a Status menu pop-up will appear.




Simply click continue and CompleteArchitect™ will update the drive identification and assigned the correct information to identify the product. This data will show in the Drive status area as the Drive infomation group.

The Drive infomation group shows the specific details about the drive type, serial number, firmware, etc as well as drive status. All fields in this window are write-protected and the data varies depending on the drive that is attached via USB cable, see Figure 33 below for an example.

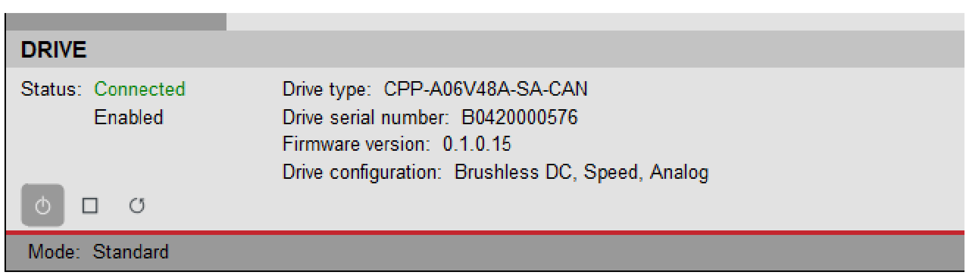



**Figure 33: Drive infomation**

# 6 Configuration Groups

## 6.1 Application Setup

The Application Setup group shows the drive model number, firmware, motor name and application description as shown in Figure 34. The *Drive*, *Firmware* and *Motor* fields are populated from the database. The motor name can be edited if desired. The *Application Description* is a place to enter background data to aid in understanding the concept and context of the application.

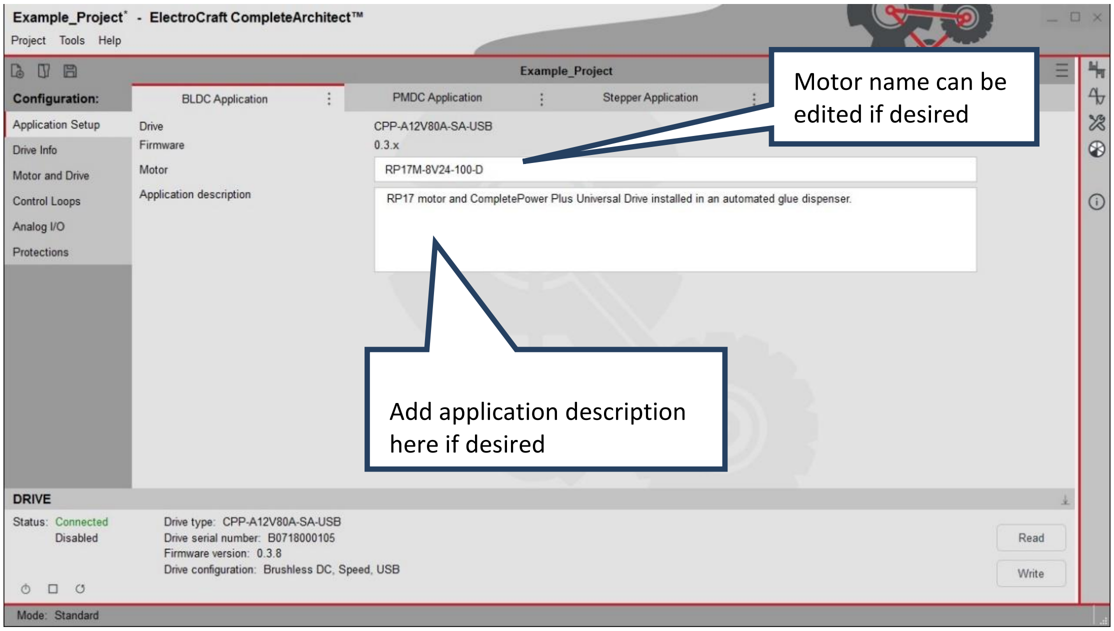



**Figure 34: Application Setup Window**

## 6.2 Drive Info

The Drive info group shows the details about the drive. All fields in this window are write-protected and the data varies depending on the drive selected, an example of this window is shown in Figure 35.

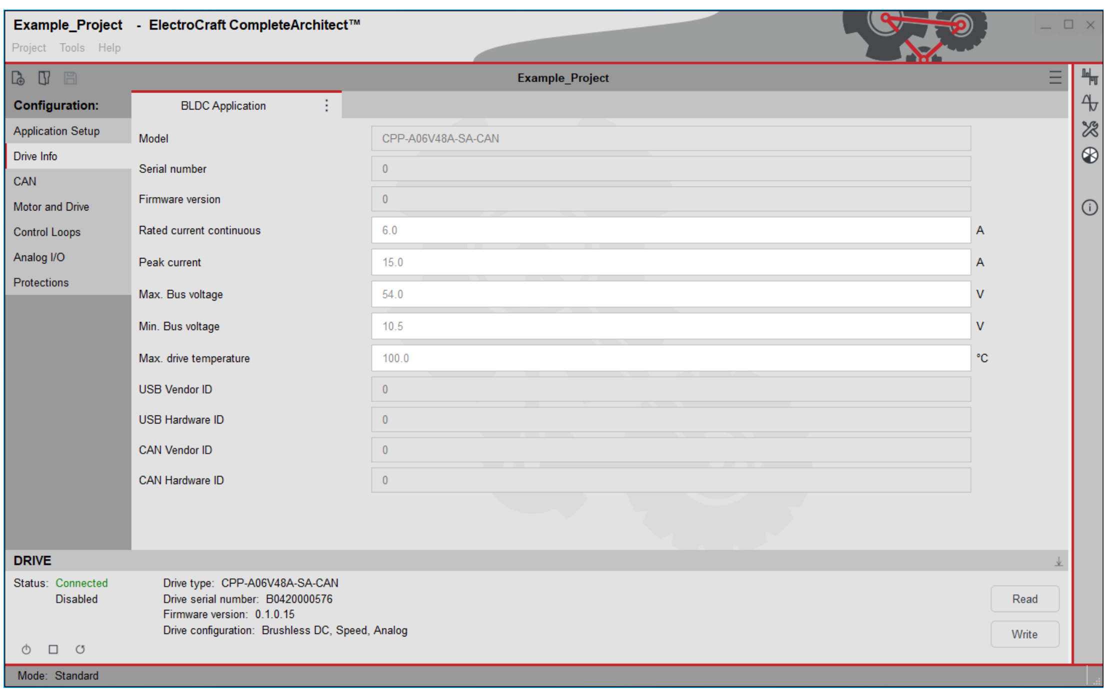



**Figure 35: Drive Info Window**

## 6.3 CAN Setup

The CAN setup allows the user access to adjust the settings for CAN networking. Axis ID and Group fields, Addressing, and Bit rate can be changed with this setup field as shown in Figure 36. This setup has options to Enable/Disable the drive and monitor current, speed and position over the CAN network. Details for CAN functions can be found in the ElectroCraftCAN™ User manual document number 198-0000088.

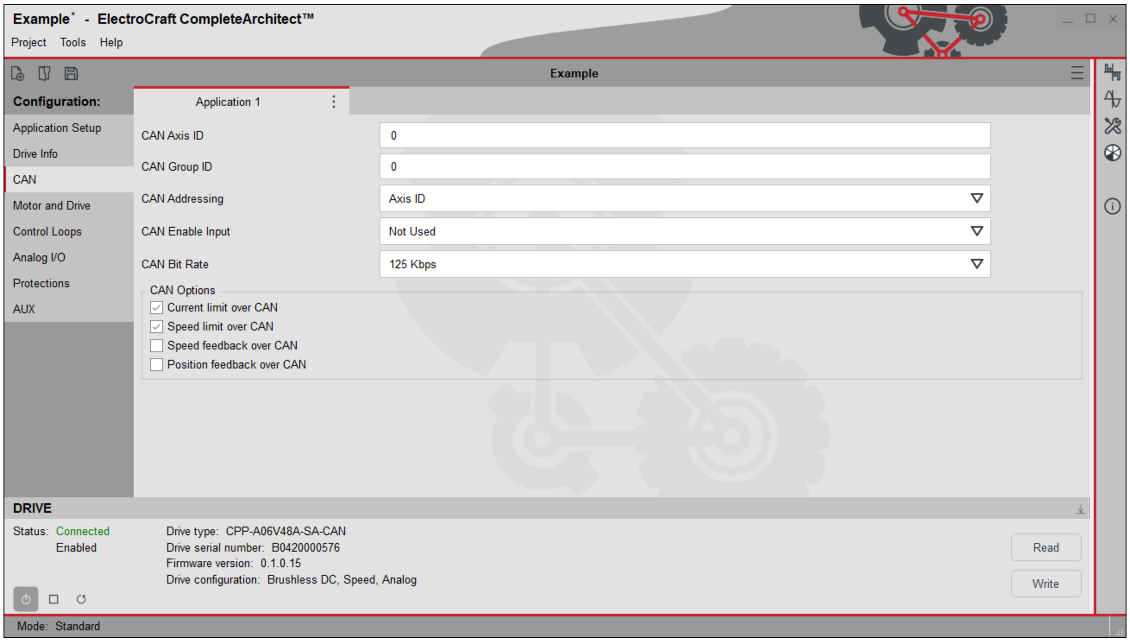



**Figure 36: CAN  Info Window**

### 6.3.1 CAN Axis ID

Value range: 0 to 127
Default Axis ID: 0 Note: Does not function as a usable CAN address.

Axis identification- ID field, representing the Axis ID (address of one drive).
In multiple axis configurations, each axis needs to be identified through a unique number – the Axis ID. This is a value between 0 and 127. If the destination of a message is specified via an Axis ID, the message is received only by the axis with the same Axis ID.

Set the axis number to your desired drive Axis ID.

The axis ID of a Universal drive can be set in 2 ways:
- Hardware (HW) switches
- Software (via Setup) – any value between 0 and 127.

### 6.3.2 CAN Group ID

Value range: 0 to 127
Default Group ID: 0 Note: This is a “All Call Group” ID.

All drives on the CAN network will respond to all messages addressed to group ID 0.

Apart from the Axis ID, each drive also has a Group ID. The Group ID represents a filter for multicast messages. The destination of a multicast message is specified via a Group ID. When a multicast message is received, each axis compares the Group ID from the message with its own Group ID. The host can send commands to multiple drives at the same time by using the group ID address. This is a value between 0 and 127.

### 6.3.3 CAN Addressing

Addressing can be done using Axis ID and/or the drive HW (hardware) switch SW1.

Axis ID allows for multi-axis control of up to 127 addresses. In addition, the HW (hardware) switch SW1 allows for 16 addresses. Both can be combined using the Axis ID base + HW switches setting. Use the down arrow to choose the needed CAN addressing.

### 6.3.4 CAN Enable Input

Enable drive operation via software or external reference.

If not using a CAN interface leave setting at Not Used.

Selection of how the drive's CAN Enable input will function.

- Not Used - The drive will ignore this input.
- Enable CAN - This will enable the CAN operation. The drive will not transmit or receive any messages on the CAN network until this input is in the Enabled state.
- Enable Drive - Use this input as the drive's Enable input instead of the default Enable input on the I/O connector.
- Enable CAN and Drive - Use this input to enable both CAN and the drive.

### 6.3.5 CAN Bit Rate

Selection of the bit rate used on the CAN network.

CAN bus can use multiple bit rates up to 1 Mbit/s. The most common bit rate is 125 kbit/s (default). All nodes of the network must use the same bit rate to communicate properly.

Using the setup dialogue choose the CAN bit rate needed. Bit rate can be set to the following CAN rates: 125Kbps, 250 Kbps, 500kbps and 1Mbps.

### 6.3.6 CAN options

Enables or disables available options for CAN operation.

**Available options:**

– Current Limit over CAN
This field introduces current limit over CAN will dynamically change the Current Limit of the drive, up to the limit set in Protections.

– Speed Limit over CAN
This field introduces maximum speed limit over CAN and will dynamically change the Speed Limit of the drive. Drive will set the current output to zero when the motor exceeds the limit set and restore current when the speed drops below the limit.

– Speed feedback over CAN
Used as the Speed feedback into the drive's speed control loop. Some drive and motor combinations that may still require feedback from the motor for commutation.

– Position feedback over CAN
Used as the Position feedback into the drive's position control loop. Some drive and motor combinations that may still require feedback from the motor for commutation.

## 6.4 Motor and Drive

The Motor and Drive group allows the user to set the motor and drive parameters for their specific application. This configuration group is different for BLDC, PMDC and Stepper motors which are discussed below.

### 6.4.1 Motor and Drive Configuration Group for BLD Motor

The Motor and Drive window for a BLDC motor is shown in Figure 37.

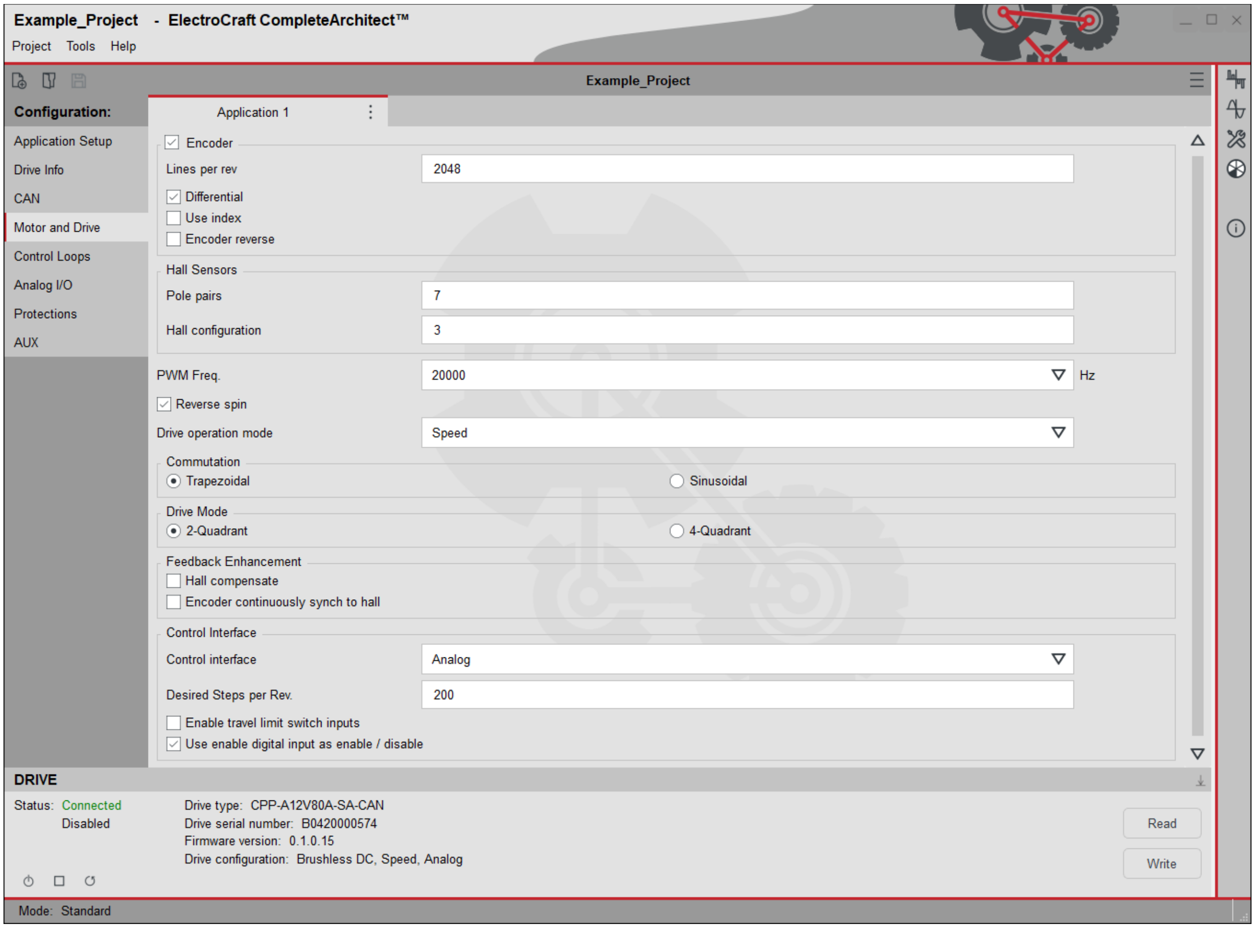



**Figure 37: Motor and Drive Window for BLDC Motor**

**All parameters in this window are described below:**

***Encoder*** - When enabled, the encoder will be used for speed and position feedback. When disabled, the hall sensors will be used for speed feedback.

***Lines per rev*** – This field represents the resolution of the encoder in units of lines per revolution. An encoder datasheet may specify resolution in units of lines, cycles per revolution (CPR), pulses per revolution (PPR) or quadrature counts per revolution. Lines, CPR and PPR are same and are often used interchangeably. To convert quadrature counts per revolution to lines, divide by 4. Example: 4000 quadrature counts = 1000 lines.

***Differential*** - When enabled, the drive enables the differential encoder transceiver. When disabled, the drive will accept a single ended encoder input. A differential encoder may be more immune to electrically noise than a single-ended encoder. Reference the Drive User manual for electrical connection requirements and compatibility.

***Use Index*** - When enabled, the drive will use the encoder index to synchronize motor commutation while rotating. This is useful to re-align the sine wave commutation when using single-ended encoders in electrically noisy environments. This option will not compensate for corrupted speed or position feedback due to electrical noise on the encoder signals. This function is recommended for use in current mode operation.

***Encoder Reverse*** - Encoder manufacturers do not use a common mechanical convention for "positive" direction. There are encoders that count positive when turning clockwise (CW) and some when turning counterclockwise (CCW). When enabled, this option reverses the polarity of the encoder counting and encoder speed reporting.

***Hall Sensors:***
***Pole pairs*** – This represents the number of pole pairs that the connected motor possesses. This should be listed on the motor datasheet as either Poles or Pole Pairs. Motor Poles / 2 = Pole Pairs.
Example: 4 Motor Poles = 2 Motor Pole Pairs.

***Hall configuration*** – This setting is an adjustment to align hall sensor states to the motor phase output sequence. Each increment of this variable shifts the commutation alignment by 60 electrical degrees.

The Hall configuration value is divided into two parts:

- Configurations 0 through 5 = Standard table
- Configurations 6 through 11 = Alternate table

Each table is separate from the other and circular in function. Incrementing values for the standard table are: 0 - 1 - 2 - 3 - 4 - 5 - 0 - 1 - etc. Incrementing values for the alternate table are: 6 - 7 - 8 - 9 - 10 - 11 - 6 - 7 - etc.

Below is the procedure to find the correct Hall configuration for a new motor:

1. Start with Hall configuration = 0 (beginning of the standard hall table).
2. Disable the encoder to force the drive to use the hall sensors for commutation and speed feedback.
3. Disable the Reverse Spin option.
4. Configure the drive for current mode.
5. Setup the analog input command to allow a safe current level.
6. Enable the drive and observe the motor.
7. If the motor will not turn, is difficult to turn or seems like the motor wants to hold a position, the alternate hall table may be required. Disable the drive and set Hall Configuration = 6 to use the alternate table.
8. If the motor is able to turn, but seems like a reduced torque, increment the Hall configuration by 1.
9. With the motor spinning, verify that the no-load speed is the same for both directions.
10. If the motor does not spin the same speed in both directions, increment the Hall configuration by 1. Repeat step 6.
11. Verify that the speed reported by the drive is positive when a positive current command is applied. It is important that the command input and the reported speed are of the same polarity.
12. If the polarity of the command and speed are different, increment the Hall configuration by 3 (creating a 180 electrical degree shift). Remember that the tables are circular and to stay within the selected hall table. Example: Incrementing Hall configuration 1 by 3 results in Hall configuration 4 (1 -> 2 -> 3 -> 4). Incrementing Hall configuration 5 by 3 results in Hall configuration 2 (5 -> 0 -> 1 -> 2).
13. Verify that the speed reported by the drive is positive when a positive current command is applied.
14. Use the Reverse Spin option to configure whether a positive command produces clockwise (CW) or counterclockwise (CCW) physical rotation of the motor.

A motor should spin with balanced speed in both directions with Hall configurations 0, 1 or 2 for the standard hall table or 6, 7 or 8 for the alternate table. Generally, values of 3, 4 or 5 and 9, 10, or 11 are used when the reported speed and command polarity do not match.

As the motor rotates, the hall signal pattern will progress from one state in the table to the next. When the hall signal pattern reaches the end of the table, it will loop back to the top. The motor outputs will energize in the sequence shown in the tables below.
*Note: An increment of 3 within either table will create a shift of 180 electrical degrees, resulting in an inversion of the motor outputs.*

## Standard Commutation Table:

| Hall Configuration = 0 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | x | H | L |
| 0 | 1 | 1 | H | x | L |
| 0 | 1 | 0 | H | L | x |
| 1 | 1 | 0 | x | L | H |
| 1 | 0 | 0 | L | x | H |
| 1 | 0 | 1 | L | H | x |

| Hall Configuration = 1 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | H | x | L |
| 0 | 1 | 1 | H | L | x |
| 0 | 1 | 0 | x | L | H |
| 1 | 1 | 0 | L | x | H |
| 1 | 0 | 0 | L | H | x |
| 1 | 0 | 1 | x | H | L |

| Hall Configuration = 2 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | H | L | x |
| 0 | 1 | 1 | x | L | H |
| 0 | 1 | 0 | L | x | H |
| 1 | 1 | 0 | L | H | x |
| 1 | 0 | 0 | x | H | L |
| 1 | 0 | 1 | H | x | L |

| Hall Configuration = 3 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | x | L | H |
| 0 | 1 | 1 | L | x | H |
| 0 | 1 | 0 | L | H | x |
| 1 | 1 | 0 | x | H | L |
| 1 | 0 | 0 | H | x | L |
| 1 | 0 | 1 | H | L | x |

| Hall Configuration = 4 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | L | x | H |
| 0 | 1 | 1 | L | H | x |
| 0 | 1 | 0 | x | H | L |
| 1 | 1 | 0 | H | x | L |
| 1 | 0 | 0 | H | L | x |
| 1 | 0 | 1 | x | L | H |

| Hall Configuration = 5 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | L | H | x |
| 0 | 1 | 1 | x | H | L |
| 0 | 1 | 0 | H | x | L |
| 1 | 1 | 0 | H | L | x |
| 1 | 0 | 0 | x | L | H |
| 1 | 0 | 1 | L | x | H |

## Alternate Commutation Tables:

| Hall Configuration = 6 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | H | L | x |
| 0 | 1 | 1 | H | x | L |
| 0 | 1 | 0 | x | H | L |
| 1 | 1 | 0 | L | H | x |
| 1 | 0 | 0 | L | x | H |
| 1 | 0 | 1 | x | L | H |

| Hall Configuration = 7 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | H | x | L |
| 0 | 1 | 1 | x | H | L |
| 0 | 1 | 0 | L | H | x |
| 1 | 1 | 0 | L | x | H |
| 1 | 0 | 0 | x | L | H |
| 1 | 0 | 1 | H | L | x |

| Hall Configuration = 8 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | x | H | L |
| 0 | 1 | 1 | L | H | x |
| 0 | 1 | 0 | L | x | H |
| 1 | 1 | 0 | x | L | H |
| 1 | 0 | 0 | H | L | x |
| 1 | 0 | 1 | H | x | L |

| Hall Configuration = 9 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | L | H | x |
| 0 | 1 | 1 | L | x | H |
| 0 | 1 | 0 | x | L | H |
| 1 | 1 | 0 | H | L | x |
| 1 | 0 | 0 | H | x | L |
| 1 | 0 | 1 | x | H | L |

| Hall Configuration = 10 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | L | x | H |
| 0 | 1 | 1 | x | L | H |
| 0 | 1 | 0 | H | L | x |
| 1 | 1 | 0 | H | x | L |
| 1 | 0 | 0 | x | H | L |
| 1 | 0 | 1 | L | H | x |

| Hall Configuration = 11 | | | | | |
|---|---|---|---|---|---|
| Hall 1 | Hall 2 | Hall 3 | Motor A | Motor B | Motor C |
| 0 | 0 | 1 | x | L | H |
| 0 | 1 | 1 | H | L | x |
| 0 | 1 | 0 | H | x | L |
| 1 | 1 | 0 | x | H | L |
| 1 | 0 | 0 | L | H | x |
| 1 | 0 | 1 | L | x | H |

***PWM Freq.*** - This option controls the drive output switching frequency. ElectroCraft recommends using a lower PWM frequency unless there is a valid reason to use a higher frequency. Higher switching frequency will increase the switching losses and reduces the drive efficiency. Refer to the Drive User manual for recommendations and limitations related to PWM Frequency.

***Reverse Spin*** - This option is used to configure whether a positive command produces clockwise (CW) or counter-clockwise (CCW) physical rotation of the motor output. This option does not correct for a polarity mismatch in command input vs speed feedback. Use Hall configuration to resolve a polarity mismatch with the hall sensors (reference Hall configuration) and Encoder Reverse to resolve a polarity mismatch with the encoder (reference Encoder reverse).

***Drive operation mode:***

***Current*** – This mode configures the drive to run in current control mode. In this mode, the drive operates the motor at a commanded current value for a required amount of torque from the motor. Speed of the motor is not controlled in this mode.

***Speed*** – This mode configures the drive to run in speed control mode. In this mode, the drive operates the motor at a commanded speed. To maintain the commanded speed, the current supplied to the motor is controlled depending on the load.

Note: Control interface cannot be set to *Step and Direction* for Current and Speed drive operation modes.

***Position*** – This mode configures the drive to run in position control mode. In this mode, *CPP-xxxVxxA-SA-CAN* version drives operate the motor in closed-loop position control. Position and Current control loops are active in this control mode. When using *CPP-xxxVxxA-SA-USB version drives* Position mode can only be used with *Step and Direction* or *USB* control interface. *CPP-xxxVxxA-SA-CAN* version drives will work with all Control interfaces. Position commands from *Step and Direction* or *USB* interface are immediate. There is no Ramp or Trajectory generation in this mode.

***Position with Speed*** – This mode configures the drive to run in position with speed control mode. In this mode, the drive operates the motor in closed-loop position control. Position, Speed and Current control loops are active in this control mode. When using CPP-xxxVxxA-SA-USB version drives Position with Speed mode can only be used with *Step and Direction* or *USB* control interface. CPP-xxxVxxA-SA-CAN version drives will work with all Control interfaces. All position commands from *Step and Direction* or *USB* interface are immediate. There is no Ramp or Trajectory generation in this mode

Note: The Drive operation mode must be set to *4-Quadrant*. BLDC motors require an encoder for Position or Position with Speed mode operation.

***Commutation:***

***Trapezoidal*** - Trapezoidal or '6-step' commutation mode produces current in the motor by sourcing current in one phase, sinking current in another, leaving the third phase at a high impedance state. It is recommended for use with 'Trap-wound' BLDC motors typically associated with high-speed applications.

***Sinusoidal*** - Sinusoidal commutation produces 3-phase sinusoidal current on all three phase outputs. Sinusoidal commutation produces less torque ripple than trapezoidal commutation. Audible motor noise may also be reduced while rotating.

***Drive Mode:***

***2-Quadrant*** - 2-Quadrant mode allows the drive to output current to accelerate the motor, but not decelerate the motor. This mode is especially useful in unidirectional applications where the motor does not need to (or it is best not to) actively decelerate the motor. Examples of applications where 2-Quadrant mode may be useful are: Loads with a drive belt and tensioner, pump, blower, grinder, or a compressor.

***4-Quadrant*** - This mode allows the drive to output current to accelerate and decelerate the motor. This mode is used in servo applications where speed overshoot is not desired or when the application requires the motor to be actively controlled during deceleration.

***Feedback Enhancement:***

***Hall Compensate*** – This feature compensates for minor variations of hall signal symmetry for speed calculations. It is applicable only when using a BLDC motor with hall switches without an encoder.

***Encoder continuously synch to hall*** - When enabled, the drive will synchronize the encoder to the hall sensor 1 while rotating. This is useful to re-align the sine wave commutation when using single-ended encoders in electrically noisy environments. This option will not compensate for corrupted speed or position feedback due to electrical noise on the encoder signals. It is recommended only for use in current mode operation.

***Control Interface:***

***Control Interface*** - Selects how a control command is communicated to the drive.

*Analog*: Sets command source to analog input signals on the I/O connector. Polarity of the command can be changed using the Direction digital input.

*Step and Direction*: Sets command source to Step and Direction digital inputs.

*USB*: Sets command source to the USB communications port. This mode is used with the Online Monitor and Diagnostics tools within CompleteArchitect™ software.

CAN: Sets command source to the CAN communications port.

Note: Regardless of the control interface selected, the drive's digital input 'Enable' must be in an enabled state for the drive to operate. Refer to the Drive User manual for details of the Enable input.

***Desired Steps per Rev.*** – For BLDC motors this is the desired number of steps per revolution of the motor when in Step and Direction mode. The motor will move one Step for each rising edge on the Step digital input. The Step pulse input from the user is converted into encoder counts. The position displayed in Online Monitor and Diagnostics are in Encoder Counts (IU = Internal Units). The user may enter any value 1 <= steps <= 65535. The Universal Drive will divide the Desired Steps per Rev. into the Encoder resolution. Step pulse input accuracy on this conversion is +/- 1 encoder count.

***Enable travel limit switch inputs*** – This feature enables and disables the limit switch functionality of the Limit+ and Limit- digital inputs. When enabled, the Limit+ input will inhibit torque output in the positive direction and the Limit- input will inhibit torque output in the negative direction. Refer to the Drive User manual for connection details for these inputs.

***Use enable digital input as enable / disable*** – This feature enables and disables the drive enable functionality input. When enabled it decouples the Drive Enable function from the digital input on the drive I/O connector. When unchecked, the drive will automatically enable after power-on or reset (in Analog mode only). After power-up or reset, the drive is disabled and requires an enable command over the communication channel to enable. It may be useful in CAN or USB mode to enable/disable over the network without having anything plugged into the drive I/O connector. Refer to the Drive User manual for connection details for this input.

## 6.4.2 Motor and Drive Configuration Group for PMDC Motor

The Motor and Drive window for a PMDC motor is shown in Figure 38.

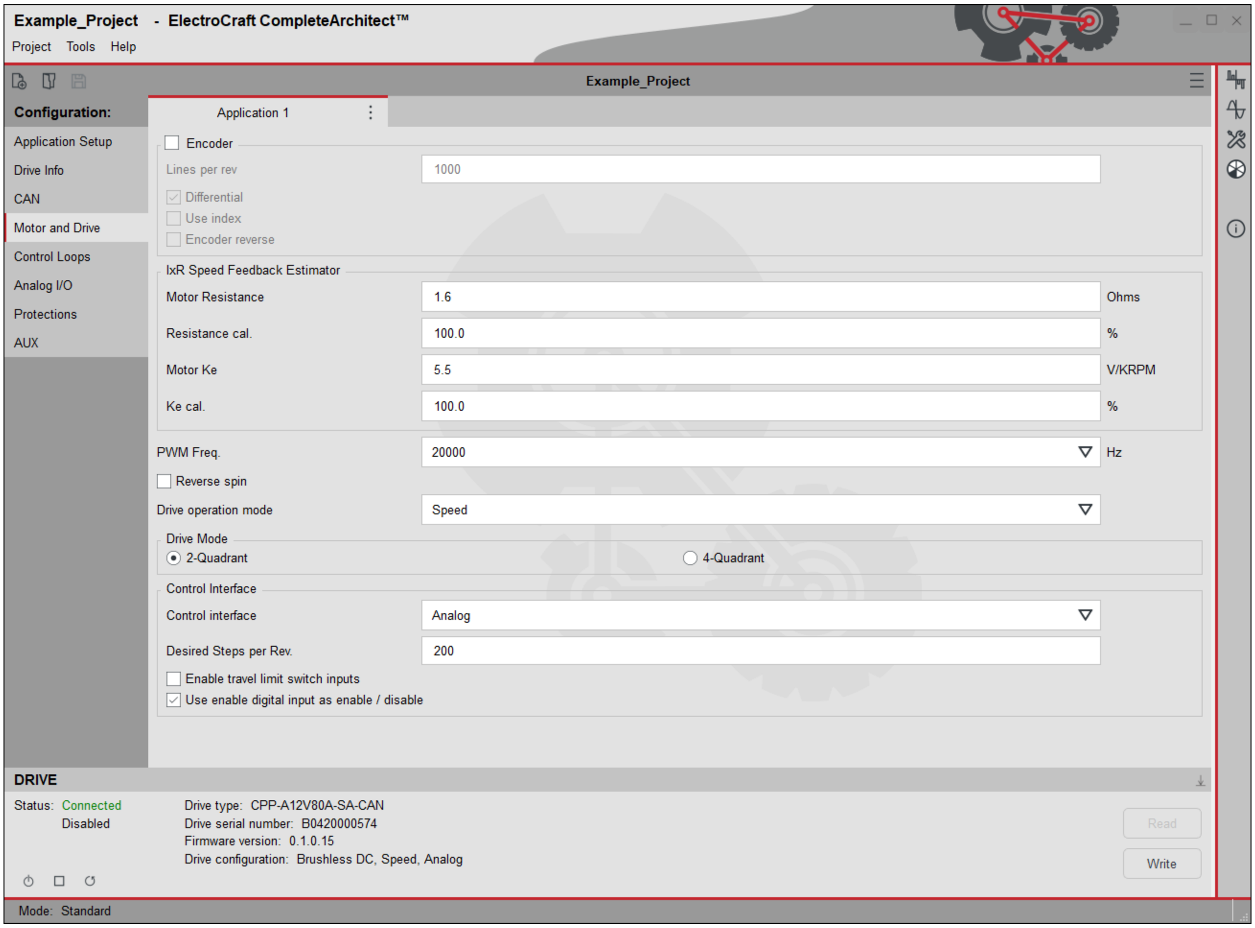



**Figure 38: Motor and Drive Window for PMDC Motor**

**All parameters in this window are described below:**

***Encoder*** - When enabled, the encoder will be used for speed and position feedback. When disabled, the IxR Speed Feedback Estimator will be used for speed estimation.

***Lines per rev*** – This field represents the resolution of the encoder in units of lines per revolution. An encoder datasheet may specify resolution in units of lines, cycles per revolution (CPR), pulses per revolution (PPR) or quadrature counts per revolution. Lines, CPR and PPR are same and are often used interchangeably. To convert quadrature counts per revolution to lines, divide by 4. Example: 4000 quadrature counts = 1000 lines.

***Differential*** - When enabled, the drive enables the differential encoder transceiver. When disabled, the drive will accept a single ended encoder input. A differential encoder may be more immune to electrically noise than a single-ended encoder. Reference the drive’s user manual for electrical connection requirements and compatibility.

***Use Index*** - When enabled, the drive will use the encoder index to synchronize motor commutation while rotating. This is useful to re-align the sine wave commutation when using single-ended encoders in electrically noisy environments. This option will not compensate for corrupted speed or position feedback due to electrical noise on the encoder signals. This function is recommended for use in current mode operation.

***Encoder Reverse*** - Encoder manufacturers do not use a common mechanical convention for "positive" direction. There are encoders that count positive when turning clockwise (CW) and some when turning counterclockwise (CCW). When enabled, this option reverses the polarity of the encoder counting and encoder speed reporting.

***IxR Speed Feedback Estimator*** - This feature estimates motor speed using the motor's Resistance and motor's back EMF (Ke). It is used when an actual speed feedback device (an encoder or other sensor) is unavailable. Refer section 6.4.3 for details. If the Encoder is enabled, the encoder will be used for speed and position feedback and IxR Speed Feedback Estimator will not be used.

***Motor Resistance*** - Resistance of the motor winding in units of Ohms. This value can be found on the motor datasheet.

***Resistance cal.*** - The Resistance Compensation (Resistance cal) value is used to calibrate the IxR speed feedback estimator for speed regulation under changing loads. Refer section 6.4.3 for details.

***Motor Ke*** - This is the motor's BEMF (Back EMF) voltage constant in units of V/KRPM. This value can be found on the motor datasheet.

***Ke cal.*** - The Motor Ke Compensation (Ke cal) value is used to calibrate the IxR Compensation speed feedback estimator under steady state no load conditions. Refer section 6.4.3 for details.

***PWM Freq.*** - This option controls the drive output switching frequency. ElectroCraft recommends using a lower PWM frequency unless there is a valid reason to use a higher frequency. Higher switching frequency will increase the switching losses and reduces the drive efficiency. Refer to the Drive User manual for recommendations and limitations related to PWM Frequency.

***Reverse Spin*** - This option is used to configure whether a positive command produces clockwise (CW) or counter-clockwise (CCW) physical rotation of the motor output. This option does not correct for a polarity mismatch in command input vs speed feedback. Use Encoder Reverse to resolve a polarity mismatch with the encoder (reference Encoder reverse).

***Drive operation mode:***

***Current*** – This mode configures the drive to run in current control mode. In this mode, the drive operates the motor at a commanded current value for a required amount of torque from the motor. Speed of the motor is not controlled in this mode.

***Speed*** – This mode configures the drive to run in speed control mode. In this mode, the drive operates the motor at a commanded speed. To maintain the commanded speed, the current supplied to the motor is controlled depending on the load.

Note: Control interface cannot be set to *Step and Direction* for Current and Speed drive operation modes.

***Position*** – This mode configures the drive to run in position control mode. In this mode, *CPP-xxxVxxA-SA-CAN* version drives operate the motor in closed-Loop position control. Position and Current control loops are active in this control mode. When using *CPP-xxxVxxA-SA-USB version drives* Position mode can only be used with *Step and Direction* or *USB* control interface. *CPP-xxxVxxA-SA-CAN* version drives will work with all Control interfaces. All position commands from *Step and Direction* or *USB* interface are immediate. There is no Ramp or Trajectory generation in this mode.

***Position with Speed*** – This mode configures the drive to run in position with speed control mode. In this mode, the drive operates the motor in closed-loop position control. Position, Speed and Current control loops are active in this control mode. When using CPP-xxxVxxA-SA-USB version drives, Position with Speed mode can only be used with *Step and Direction* or *USB* control interface. CPP-xxxVxxA-SA-CAN version drives will work with all Control interfaces. All position commands from *Step and Direction* or *USB* interface are immediate. There is no Ramp or Trajectory generation in this mode.

Note: The Drive operation mode must be set to *4-Quadrant*. PMDC motors require an encoder for Position or Position with Speed mode operation.

***Drive Mode:***

***2-Quadrant*** - 2-Quadrant mode allows the drive to output current to accelerate the motor, but not decelerate the motor. This mode is especially useful in unidirectional applications where the motor does not need to (or it is best not to) actively decelerate the motor. Examples of applications where 2-Quadrant mode may be useful are: Loads with a drive belt and tensioner, pump, blower, grinder, or a compressor.

***4-Quadrant*** - This mode allows the drive to output current to accelerate and decelerate the motor. This mode is used in servo applications where speed overshoot is not desired or when the application requires the motor to be actively controlled during deceleration.

***Control Interface:***

***Control Interface*** - Selects how a control command is communicated to the drive.

*Analog*: Sets command source to analog input signals on the I/O connector. Polarity of the command can be changed using the Direction digital input.

*Step and Direction*: Sets command source to Step and Direction digital inputs.

*USB*: Sets command source to the USB communications port. This mode is used with the Online Monitor and Diagnostics tools within CompleteArchitect™ software.

CAN: Sets command source to the CAN communications port.

Note: Regardless of the control interface selected, the drive's digital input 'Enable' must be in an enabled state for the drive to operate. Refer to the Drive User manual for details of the Enable input.

***Desired Steps per Rev.*** – For PMDC motors this is the desired number of steps per revolution of the motor. The motor will move one Step for each rising edge on the Step digital input. The Step pulse input from the user is converted into encoder counts. The position displayed in Online Monitor and Diagnostics are in Encoder Counts (IU = Internal Units). The user may enter any value 1 <= steps <= 65535. The Universal Drive will divide the Desired Steps per Rev. into the Encoder resolution. Step pulse input accuracy on this conversion is +/- 1 encoder count.

***Enable travel limit switch inputs*** – This feature enables and disables the limit switch functionality of the Limit+ and Limit- digital inputs. When enabled, the Limit+ input will inhibit torque output in the positive direction and the Limit- input will inhibit torque output in the negative direction. Refer to the Drive User manual for connection details for these inputs.

***Use enable digital input as enable / disable*** – This feature enables and disables the drive enable functionality input. When enabled it decouples the Drive Enable function from the digital input on the drive I/O connector. When unchecked, the drive will automatically enable after power-on or reset (in Analog mode only). After power-up or reset, the drive is disabled and requires an enable command over the communication channel to enable. It may be useful in CAN or USB mode to enable/disable over the network without having anything plugged into the drive I/O connector. Refer to the Drive User manual for connection details for this input.

### 6.4.3 IxR Speed Feedback Estimator

The IxR Speed Feedback Estimator is used to estimate motor speed when an actual speed feedback device (an encoder or other sensor) is unavailable. It uses the motor resistance and motor's BEMF (Back EMF) voltage constant (Ke) to estimate the speed of the PMDC motor. When properly adjusted, the speed displayed in CompleteArchitect should be close to the motor's actual speed when measured by an external device. IxR Speed Feedback Estimator can be used to monitor the speed of the motor in Current operation mode and can be used to input the speed to the speed control loop in Speed operation mode.


**Figure 39: Example of IxR Speed Feedback Estimator section**

**Derivation of parameter values**

***Motor Resistance:*** This value can be obtained from the motor datasheet. If the data is unavailable, use an ohm meter to measure the resistance between the PMDC motor positive and negative terminals when the motor shaft is not rotating. Take multiple readings of the resistance value at different motor shaft positions and use the average of all measurements as the resistance value.

***Resistance cal.:*** The Resistance Calibration (Resistance cal.) value is used to calibrate the IxR Speed Feedback Estimator for speed regulation under changing loads. Increase or decrease this value to change the speed estimate of the motor when loaded (lowering the Resistance Cal. reduces motor speed and vice versa). Typical range of adjustment is 90% to 110%. A feasible way to set Resistance Cal parameter value is to lock the motor output shaft and output current to the motor. Adjust Resistance cal. value so that speed feedback is zero. This parameter is used with Motor Ke by the IxR Speed Feedback Estimator to compute an estimated motor speed.

***Motor Ke (Back EMF):*** This value can be obtained from the motor datasheet. If the data is unavailable, look for rated voltage of the motor and maximum motor RPM at no load. Use the equation below to obtain the Ke value. Another method is to back drive the motor at a known RPM and measure the voltage generated at the PMDC motor positive and negative terminals using voltmeter. Use the equation below to obtain the Ke value.

$$Ke = (\text{Voltage} \times 1000)/\text{RPM}$$

For example, if the back driven PMDC motor generates 24 V at 10,000 RPM; Ke is found to be 2.4 V/KRPM using the formula.

$$Ke = (24 \times 1000)/10{,}000 = 2.4 \text{ V/KRPM}$$

***Ke cal.:*** The Motor Ke Calibration (Ke cal.) value is used to calibrate the IxR Speed Feedback Estimator under steady state no load conditions. Increase or decrease this value to change the no-load speed estimate of the motor (lowering Ke cal. reduces motor speed and vice versa). Typical range of adjustment is 90% to 110%. This parameter is used with Motor Resistance by the IxR Speed Feedback Estimator to compute an estimated motor speed. Adjust motor Ke cal. first to calibrate no-load speed and then adjust Resistance cal. to calibrate speed regulation for load changes. The recommended procedure to set the Ke Cal parameter value is to run motor at no-load and adjust Ke Cal parameter value so that IxR Speed Feedback Estimator reported speed equals the actual measured speed.

**Setting up IxR Speed Feedback Estimator**

Step 1: Open the Motor and Drive configuration group in a PMDC project window.
Step 2: Enter the Motor Resistance and Motor Ke in the appropriate boxes in IxR Speed Feedback Estimator section.
Step 3: Enter 100% in the Resistance cal. and Ke cal. boxes in IxR Speed Feedback Estimator section.
Step 4: Run the motor at a known RPM without any load and check the motor speed using an external speed measuring device like a tachometer. If the speed of the motor displayed in the software is greater than the external speed measuring device, then reduce the Ke cal. value until both the speed measurements are approximately the same. If the speed displayed in the software is less than the external speed measuring device, then increase the Ke cal. value until both the speed measurements are approximately the same.
Step 5: Run the motor at a known RPM with load and check the motor speed using an external speed measuring device. If the speed of the motor displayed in the software is greater than the external speed measuring device, then reduce the Resistance cal. value until both the speed measurements are approximately the same. If the speed displayed in the software is lesser than the external speed measuring device, then increase the Resistance cal. value until both the speed measurements are approximately the same.

Note: As a PMDC motor heats up, the motor resistance will also increase which causes error in the IxR speed feedback estimation. IxR speed feedback is best used for applications where precise control of speed is not important.

## 6.4.4 Motor and Drive Configuration Group for Open-Loop Stepper Motor

When setting the Drive operation mode to Open-Loop stepper, the Control interface cannot be set to Analog and will result in a configuration error, see the Control Interface section below.

The Motor and Drive window for an open-loop stepper motor is shown in Figure 40.

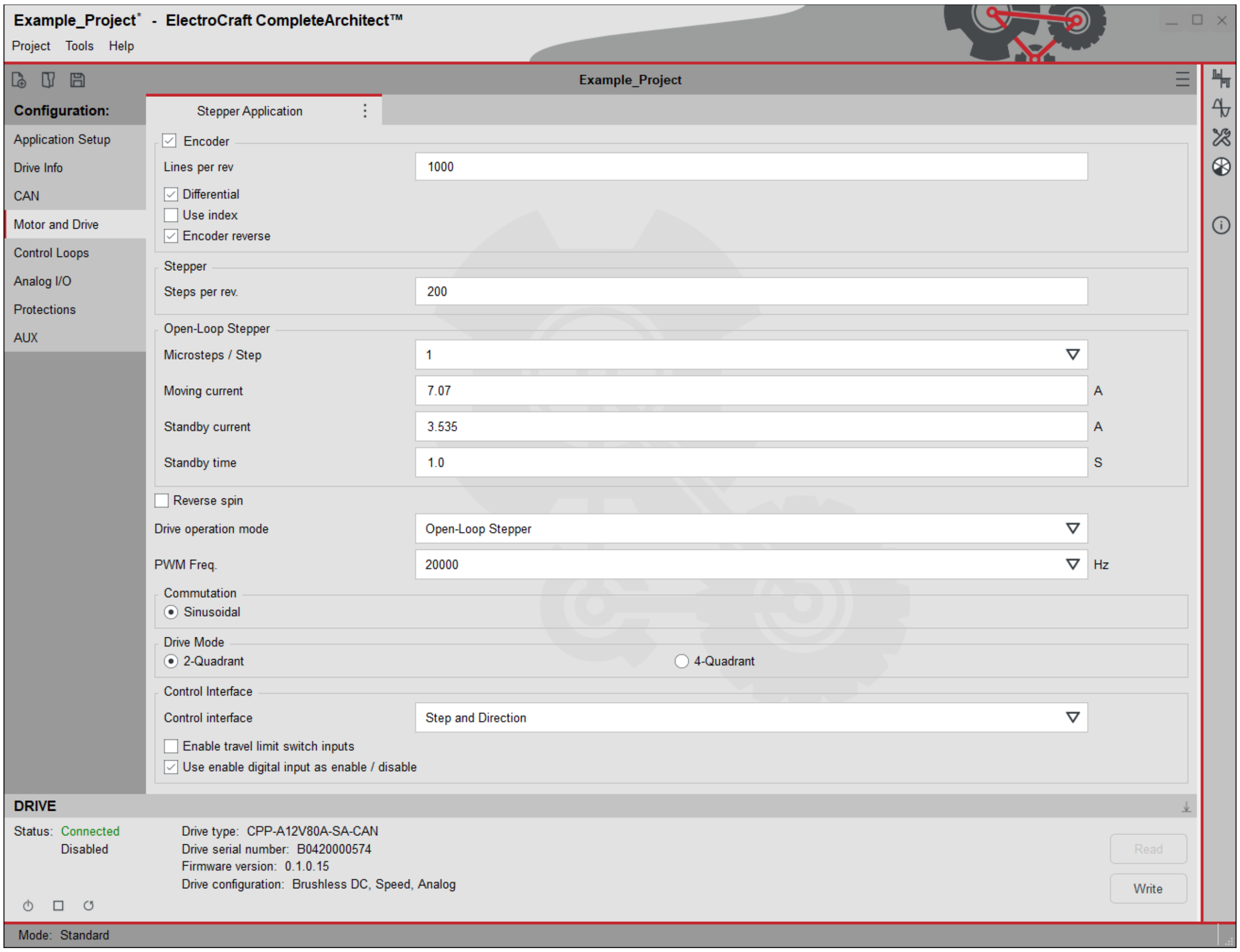



**Figure 40: Motor and Drive Window for Open-Loop Stepper Motor**

**All parameters in this window are described below:**

***Encoder*** – Not used for open-loop stepper. Checking this box will not have any effect.

***Stepper Motor:***

***Steps per rev.*** - This is the physical/mechanical Steps per Revolution of the stepper motor. The correct value should be listed on the motor datasheet. The User may select several Microsteps options per Rev for more or less resolution.

***Open-Loop Stepper:***

***Microsteps / Step*** - This value divides each physical/mechanical step of a Stepper motor (set by the *Steps per rev*. parameter) into fractional steps.

***Moving current*** - This sets the amount of current that the drive will output to the open-loop Stepper motor while the motor is commanded to move.

***Standby current*** - This sets the amount of current that the drive will output to the open-loop Stepper motor when the motor has stopped for longer than the Standby Time.

***Standby time*** - This sets the amount of time after the open-loop Stepper motor stops before the drive's output current changes from the *Moving Current* level to the *Standby Current* level.

***Reverse Spin*** - This option is used to configure whether a positive command produces clockwise (CW) or counter-clockwise (CCW) physical rotation of the motor output. This option does not correct for a polarity mismatch in command input vs speed feedback.

***Drive operation mode:***

From the drop-down menu, selecting Open-Loop Stepper configures the application for open-loop mode and enables the Open-Loop Stepper parameter group. All other modes in this drop-down menu box will configure the application for closed-loop stepper mode.

***Open-Loop Stepper*** – In this mode, the drive operates the motor in Open-Loop position control. The Current control loop is active in this control mode. When using CPP-xxxVxxA-SA-USB version drives, Open-Loop Stepper mode can only be used with *Step and Direction or USB* control interface. CPP-xxxVxxA-SA-CAN version drives will work with *Step and Direction*, *USB*, or *CAN* Control interfaces. Position commands from *Step and Direction or USB* interface are immediate. There is no Ramp or Trajectory generation in this mode. USB commands for Open-Loop Stepper motors in Online Monitor are normalized for all Microstep settings to approximately 23 RPM for a 200 Step per Rev motor. The motor speed is not calculated by the drive.

***PWM Freq.*** - This option controls the drive output switching frequency. ElectroCraft recommends using a lower PWM frequency unless there is a valid reason to use a higher frequency. Higher switching frequency will increase the switching losses and reduces the drive efficiency. Refer to the Drive User manual for recommendations and limitations related to PWM Frequency.

***Commutation*** – Sinusoidal is the only supported type of commutation for stepper motors and cannot be changed.

***Drive Mode:***

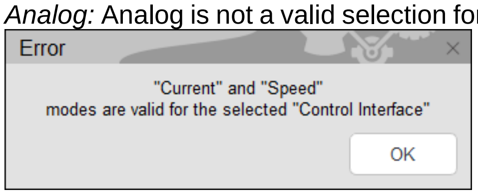
***2-Quadrant*** - 2-Quadrant mode allows the drive to output current to accelerate the motor, but not decelerate the motor. This mode is especially useful in unidirectional applications where the motor does not need to (or it is best not to) actively decelerate the motor. Examples of applications where 2-Quadrant mode may be useful are: Loads with a drive belt and tensioner, pump, blower, grinder, or a compressor. This selection has no effect in open-loop stepper mode.

***4-Quadrant*** - This mode allows the drive to output current to accelerate and decelerate the motor. This mode is used in servo applications where speed overshoot is not desired or when the application requires the motor to be actively controlled during deceleration. 4-Quadrant must be set when using Step and Direction Control Interface

***Control Interface:***

***Control Interface*** - Selects how a control command is communicated to the drive.

*Analog:* Analog is not a valid selection for open-loop stepper and will cause a configuration error if selected.




*Step and Direction:* Sets command source to Step and Direction digital inputs.

*USB:* Sets command source to the USB communications port. This mode is used with the Online Monitor and Diagnostics tools within CompleteArchitect™ software.

*CAN*: Drive takes its command from the CAN communications port.

Note: Regardless of the control interface selected, the drive's digital input 'Enable' must be in an enabled state for the drive to operate with all motor types. Refer to the Drive User manual for details of the Enable input.

***Travel limit switch inputs*** – This feature enables and disables the limit switch functionality of the Limit+ and Limit- digital inputs. When enabled, the Limit+ input will inhibit torque output in the positive direction and the Limit- input will inhibit torque output in the negative direction. Refer to the Drive User manual for connection details for these inputs.

**Use enable digital input as enable / disable** – This feature enables and disables the drive enable functionality input. When enabled it decouples the Drive Enable function from the digital input on the drive I/O connector. When unchecked, the drive will automatically enable after power-on or reset (in Analog mode only). After power-up or reset, the drive is disabled and requires an enable command over the communication channel to enable. It may be useful in CAN or USB mode to enable/disable over the network without having anything plugged into the drive I/O connector. Refer to the Drive User manual for connection details for this input.

## 6.4.5 Motor and Drive Configuration Group for Closed-Loop Stepper Motor

The Motor and Drive window for closed-loop stepper motor motor is shown in Figure 41.

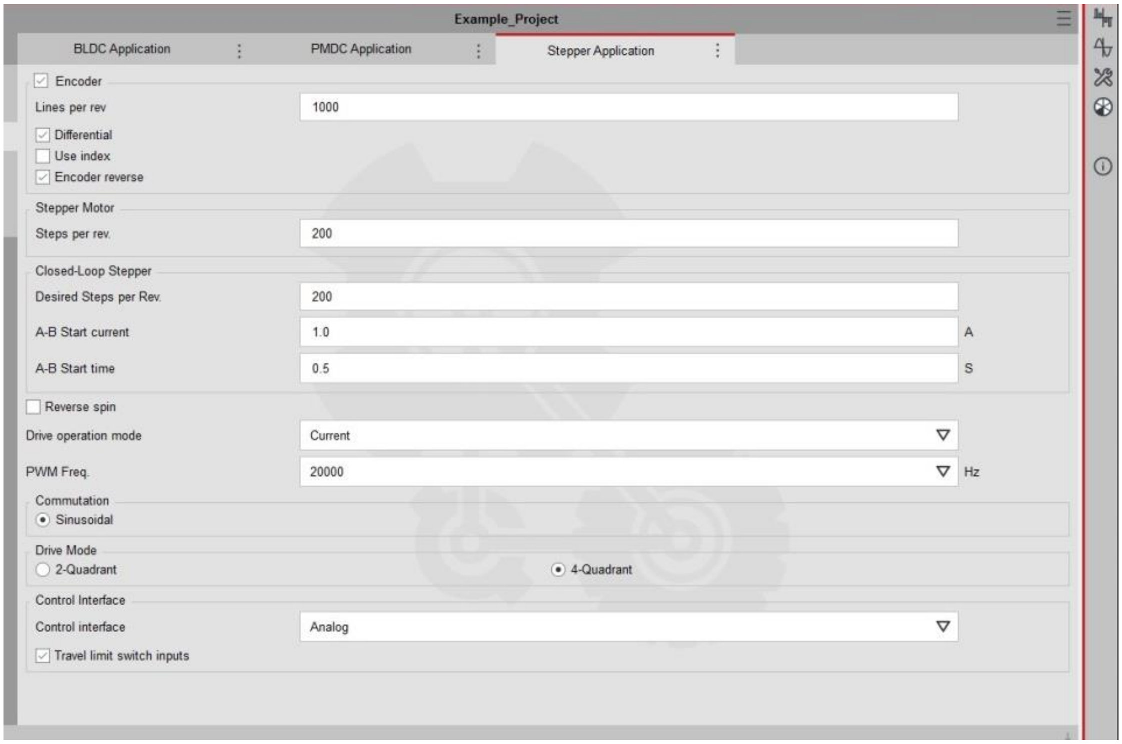



**Figure 41: Motor and Drive Window for Closed-Loop Stepper Motor**

**All parameters in this window are described below:**

***Encoder*** – Required for closed-loop stepper. Unchecking this box in closed-loop stepper will cause a configuration error.

***Lines per rev*** – This field represents the resolution of the encoder in units of lines per revolution. An encoder datasheet may specify resolution in units of lines, cycles per revolution (CPR), pulses per revolution (PPR) or quadrature counts per revolution. Lines, CPR and PPR are same and are often used interchangeably. To convert quadrature counts per revolution to lines, divide by 4. Example: 4000 quadrature counts = 1000 lines.

Note: In Closed-Loop Stepper mode, the encoder resolution must be a multiple of the stepper motor's Steps Per Rev. (Encoder Lines * 4) / Steps_Per_Rev must be an integer.
Example 1: (1000 * 4) / 200 = 20. The value of 20 is an integer and is acceptable.
Example 2: (1024 * 4) / 200 = 20.48. The value of 20.48 is not an integer and is not acceptable.

***Differential*** - When enabled, the drive enables the differential encoder transceiver. When disabled, the drive will accept a single ended encoder input. A differential encoder may be more immune to electrically noise than a single-ended encoder. Reference the drive's user manual for electrical connection requirements and compatibility.

***Use Index*** - When enabled, the drive will use the encoder index to synchronize motor commutation while rotating. This is useful to re-align the sine wave commutation when using single-ended encoders in electrically noisy environments. This option will not compensate for corrupted speed or position feedback due to electrical noise on the encoder signals. This function is recommended for use in current mode operation.

***Encoder Reverse*** - Encoder manufacturers do not use a common mechanical convention for "positive" direction. There are encoders that count positive when turning clockwise (CW) and some when turning counterclockwise (CCW). When enabled, this option reverses the polarity of the encoder counting and encoder speed reporting.

***Stepper Motor:***

***Steps per rev.*** - This is the physical/mechanical Steps per Revolution of the stepper motor. The correct value should be listed on the motor datasheet. The User may then select a Desired Steps per Rev for step resolution required.

***Closed-Loop Stepper:***

***Desired Steps per Rev*** - This value divides one revolution of a Stepper motor into the required step resolution. This parameter sets the size of the angle of rotation for a single step. Example: For Desired Steps per Rev = 1000, the motor will rotate 360º/1000 = 0.36º. Note this value is independent of the physical Steps per rev listed on the motor datasheet. If the physical Steps per Rev. is not a factor of both Desired Steps per Rev and Encoder Lines per Rev. the actual step size will not be exactly as calculated for every step in a revolution due to rounding errors.

***A-B Start current*** - This sets the amount of current that the drive will output to align the motor to phase A winding then phase B winding to align the encoder.

***A-B Start time*** - This sets the time that the A-B Start current will output to each stepper motor phase at initial startup to align the motor and encoder for closed-loop operation

***Reverse Spin*** - This option is used to configure whether a positive command produces clockwise (CW) or counter-clockwise (CCW) physical rotation of the motor output. This option does not correct for a polarity mismatch in command input vs speed feedback.

***Drive operation mode:***

From the drop-down menu only Current, Speed, Position or Position with Speed modes are valid for closed-loop stepper. Selecting Open-Loop Stepper will change the mode to open-loop stepper.

***Current*** – This mode configures the drive to run in current control mode. In this mode, the drive operates the motor at a commanded current value for a required amount of torque from the motor. Speed of the motor is not controlled in this mode.

***Speed*** – This mode configures the drive to run in speed control mode. In this mode, the drive operates the motor at a commanded speed. To maintain the commanded speed, the current supplied to the motor is controlled depending on the load in this mode.

Note: Control interface cannot be set to *Step and Direction* for Current and Speed drive operation modes.

***Position*** – In this mode, the drive operates the motor in closed-loop position control. The Current control loop and Position control loops are active in this control mode. When using CPP-xxxVxxA-SA-USB version drives Position mode can only be used with Step and Direction or USB control interface. CPP-xxxVxxA-SA-CAN version drives will work with all Control interfaces. All position commands from Step and Direction or USB interface are immediate. There is no Ramp or Trajectory generation in this mode.

***Position with Speed*** – In this mode, the drive operates the motor in closed-loop position and speed control. Current control loop, Speed control loop and Position with Speed control loops are active in this control mode. When using CPP-xxxVxxA-SA-USB version drives Position mode can only be used with Step and Direction or USB control interface. CPP-xxxVxxA-SA-CAN version drives will work with all Control interfaces. All position commands from Step and Direction or USB interface are immediate. There is no Ramp or Trajectory generation in this mode.

***PWM Freq.*** - This option controls the drive output switching frequency. ElectroCraft recommends using a lower PWM frequency unless there is a valid reason to use a higher frequency. Higher switching frequency will increase the switching losses and reduces the drive efficiency. Refer to the Drive User manual for recommendations and limitations related to PWM Frequency.

***Commutation*** – Sinusoidal is the only supported type of commutation and cannot be changed.
***Drive Mode:***

***2-Quadrant*** - 2-Quadrant mode allows the drive to output current to accelerate the motor, but not decelerate the motor. This mode is especially useful in unidirectional applications where the motor does not need to (or it is best not to) actively decelerate the motor. Examples of applications where 2-Quadrant mode may be useful are: Loads with a drive belt and tensioner, a pump, a blower, a grinder, or a compressor.

***4-Quadrant*** - This mode allows the drive to output current to accelerate and decelerate the motor. This mode is used in servo applications where speed overshoot is not desired or when the application requires the motor to be actively controlled during deceleration.

***Control Interface:***

***Control Interface*** - Selects how a control command is communicated to the drive.

*Analog*: Sets command source to analog input signals on the I/O connector. Polarity of the command can be changed using the Direction digital input.

*Step and Direction*: Sets command source to Step and Direction digital inputs.

*USB*: Sets command source to the USB communications port. This mode is used with the Online Monitor and Diagnostics tools within CompleteArchitect™ software.

*CAN*: Drive takes its command from the CAN communications port.

Note: Regardless of the control interface selected, the drive's digital input 'Enable' must be in an enabled state for the drive to operate with all motor types. Refer to the Drive User manual for details of the Enable input.

***Travel limit switch inputs*** – This feature enables and disables the limit switch functionality of the Limit+ and Limit- digital inputs. When enabled, the Limit+ input will inhibit torque output in the positive direction and the Limit- input will inhibit torque output in the negative direction. Refer to the Drive User manual for connection details for these inputs.

***Use enable digital input as enable / disable*** – This feature enables and disables the drive enable functionality input. When enabled it decouples the Drive Enable function from the digital input on the drive I/O connector. When unchecked, the drive will automatically enable after power-on or reset (in Analog mode only). After power-up or reset, the drive is disabled and requires an enable command over the communication channel to enable. It may be useful in CAN or USB mode to enable/disable over the network without having anything plugged into the drive I/O connector. Refer to the Drive User manual for connection details for this input.

## 6.5 Control Loops

The Control Loops group allows the user to adjust the tuning values for current, speed, position and position with speed control modes.The default tuning values will vary depending on the drive and motor selected when the project was created. An example of this window is shown in Figure 42.

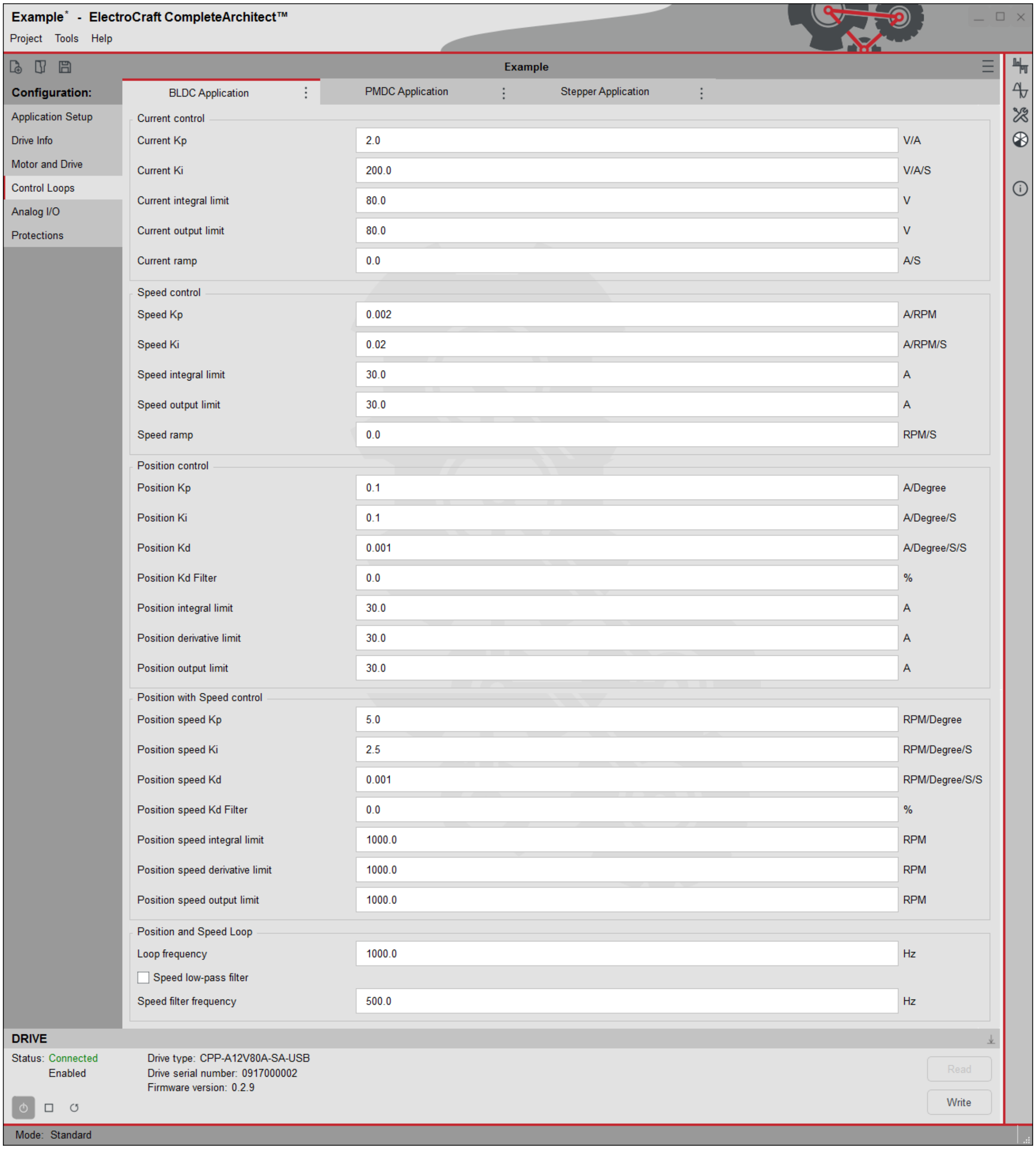



**Figure 42: Control Loops Window**

Depending on the Drive operation mode selected in the *Motor and Drive* configuration group, a combination of control parameters is enabled and visible. For example, if the user selects "*Current*" operation mode from the *Motor and Drive* configuration group, the *Current* control parameters will be enabled and visible. The *Speed* control, *Position* control, *Position with Speed* control parameters will be disabled and not visible.

**Parameters in this group are described below:**

***Current control:***
**These parameters configure the Current Loop. The output of this control loop is a voltage that is applied to the motor. Therefore, the parameters are Voltage-based.**

***Current Kp*** – A value representing the proportional gain for the current PI control loop.

***Current Ki*** - A value representing the integral gain for the current PI control loop.

***Current integral limit*** – Limits the maximum voltage contribution that the integral can make to the current PI control loop output.

***Current output limit*** - Limits the maximum voltage output of the current PI control loop.

*Note: Output voltage is created using PWM to output a percentage of the power supply voltage. Therefore, the measured peak voltage will equal the power supply voltage.*

***Current ramp*** - The current ramp is only enabled in current control mode. It is disabled in all other drive operation modes. When enabled, the drive will increase (or decrease) the internal current command reference toward the user's desired current command at this ramp rate. A current ramp value of zero (0) disables the current ramp.

***Speed control:***
**These parameters configure the Speed Loop. The output of this control loop is the input to the Current Loop. Therefore, the parameters are Current-based.**

***Speed Kp*** - A value representing the proportional gain for the speed PI control loop.

***Speed Ki*** - A value representing the integral gain for the speed PI control loop.

***Speed integral limit*** - This value limits the maximum current contribution the integral can make to the speed PI control loop output.

***Speed output limit*** - This value limits the maximum current output of the speed PI control loop.
*Note: The maximum current output of the drive is also limited by the I2T current limit protection settings.*

***Speed Ramp*** - The speed ramp is only enabled in speed control mode. It is disabled in all other drive operation modes. When enabled, the drive will increase (or decrease) the internal speed command reference toward the user's desired speed command as a maximum rate indicated by this value. A value of zero (0) disables the speed ramp.

***Position control:***
**These parameters configure the Position Loop when the Speed Loop is disabled. The output of this control loop is the input to the Current Loop. Therefore, the parameters are Current-based.**

***Position Kp*** - A value representing the proportional gain for the Position PID control loop.

***Position Ki*** - A value representing the integral gain for the Position PID control loop.

***Position Kd*** - A value representing the derivative gain for the Position PID control loop.

***Position Kd Filter*** - Filter to smooth the derivative contribution to the Position PID control loop.

***Position integral limit*** - Limits the maximum current contribution the integral can make to the Position PID control loop output.

***Position derivative limit*** - Limits the maximum current contribution the derivative can make to the Position PID control loop output.

***Position output limit*** **-** Limits the maximum current output of the Position PID control loop.

Note: Current output is also limited by the *I2T* current limit protection settings.

***Position with Speed control:***
**These parameters configure the Position Loop when the Speed Loop is also enabled. The output of this control loop is the input to the Speed Loop. Therefore, the parameters are RPM-based.**

***Position speed Kp*** - A value representing the proportional gain for the Position PID control loop when the Speed control loop is active.

***Position speed Ki*** - A value representing the integral gain for the Position PID control loop when the Speed control loop is active.

***Position speed Kd*** - A value representing the derivative gain for the Position PID control loop when the Speed control loop is active.

***Position speed Kd filter*** - Filter to smooth the derivative contribution to the Position PID control loop when the Speed control loop is active.

***Position speed integral limit*** - Limits the maximum speed contribution the integral can make to the Position PID control loop output when the Speed control loop is active.

***Position speed derivative limit*** - Limits the maximum speed contribution the derivative can make to the Position PID control loop output when the Speed control loop is active.

***Position speed output limit*** - Limits the maximum speed output of the Position PID control loop.
Note: This is a limit on the maximum speed the motor will be commanded to move to follow a position command.

***Position and Speed Loop:***
**These parameters configure the Position and Speed Loop time base Speed feedback update rate and filter.**

***Loop frequency*** – The frequency at which the motor speed is measured, and the Position and Speed control loops are calculated. Typical loop frequency is 1000 - 5000 Hz. Refer to the Drive User manual for recommendations and limitations related to Position and Speed Loop frequency.

This value must be within the range of 100-20,000Hz. ElectroCraft recommends a loop frequency of 1000 Hz.

**Speed Filter** – Setting for the low-pass filter for speed feedback. A higher number gives higher filtering. This value is the response frequency for the speed low-pass filter. The value must be slower than the speed loop frequency.

Warning: A filter on the speed feedback can create a 'lag' or 'phase shift' in measured vs actual motor speed, resulting in an unstable system.

Refer to section <u>8.4</u> for diagnostics window where the tuning graph is plotted to evaluate the speed and current mode response of the motor with respect to the parameters commanded by the drive.

***Trajectory Generator:***
**Settings to define the acceleration and speed for position moves.**

***Trajectory Generator Acceleration*** - Defines the acceleration and deceleration for position moves.

***Trajectory Generator Speed -*** Defines the maximum speed for position moves.

## 6.6 Analog I/O

The Analog I/O group allows the user to modify the analog input and output parameters. The values entered in all the fields of this section are committed to the drive only after the user writes it. There is an additional Analog I/O 2 group for CPP-xxxVxxA-SA-CAN drives.

### 6.6.1 Analog Input for Current Mode

The Analog I/O configuration group will display current mode parameters when the Drive operation mode is selected as “*Current*” in the Motor and Drive configuration group. An example of Analog I/O window for current mode is shown in the Figure 43.

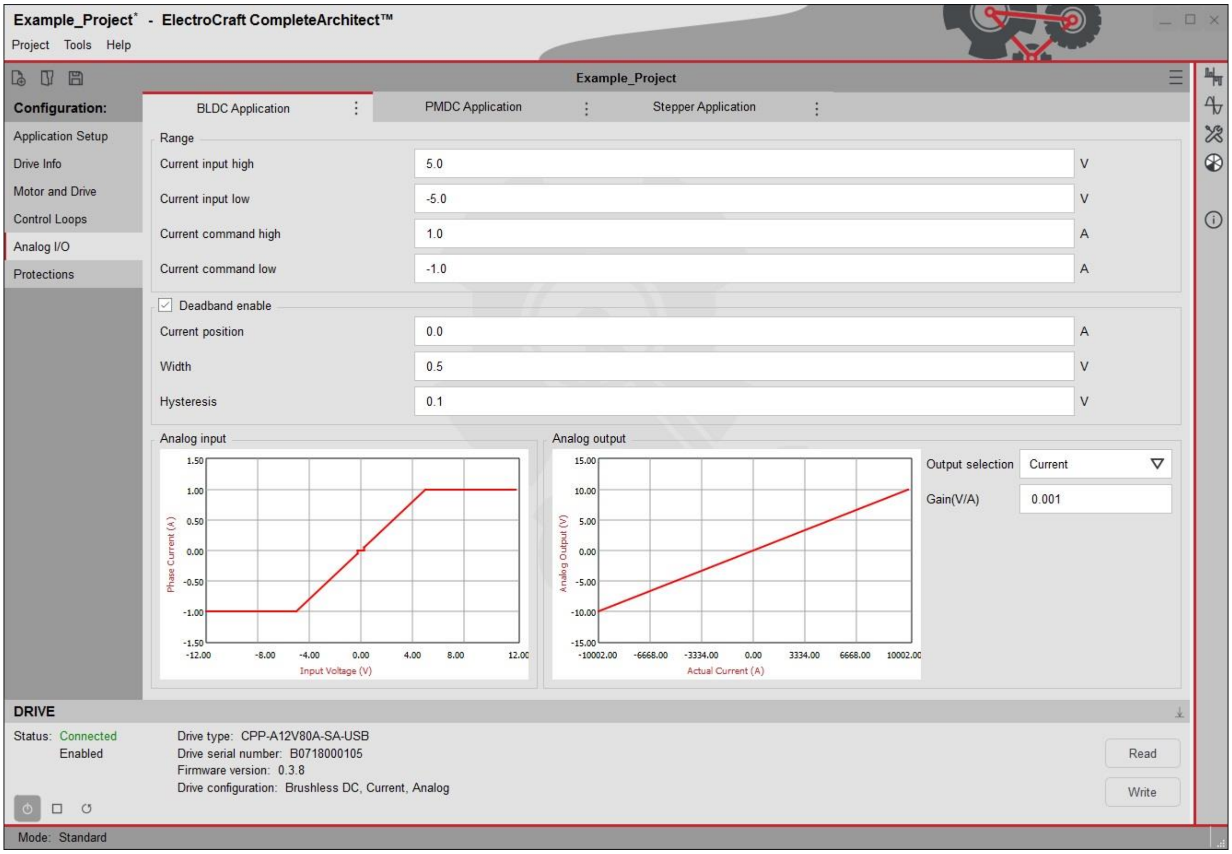



**Figure 43: Analog I/O Window for Current Mode**

**All parameters in this window are described below:**

***Range***

Analog input configuration. This sets up the linear current command transfer function from low to high input voltages. When changes are made the effect can be viewed in the Analog input graph.

***Current input high*** – High level of the input current command in volts at the drive input. Maximum voltage accepted by the analog command input. Any voltage above this value will be interpreted by the drive as the high current command.

***Current input low*** – Low level on the input current command in volts at the drive input. Minimum voltage accepted by the analog command input. Any voltage below this value will be interpreted by the drive as the minimum specified value.

***Current command high*** – Current commanded when the analog input voltage is equal to or above the Current input high voltage. Amount of output current desired when the analog input voltage is equal to or above the Current Input High voltage specified.

**Current command low** - Current commanded when the analog input voltage is equal to or below the Current input low voltage. Amount of output current desired when the analog input voltage is equal to or below the Current Input Low voltage specified.

***Deadband enable***
Deadband Position defines at what position on the Analog input graph to place the deadband. Enable / Disable a deadband on the analog command input. Deadband can be inserted into the analog input by defining the current position, width, and hysteresis. Any input voltage that falls within the deadband is interpreted as a constant output.

***Current position*** – defines the current center the deadband. The deadband can be placed anywhere in the current command range to suite the application. A common use is to place a deadband at zero current to ensure a zero-current command.

***Width*** - This value defines the width of the command input deadband in volts, centered at the current position. A width of 0.5 V results in a deadband of +/-0.25 V around the center position. If the deadband extends beyond the Range set, only the portion within the range takes effect.

***Hysteresis*** – This value is the amount of voltage added to each side of the deadband width required for the command to exit the deadband. This option can be used to reduce dither when the analog input command is at or near the edge of the defined deadband.
An example graph for Deadband position =0 A, Width = 1 V and Hysteresis = 0.1 V is shown in Figure 44.

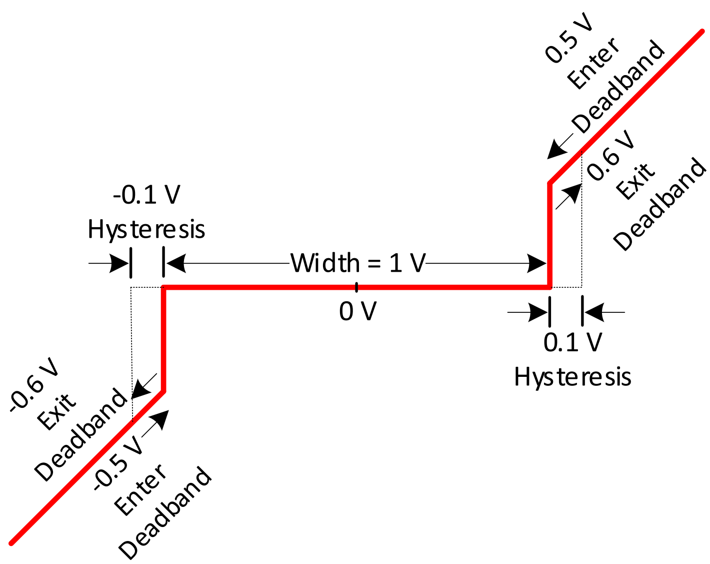



**Figure 44: Deadband Hysteresis graph**

***Analog input graphs*** - The settings Input Low, Input High, Command Low and Command High set the range and scale of the analog input. The input to output scaling of these settings can be seen in the Analog Input graphs.

The input to output scaling of Range and deadband settings is displayed in the Analog input graphs. The graph reflects any change to the parameter values as soon as it entered in the fields.

Figure 45 shows an example where:

- The drive operation mode is setup in current mode
- The motor input command of +5 V high, -5V low
- The motor torque command of +1 A high, -1A low
- Deadband enabled
- Deadband position = 0 A, Width = 0.5 V, Hysteresis = 0.1 V

These settings place a +/-0.25 V deadband on each side of the zero current command input voltage of 0V. Any analog input voltage between -0.25V and +0.25V will result in a zero-ampere current command. The analog input voltage must be greater than 0.25 V + 0.1 V of hysteresis to exit the deadband. The analog voltage must be less than 0.25 V to re-enter the deadband range. Similarly, input voltage must be less than -0.25 V - 0.1 V of hysteresis to exit the deadband. The analog voltage must be greater than - 0.25 V to re-enter the deadband range.

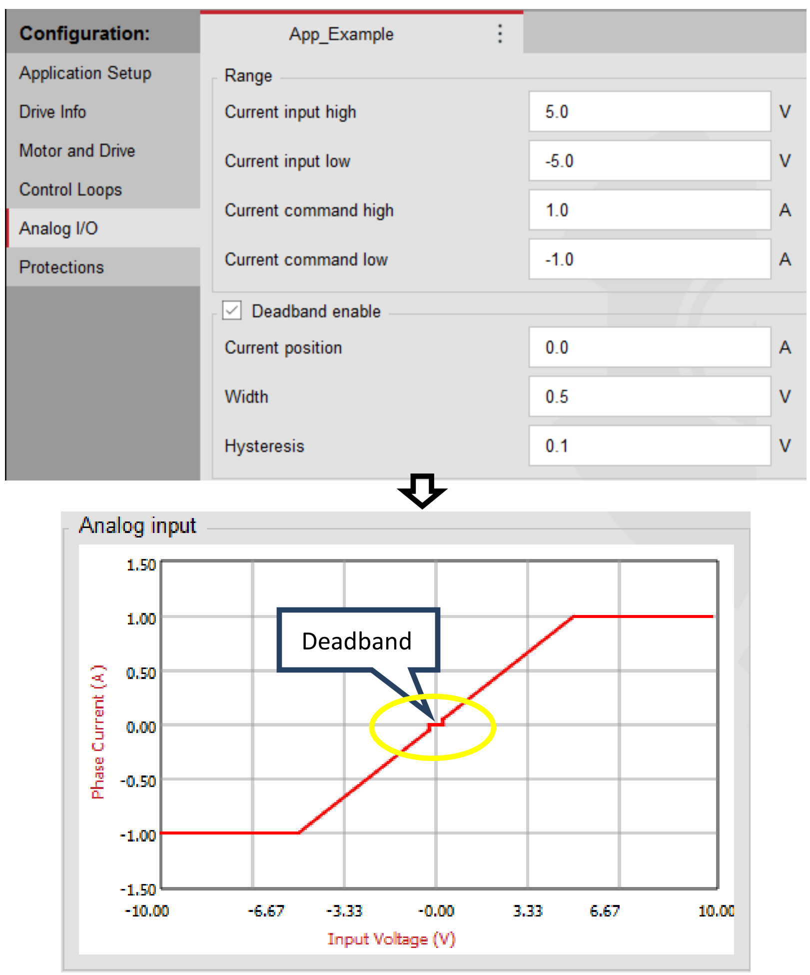



**Figure 45: Analog Input Graph**

## 6.6.2 Analog Input for Speed Mode

The Analog I/O configuration group will display speed mode parameters when the Drive operation mode is selected as "*Speed*" in the Motor and Drive configuration group. An example of Analog I/O window for speed mode is shown in the Figure 46.

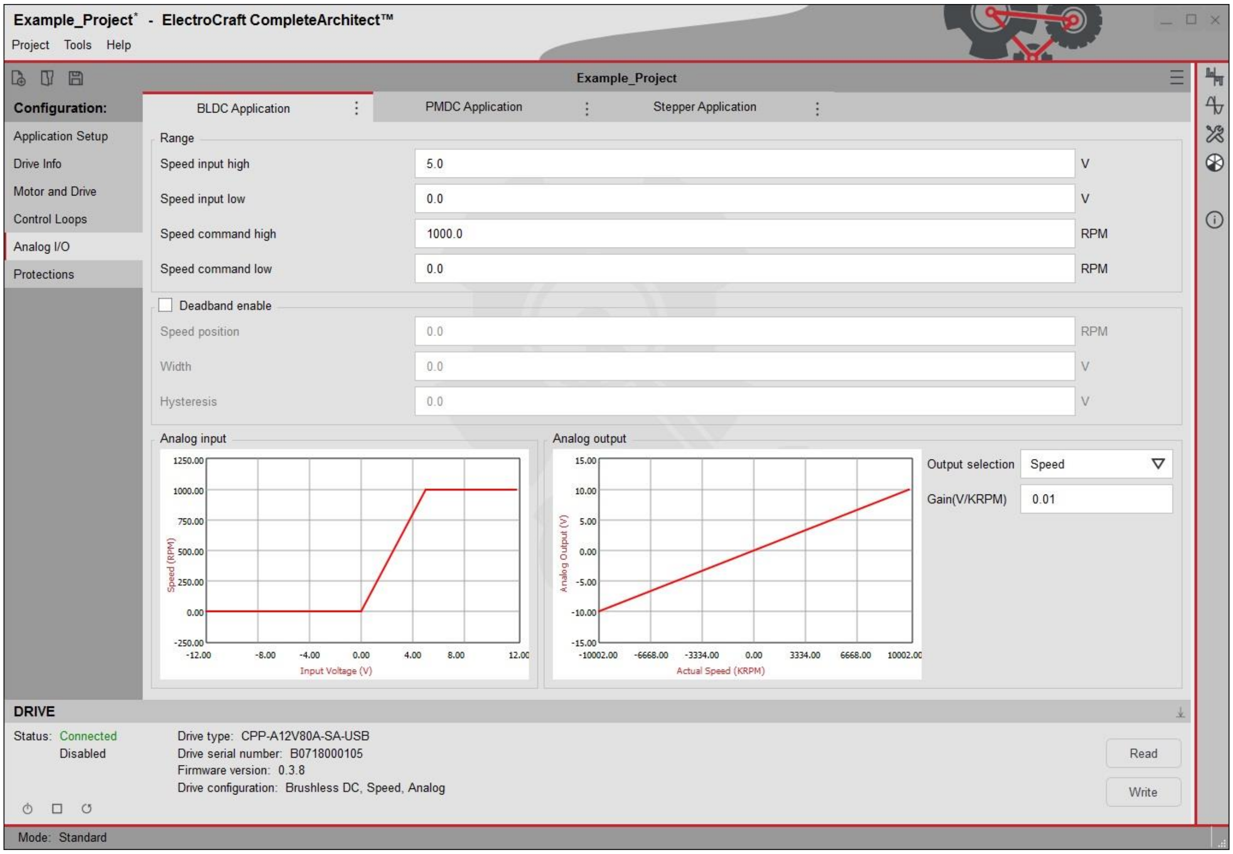



**Figure 46: Analog I/O Window for Speed mode**

**All parameters in this window are described below:**

***Range* -** The settings input low, input high, command low and command high set the range and scale of the analog input. The input to output scaling of these settings can be seen in the Analog Input graph.

***Speed input high*** – This is the maximum voltage accepted by the analog command input. Any voltage above this value will be interpreted by the drive as the maximum specified value.

***Speed input low*** – This is the minimum voltage accepted by the analog command input. Any voltage below this value will be interpreted by the drive as the minimum specified value.

***Speed command high*** – This is the motor speed desired when the analog input voltage is equal to or above the Speed input high voltage specified.

**Speed command low -** Motor speed desired when the analog input voltage is equal to or below the Speed input low voltage specified.

***Speed position*** – This value defines at which position on the Analog input graph to place the deadband. This sets the center point of the deadband. A common use is to place the deadband at zero. This allows the system the ability to ensure a zero command on the analog input.

Refer section 6.6.1 for brief explanation on Deadband enable, Width, Hysteresis, Analog input graph.

### 6.6.3 Analog output

The drive outputs a ±10 V analog voltage proportional to a user selected drive parameter. The Output selection dropdown lists available parameters for selection. The Gain value adjusts the output scaling of the analog voltage. The graph displays the output voltage range for the selected parameter. An example is shown in Figure 47 of Actual Speed scaled at V/KRPM.

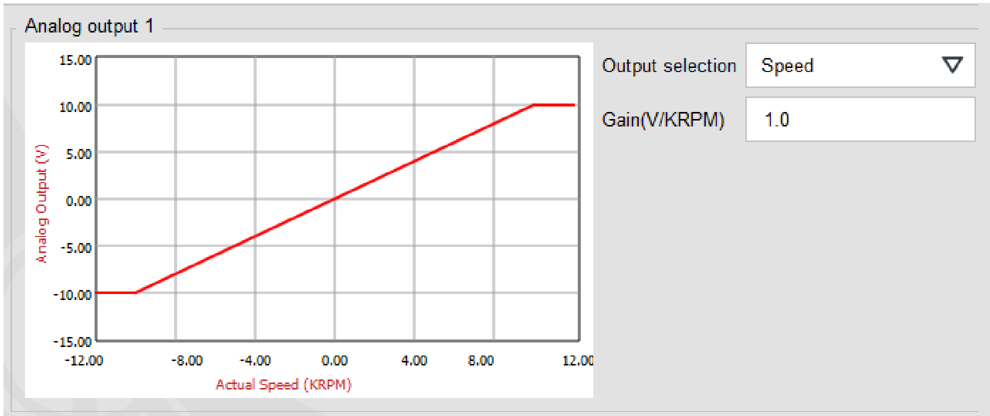



**Figure 47: Analog Output Graph**

## 6.7 Protections

The Protections group allows the user to enable or modify drive and motor protection parameters. A protections window is shown in Figure 48. The grayed-out protections at the top are factory set and cannot be changed; the user can configure the remaining protections. Some of these protections can only be enabled or disabled, others have associated setting along with being enabled or disabled.

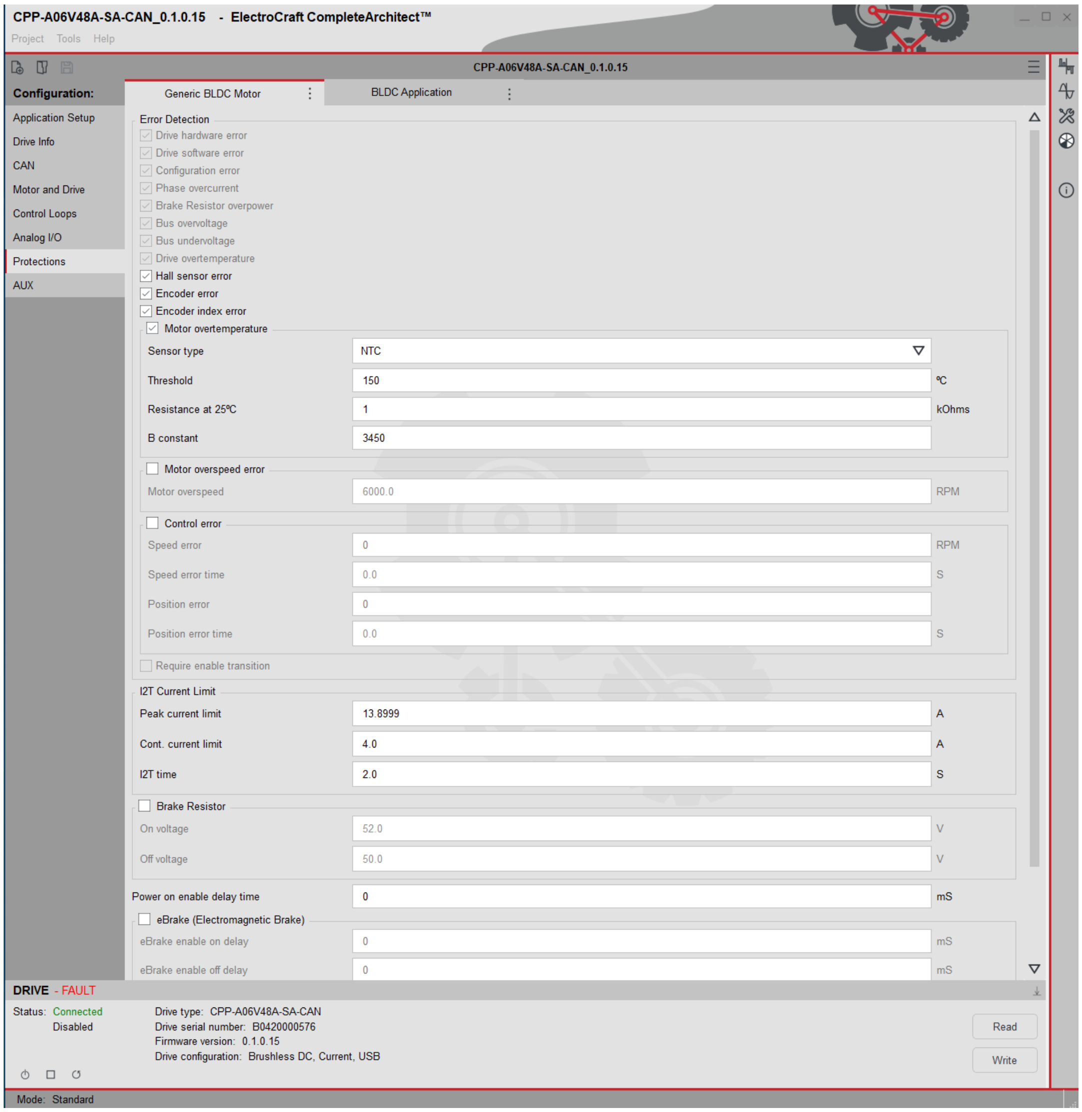



**Figure 48: Protections Window**

When a Protection is enabled, the drive will shut down with an error if the condition for the Protection is met. The error can be read in CompleteArchitect, and the drive will also flash a code as described in the Drives Technical User manual. In the section below the conditions for the drive to shut down on each Protection is covered and the associated setting if applicable.

In the event of a fault during operation the drive becomes disabled, and FAULT will appear in the DRIVE Status area as shown in Figure 49. Clicking on the FAULT text in the window will provide feedback as to which error has been detected.

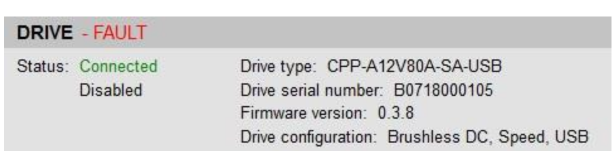



**Figure 49: Fault in Drive Status Area**

***Drive hardware error*** – Not user configurable.
An error is detected with the drive hardware.

***Drive software error*** - Not user configurable.
An error is detected with the drive software.

***Configuration error*** - Not user configurable.
An error is detected with the drive configuration. Possible error would be a parameter setting out of range or an attempt to change a drive or motor parameter while the drive is enabled.

***Phase overcurrent*** - Not user configurable.
An overcurrent is detected. This issue is typically caused by a short circuit or very low resistance condition on the motor outputs. It can also be an indication of excessive current loop gains causing the current loop to become unstable and produce large currents or high capacitance on motor phases.

***Brake Resistor overpower*** - Not user configurable.
The brake resistor is on for too long indicating the brake resistor is undersized for the application. Refer to the Drive User manual for recommendations and limitations of the brake resistor.

***Bus overvoltage*** - Not user configurable.
Internal bus voltage is above the drive maximum voltage limit. Usually caused by excessive regeneration in operation indicating the need for a braking resistor or undersized braking. Refer to the Drive User manual for electrical specifications and recommendations on how to manage regenerated energy during deceleration.

***Bus undervoltage*** - Not user configurable.
Internal bus voltage falls below the drive minimum voltage limit. Usually caused by power supply inability to supply the current demanded by the drive. Refer to the Drive User manual for electrical specifications.

***Drive overtemperature*** - Not user configurable.
Drive internal temperature exceeds the maximum temperature limit. Usually caused by insufficient cooling. Refer to the Drive User manual for environmental, mounting, and power output specifications.

***Hall sensor error*** - User configurable.
Invalid hall state or transition is detected by the drive. Error detection is not active for PMDC or Stepper motors. This error detector requires hall signal input. Refer to the Drive User manual for hall input electrical specifications.

Possible causes of a Hall sensor error:

- Broken hall signal wire
- Hall signal connector disconnected
- All three hall signals are logic High
- All three hall signals are logic Low
- Electrical noise on the hall signals
- One or more hall signal is stuck in a logic state (high or low)
- Hall signal voltage level is not correct

***Encoder error* -** User configurable.
Encoder position does not match hall state. The encoder position is compared to the BLDC motor's hall sensors position to verify that the encoder is functioning. If the encoder position does not match the BLDC motor's hall sensors position, an error is detected. Error detection is not active for PMDC or Stepper motors. This error detector requires hall signals. Refer to the Drive User manual for encoder input electrical specifications.

Possible causes of an Encoder error:

- Encoder disconnected
- Broken encoder wire
- Electrical noise on the encoder signals
- Electrical noise on the hall signals
- Incorrect Encoder Lines value
- Incorrect Encoder Reverse setting
- Incorrect Motor Pole Pairs value
- Incorrect Hall Configuration value

***Encoder index error*** - User configurable.
An error condition detected with the encoder. Encoder position does not match index. When enabled, the encoder count is compared to the Encoder Line value (encoder resolution) each time an Encoder Index is detected. If the encoder count does not match the encoder resolution, an error is detected. Refer to the Drive User manual for encoder input electrical specifications.

Possible causes of an Encoder Index error:

- Broken encoder wire
- Electrical noise on the encoder signals
- Incorrect Encoder Line value

***Motor overtemperature*** - User configurable.
Motor overtemperature condition is detected. An error condition is detected when the resistance between the motor temperature input is detected as over- temperature. The actual motor temperature is dependent upon the temperature sensor installed in the motor.

***Sensor type***
Select the temperature sensor that is installed in the motor:

- Threshold: This is a custom setting. Set the A/D conversion counts as the temperature threshold. Set a positive number to detect an over temperature condition above the threshold. Set a negative number to detect an overtemperature condition below the threshold.
- NTC: Stands for negative temperature coefficient. An NTC's resistance will decrease with temperature.
- PTC: Stands for positive temperature coefficient. A PTC's resistance will increase with temperature.
- Switch NO: Stands for Normally Open. A Normally Open switch will close at the designed temperature.
- Switch NC: Stands for Normally Closed. A Normally Closed switch will open at the designed temperature.

***Threshold* -** Active only with NTC selection
Set the desired temperature to detect a motor overtemperature condition.

***Resistance at 25*°C**
The nominal resistance value (kOhms) of the NTC sensor at 25 degrees Celsius. Locate data from sensor or motor datasheet.

***B constant***
The B value is a material constant which is determined by the material from which the sensor is made.
Enter the B constant (B value, Material constant) of the NTC.

***Motor overspeed error*** – User configurable.
Enables or disables detection of a Motor overspeed error.

***Motor overspeed*** – User setting.
Overspeed limit used by Motor overspeed error. Maximum allowable motor speed (in either positive or negative direction). Motor overspeed error detection must be enabled to detect an overspeed error.

***Control error*** **-** User configurable.
Enables or disables Speed Control and Position Control error protections. Control Error must be enabled to detect a Speed control or Position control error.

***Speed error*** – User setting.
This value sets an acceptance range around the commanded speed value. An error is detected if actual speed is greater or less than the commanded speed by more than the value set by the user for longer than the time period also set by the user. Setting Speed error to zero will disable detection of a speed control error.

***Speed error time*** – User setting.
This value sets the amount of time that the speed is permitted to exceed the Speed error value.

***Position error*** – User setting.
This value sets an acceptance range around the commanded position value. An error is detected if actual position is greater or less than the commanded position by more than the value set by the user for longer than the time period also set by the user. Setting Position error to zero will disable detection of a position control error.

***Position error time*** – User setting.
Position error time period that the Position error is permitted to exceed the allowable Position error.

***I2T Current Limit*** – This protection is always enabled.
The default values are set by the lower values of the drives rating or the motor ratings if a database motor is selected. These values can be further configured by the user but will always be limited by the drive rating. Current output above the Cont. Current Limit setting, will be restricted using the Peak Current and $I^2T$ Time settings.

These parameters configure the I2T Current limit algorithm.

***Peak current limit*** – User setting.
Maximum peak current (peak of sine) that the drive will output to the motor.

This setting is used to limit the drive output current to match the motor peak current rating. The value entered cannot exceed the maximum peak output rating of the drive. The drive will supply this current for the configurable time period. Refer to the Drive User manual for *I2T* current limit specifications.

***Cont. current limit*** – User setting.
Maximum continuous current (peak of sine) that the drive will output to the motor.

This setting is used to limit the drive output current to match the motor continuous current rating. The value entered cannot exceed the maximum continuous output rating of the drive. The drive will supply this current for the configurable time period. Refer to the Drive User manual for *I2T* current limit specifications.

***I2T time*** – User setting.
Maximum amount of time that the drive is allowed to output peak current to the motor.

This setting is used to limit the drive output current to match the motor power rating. The value entered is restricted by the peak and continuous current limit values. Refer to the Drive User manual for *I2T* current limit specifications.

The *I2T* current limit values will be automatically adjusted upon Application creation depending on the limits of the motor selected from the database. If the motor's current limits exceed the drive max limit, the values will be limited by the drive and the informational window shown in Figure 50 will appear.

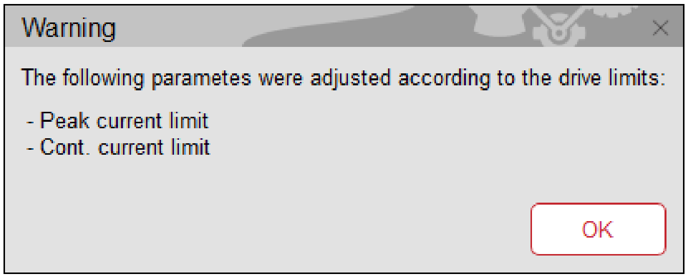



**Figure 50: Warning window when *I2T* current limits are adjusted**

***Brake Resistor*** – User configurable.
Enables or disables detection of a Drive brake (shunt) resistor. If the drive does not have a brake resistor disable the feature. Refer to the Drive User manual for the maximum voltage limit.

***On voltage*** – User setting.
This setting is used to set the voltage level where the brake resistor output will turn on. This level must be above the brake resistor turn off voltage level. Refer to the Drive User manual for brake resistor specifications.

Refer to the Drive User manual for brake resistor specifications.

***Off voltage*** – User setting.
This value sets the voltage level where the brake resistor output will turn off.
This level must be below the brake resistor turn on voltage.
Refer to the Drive User manual for brake resistor specifications.

The voltage level where the brake resistor output will turn off. This level must be below the brake resistor turn on voltage. Refer to the Drive User manual for brake resistor specifications.

If the function is not required set the On voltage and Off voltage to the drive's maximum voltage level.

***Power on enable delay time*** – User setting.
This setting is to delay time after Power-On and before drive can be enabled. This feature allows the user's system sensors and I/O to initialize and provide valid data to the drive before the drive enables.

**eBrake** – User configurable
Enables or disables the Electromechanical brake output signal. Use this signal to allow the drive to control the engagement of an electromechanical brake. If the drive does not have an Electromagnetic Brake disable this feature.

The drive includes a circuit that can control an external electromagnetic brake. CompleteArchitect™ offers these options below for setting parameters to control braking operation. Refer to the Drive User manual for eBrake specifications and control.

**eBrake enable on delay** – User setting.
If a delay is desired set a time in this parameter. The drive will wait the specified time after Drive Enable before disengaging the electromechanical brake.

**eBrake enable off delay** – User setting.
Upon Drive Disable, the drive will engage the electromechanical brake then wait the specified time before disabling the drive's motor output.

**Pull-in time** – User setting.
The drive will apply the specified Pull-in voltage to the electromechanical brake for this specified amount of time, then it will apply the specified Hold Voltage.

**Pull-in voltage** – User setting.
The drive modulates the eBrake output using Pulse-width modulation (PWM) to apply a percentage of the eBrake power supply to the electromechanical brake. The voltage required to pull in the electromechanical brake, entered as a percentage of maximum voltage.

The drive will apply the specified Pull-in Voltage (percentage) to the electromechanical brake for the specified amount of Pull-in Time, then it will apply the specified Hold Voltage.

**Hold voltage** – User setting.
The drive will apply the specified Pull-in Voltage to the electromechanical brake for the specified amount of Pull-in Time, then it will apply this specified Hold Voltage (percentage).

The voltage required to hold the electromechanical brake on, entered as a percentage of maximum voltage.

The drive modulates the eBrake output using Pulse-width modulation (PWM) to apply a percentage of the eBrake power supply to the electromechanical brake.

## 6.8 AUX

This feature is an expansion of capabilities that will allow for the customization of CompleteArchitect™ software by incorporating future parameter data that may be created with custom or customer specific applications. This AUX or auxiliary feature is similar to the Online Monitor Tool and will allow the user to monitor certain drive parameters. Consult factory for use with this feature.

***Adding parameters:***

Step 1: Select + icon to open “Add Monitoring Parameter” window as shown in Figure 51. Multiple parameters can be added simultaneously.

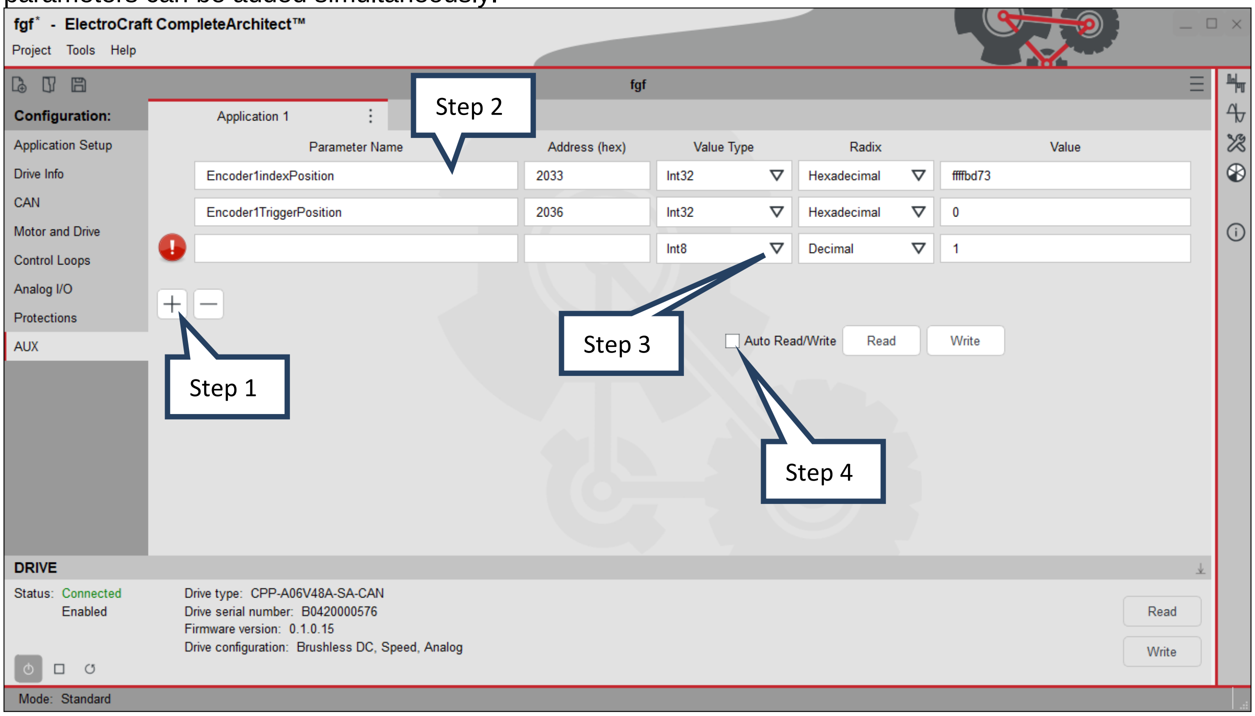



**Figure 51: Adding Parameter**

Step 2: Type Parameter Name and enter address.
Step 3: Click the dropdown arrow ▽ to view the drop-down menu and make the desired Value Type and Radix selections.
Step 4: Click the Auto Read/Write checkbox ☐ to enable or disable writing / reading to the drive automatically without having to manually write /read to the drive.
The parameter(s) will be written to the drive. Read back the parameter after configured to see the value. If an entry is incorrect or missing, then a ! will be displayed.

***Deleting monitored parameters:***

- Select — icon.
- Select the cross icon ☒ for the parameter that will be deleted and then click the delete symbol 🗑 as shown in Figure 52.

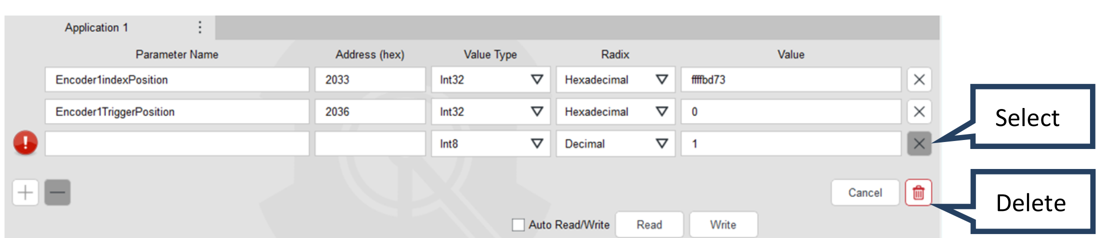



**Figure 52: Delete Parameter**

# 7 Operating the Drive in USB Mode

This mode is used with the Online Monitor and Diagnostics tools within CompleteArchitect™.

Regardless of the control interface selected, the digital input ‘Enable’ must be in the Enabled state for the drive to operate.

Below are the basic steps required for operating the drive with a motor in USB mode.

Refer to Figure 53 for step process:

- Step 1: Verify that the *Control interface* is set to USB within the *Motor and Drive* group.
- Step 2: Select a *Drive operation mode (Current, Speed, Position and Position with Speed)* within *the Motor and Drive* group.
- Step 3: Click *Write* in the Drive Status Area to write all the parameter changes to the drive.

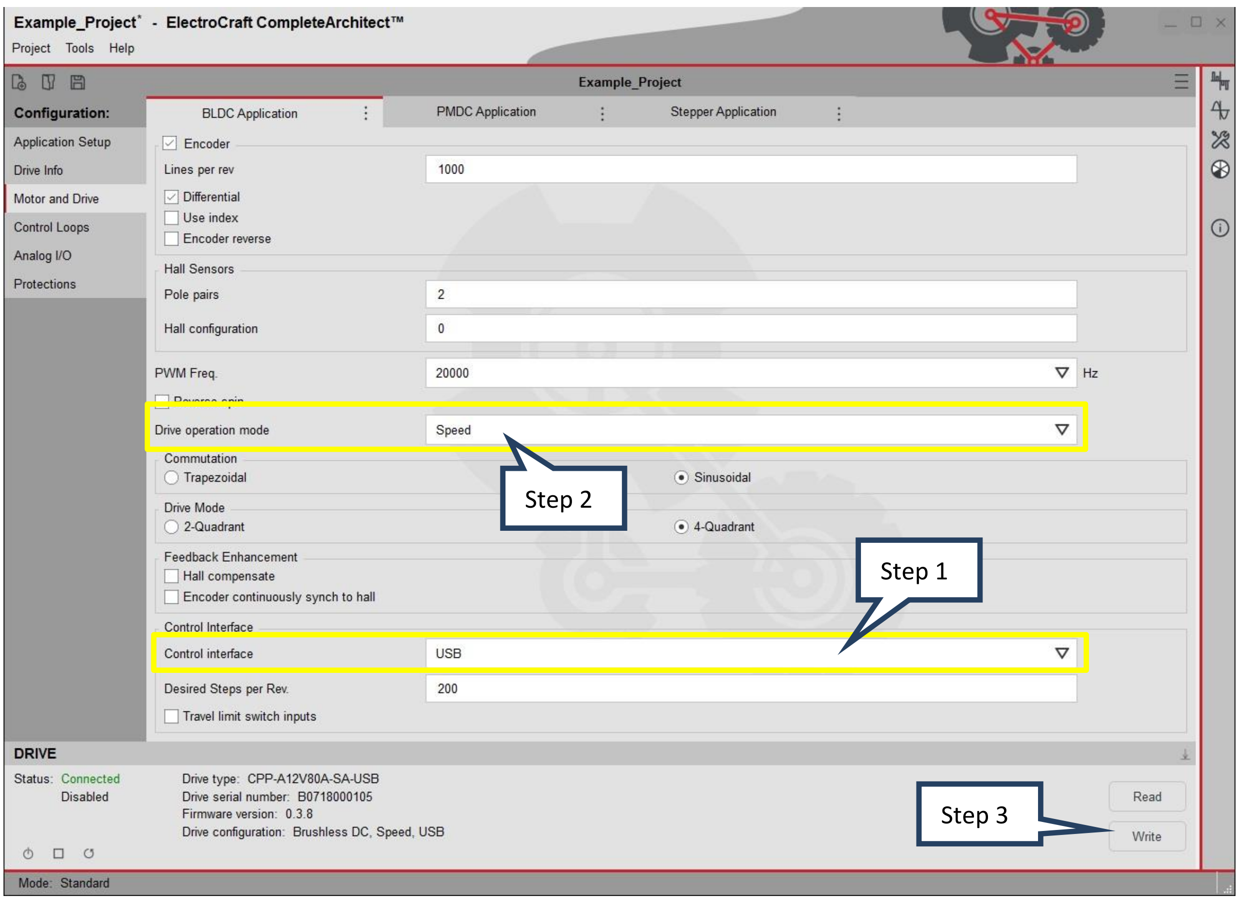



**Figure 53: Motor and Drive configuration window**

# 8 Tools

The tools section includes Online Monitor, Oscilloscope, Diagnostic and Drive I/O Monitor. These tools are future explained below.

## 8.1 Online Monitor

The Online Monitor Tool allows the user to monitor drive parameters such as the output voltage, output current, motor speed, PWM, bus voltage and position. It also provides a method for controlling the drive when the Control interface is set to USB mode from the Motor and Drive tab.

To open this tool, select *Tools -> Online Monitor* or select the icon from the toolbar.
An example of online monitor is shown in Figure 54. See detail below for brief explanation of function.

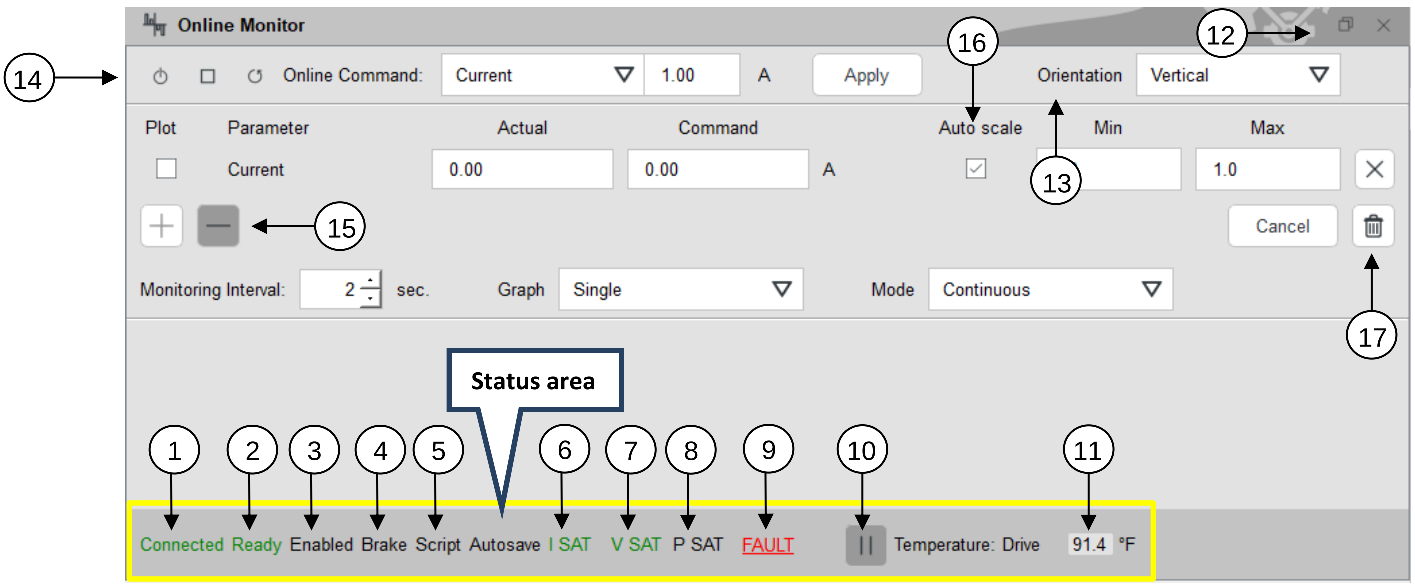



**Figure 54: Online Monitor Window**

**Status area:**
The drive status area shows the status of different characteristics of the drive. Text of the items 1 to 8 will turn green when it is active and black when it is not.

1. Connected – Drive detected.
2. Ready – Drive is ready to start motion.
3. Enabled –Drive is enabled.
4. Brake – Brake input is active.
5. Script – *Script is running.
6. I SAT – Current loop is saturated.
7. V SAT – Speed loop is saturated.
8. P SAT – Position loop is saturated.
9. FAULT– Appears when a fault is detected
10. Pause / Play – This button will pause or resume the plotting.
11. Temperature – Displays the internal temperature of the drive.
12. Docking and undocking – This will dock/undock the tool from the main window.
13. Orientation – Changes position of the graphs.
14. Enable/Disable, Brake/Release, Reset Drive.
15. Add/Remove new parameter.
16. Auto scale – Rescales graphing during operation to fit window.
17. Remove selected parameter. Click to enable feature, then click “X” at each parameter and then click to remove.

*Script or scripting language is a computer language with a series of commands within a file that is capable of being executed without being compiled.

## 8.2 Online Monitor Use

The Online Monitor Tool allows the user to monitor drive parameters such as the output voltage, output current, motor speed, PWM, bus voltage, and position.

Ensure that the "Enable" digital input is set to disable to begin.

The motor shaft will spin, ensure that the motor is safely mounted and motor shaft doesn't make contact with person or machine. Never touch any moving parts of the motor during its operation. Failure to observe this warning may result in injury.

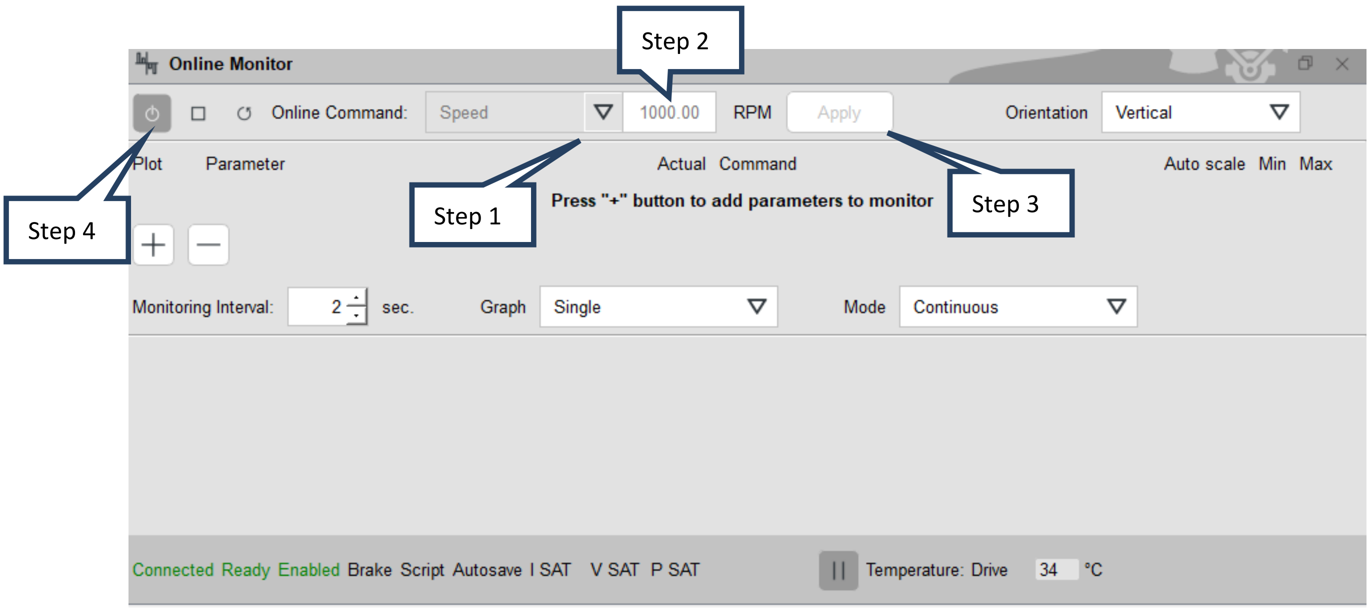



**Figure 55: Adding Parameter**

When performing a trial operation, fasten the motor and disconnect it from the mechanical system. Check the operation, then connect it to the machine after trial operation. Failure to do so may cause injury.

Product Safety Precautions – Refer to the Product Users Manual for detailed safety Precautions.

Refer to Figure 55 for step process:

- Step 1: Select from the dropdown list (Current, Speed, Position or Pos. with speed depending on the drive operation mode selected) in the Online Monitor window.
- Step 2: Enter an RPM value for a speed command or Ampere value for current command or Position value for Position or Pos. with speed command. A lower value to begin is best.
- Step 3: Click Apply and verify that Success appears next to the Apply button.
- Step 4: Click the "Enable" digital input to enable the drive. The motor will begin to run.

## 8.2.1 Plotting Drive Parameters

The Online Monitor will plot the selected parameter data using real-time data at a sampling rate of 100 ms. This rate is much lower than the drive sampling rate and will miss some of the data. For this reason, this display is used to provide an overview of drive operation. The Oscilloscope tool described in section 8.3 is available when data at the drive sampling rate is desired.

***Adding parameters to monitor:***

Step 1: Select [+] icon to open "*Add Monitoring Parameter*" window as shown in Figure 56.

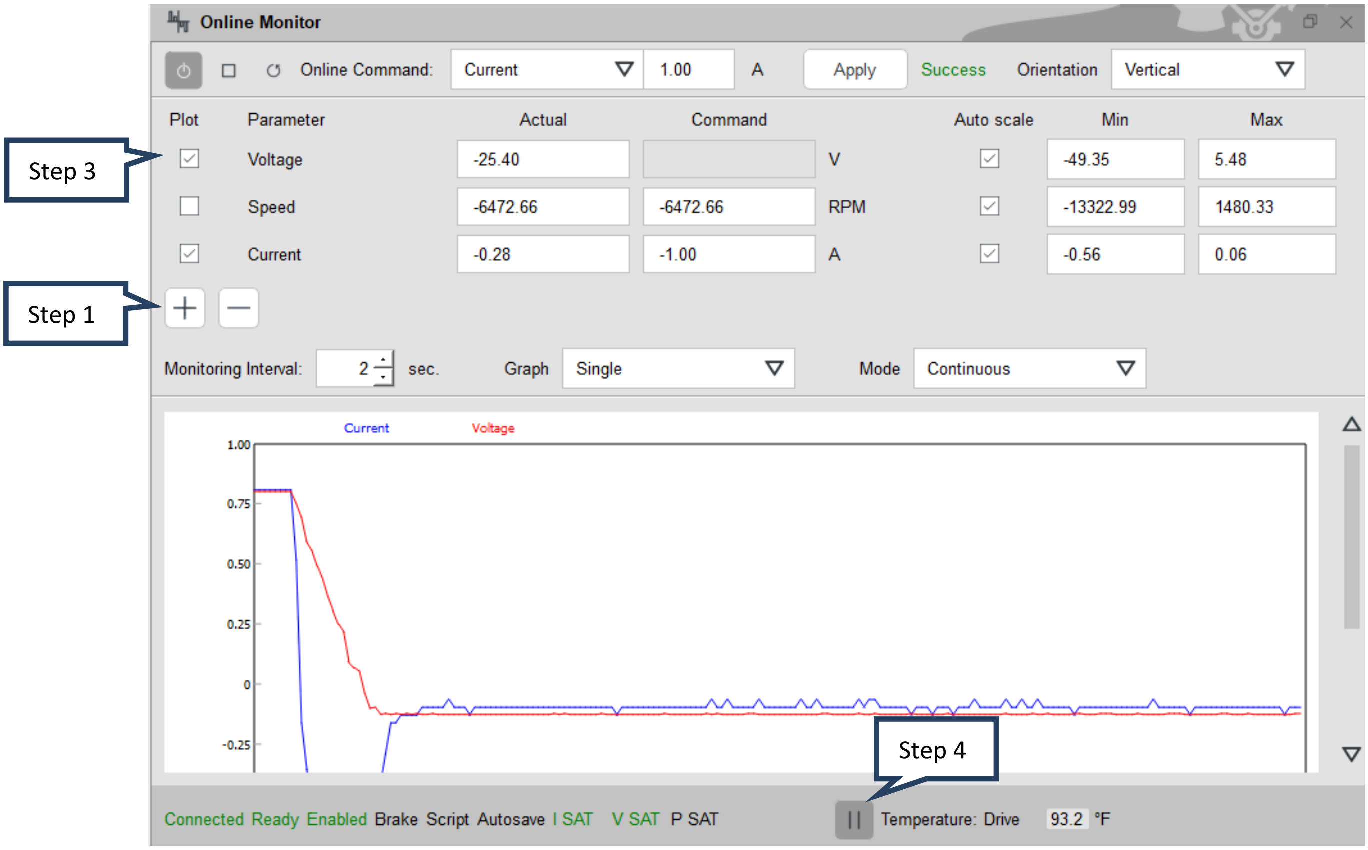



**Figure 56: Motor Speed and Current Plot**

Step 2: Click the dropdown arrow ▽ to view the drop-down menu, make the desired parameter selection, and click *OK*.

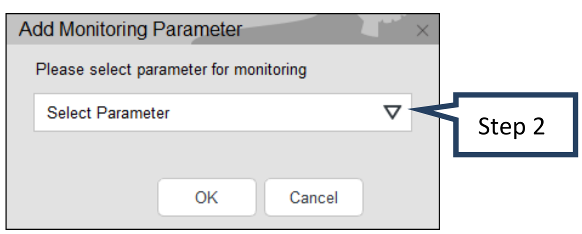



**Figure 57: Add Monitoring Parameter Window**

Step 3: Click the checkbox ☐ to enable or disable plotting. Multiple parameters can be selected and plotted simultaneously. The enabled parameters will be plotted by default when it is initially configured.

Step 4: The data will be displayed as a graph and can be paused using the [II] icon and resumed using the [▷] icon at the bottom of the window. Figure 56 shows an example in which the motor speed, current and position is graphed.

***Deleting monitored parameters:***

- Select icon.
- Select the cross icon for the parameter that will be deleted and then click the delete symbol as shown in Figure 58.

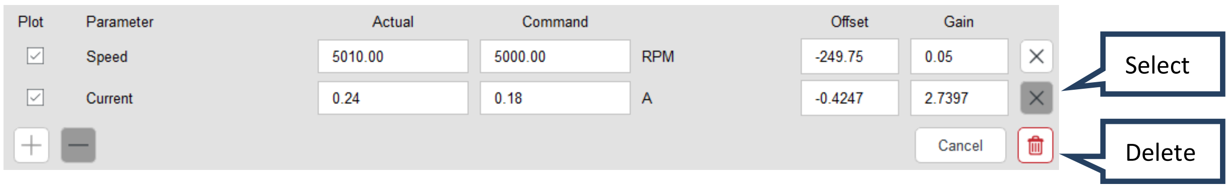



**Figure 58: Delete plot**

## 8.3 Oscilloscope

Select *Tools -> Oscilloscope* or select the icon in the toolbar menu to open the Oscilloscope tool. The purpose of this tool is to observe drive parameters with a higher resolution than available in Online Monitor but for lower time periods. The observed parameters can be analyzed for such properties as amplitude, frequency, rise time, fall time. The operation of this tool will be familiar to those who have worked with Oscilloscopes.

### 8.3.1 Setup channels

Follow the steps below to setup the channels of the Oscilloscope:

- Select *Setup Channels* and choose up to four different channels for plotting.
- Select a time base and click *OK* as shown in Figure 59. This time-base applies to all channels

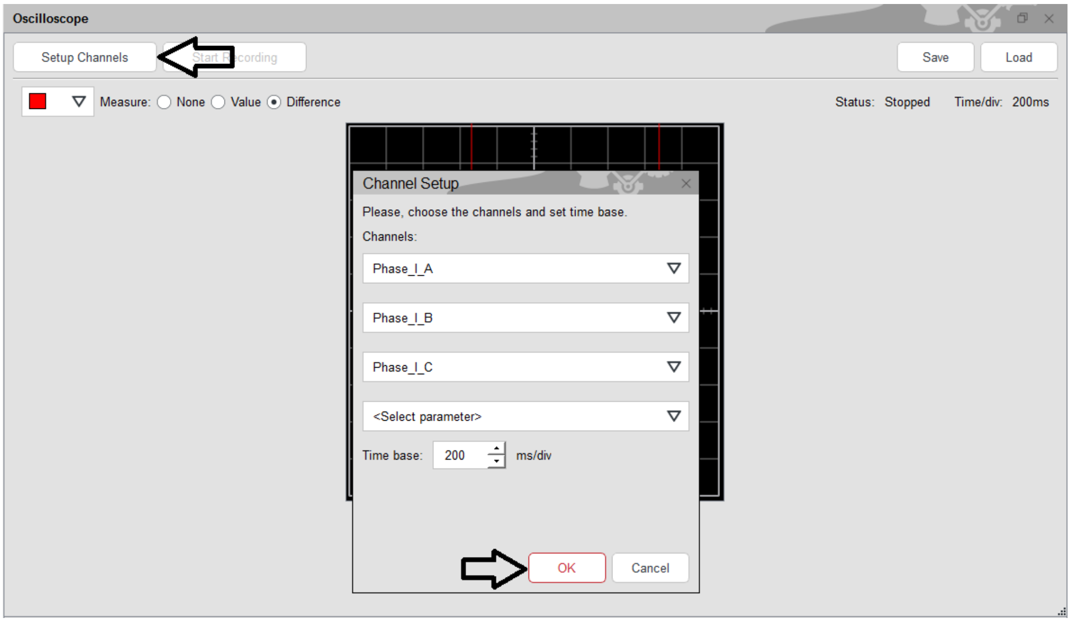



**Figure 59: Setup Channels on Oscilloscope**

- Choose the desired color for each channel from the color dropdown list.
- The Units, Units/div and Offset of each channel can be adjusted before or after plotting using the arrows or manually entering.
- There are two vertical cursors on the plot which can be used to find the value of each channel at a particular time by selecting *Value* in Measure options. Cursor can also be used to find the difference in values between the two cursors in each channel by selecting *Difference* in Measure options.
- To move the cursor lines, click and drag the lines to the necessary position.
- While operating the motor, click *Start Recording* to plot the channels.

### 8.3.2 Save and Load Plots

Saving a plot:

- Click the *Save* button on the right-top corner of the Oscilloscope window.
- Select a location for the plot and save it either in ".xml" format or ".png" format. Default location to save the plot is "C:\Users\Public\Documents\ElectroCraft\Projects\Example\Oscilloscope."

*Note: Saving plots in ".xml" format can be loaded back into the oscilloscope unlike the ".png" files.*

Loading a plot:

- Click the *Load* button on the right-top corner of the Oscilloscope window.
- Navigate to location where the plot was saved, then select the file and click *Open*.

In the examples shown in Figure 60 and Figure 61, the cursors are used to measuring the difference between two points in the oscilloscope plot. The channels are set at 0.5 Units/div and the point of origins are offset from each other by 3 divisions.

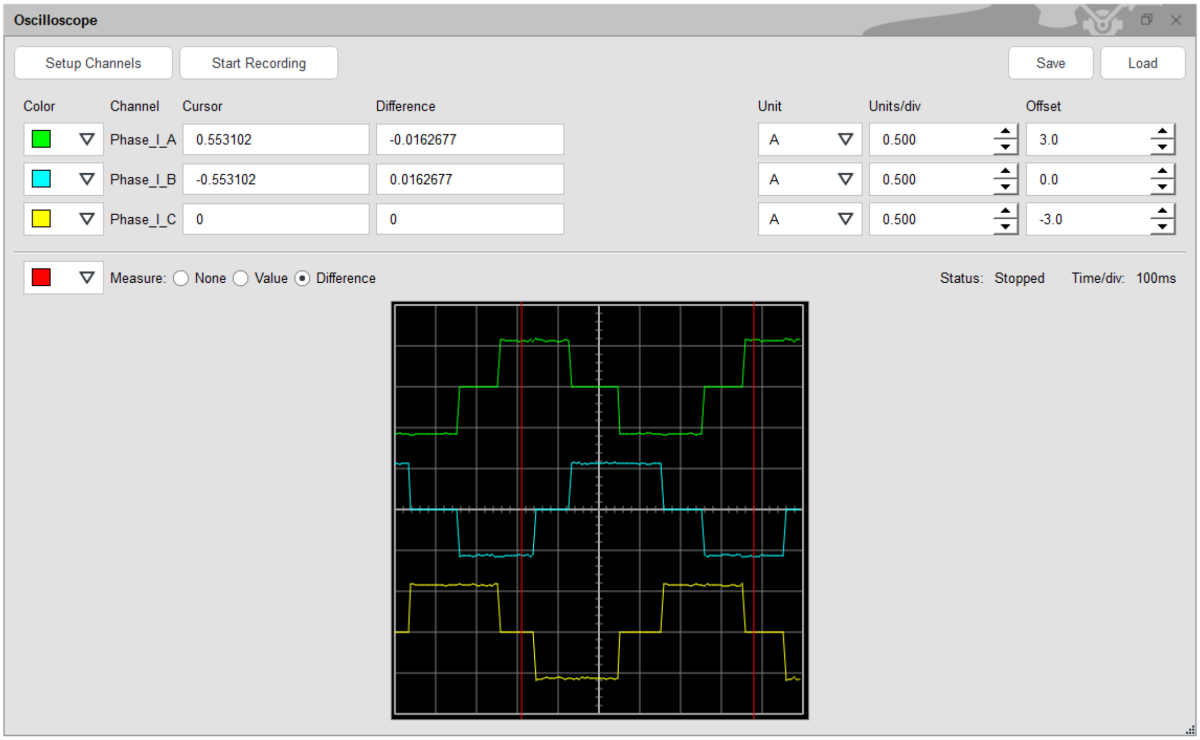



**Figure 60: Trapezoidal Motor Phase Currents Plot**

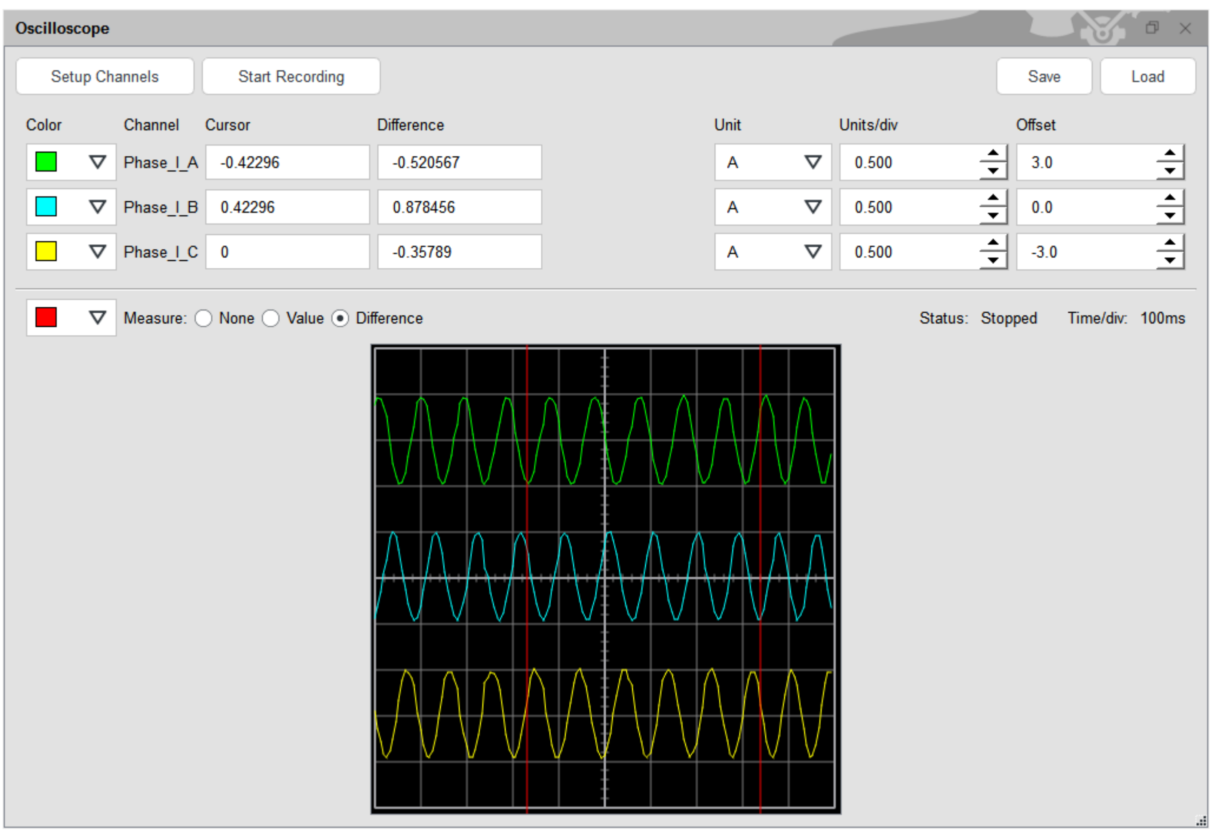



**Figure 61: Sinusoidal Motor Phase Currents Plot**

## 8.4 Diagnostic

Select *Tools -> Diagnostic* or select the icon in the toolbar menu to open the Diagnostic tool. The purpose of this tool is to help with tuning the drive's control loops.

### 8.4.1 Adjusting control loop gains

When tuning the drive, the proportional gain (Kp), integral gain (Ki) and differential gain (Kd) values are changed in the Control Loops group (section 6.5). Use the Diagnostic tool to excite the drive and motor (this procedure applies for BLDC, PMDC and Stepper motors) and observe the response. Adjust the gain parameters until the system is critically damped. When *Reverse spin* checkbox in *Motor and Drive* group is checked, the direction of motor rotation is reversed which in turn reverses the polarity of data in the diagnostic graph.

### 8.4.2 Selecting reference waveform shape

The shape of reference waveform can be selected from the dropdown list in the diagnostics window. The three options available are Unidirectional, Bidirectional and Gap bidirectional. Enter a Current and Speed ramp value in the Control loops group depending on the motor and load. The solid line in Figure 62, Figure 63 and Figure 64 represents reference waveforms at ramp value zero and the broken line represents reference waveform at ramp value not equal to zero.

A unidirectional reference waveform rises up to the Height specified, stays there for the Width specified and then falls to zero. An example of unidirectional reference waveform is shown in Figure 62.


**Figure 62: Unidirectional Reference Waveform**

A bidirectional reference waveform rises up to the Height specified, stays there for the Width specified and then falls to negative value of Height, stays there for the width specified and comes back to zero. An example of bidirectional reference waveform is shown in Figure 63.

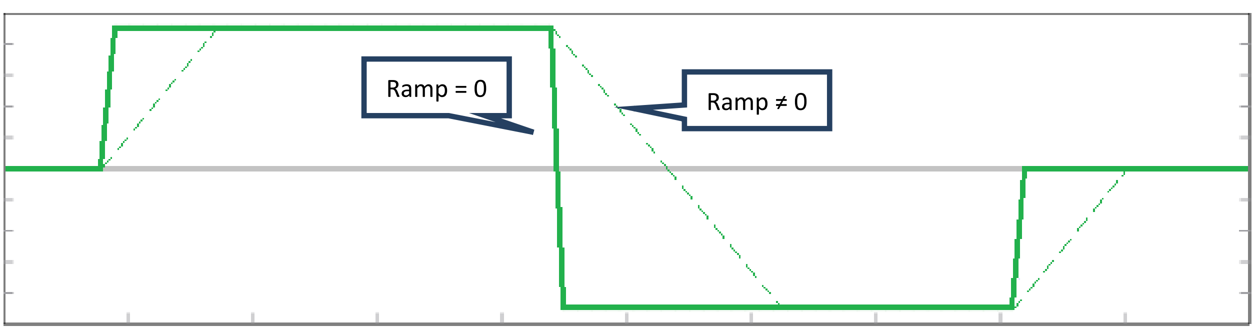



**Figure 63: Bidirectional Reference Waveform**

A gap-bidirectional reference waveform rises up to the Height specified, stays there for the Width specified and then falls to zero and stays there for the Width specified and falls to negative value of Height, stays there for the width specified and comes back to zero. An example of gap-bidirectional reference waveform is shown in Figure 64

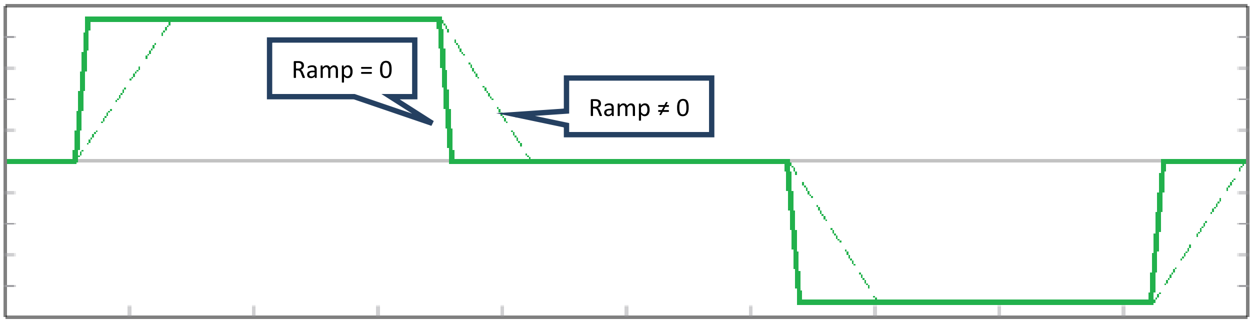



**Figure 64: Gap-bidirectional Reference Waveform**

Note: Diagnostic tool can be used only in USB control interface and the digital input 'Enable' must be in the Enabled state.

### 8.4.3 Different types of damped systems

A system is critically damped when the actual speed/current of the motor does not overshoot, and the speed/current of motor responds to changes in a controlled, non-oscillatory manner as shown in Figure 65. This phenomenon occurs when the correct amount of Kp and Ki gains are applied.

A system is under-damped when the actual speed/current of the motor overshoots and oscillates before settling at the reference speed/current. This phenomenon occurs due to high current/speed proportional gain (Kp). Example waveform of an under-damped system is shown in Figure 65.

A system is over-damped when the actual speed/current of the motor takes longer time to rise to the reference speed/current. This phenomenon occurs due to high current/speed integral gain (Ki). Example waveform of an over-damped system is shown in Figure 65.

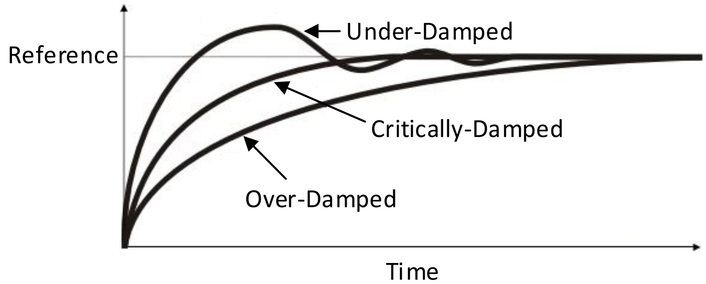



**Figure 65: Under, Over, Critically damped Systems**

### 8.4.4 Current Loop Tuning

Current loop tuning:

Step 1: Select *Current* under *Drive operation mode* section in *Motor and Drive* group.
Select 4-Quadrant in Drive Mode. By default, the Control Interface should be set to USB mode.

Step 2: In the *Diagnostic* window, select *Current PI* from the dropdown list.

Step 3: Select the required *Width* in milliseconds (default 10 ms), *Height* in Ampere (default 1 A) and *Shape* of the reference waveform from the dropdown list.

Step 4: Enter the *Current Kp* and *Ki* values in the *Control Loops* group (It is recommended to set current ramp at zero).

Step 5: Click *Write* for the parameters to be written into drive.

Step 6: Click *Test* and wait until the progress bar gets to 100%.
- It is recommended that the motor shaft does not turn during tuning (to prevent Back EMF and motor commutation from influencing the test).
- It is also recommended to use 4-Quadrant mode when tuning the current loop to allow full control of positive and negative currents.

Repeat steps 4 to 6 if the drive needs better tuning. An example of critically damped system tuned using the software is shown in Figure 66.

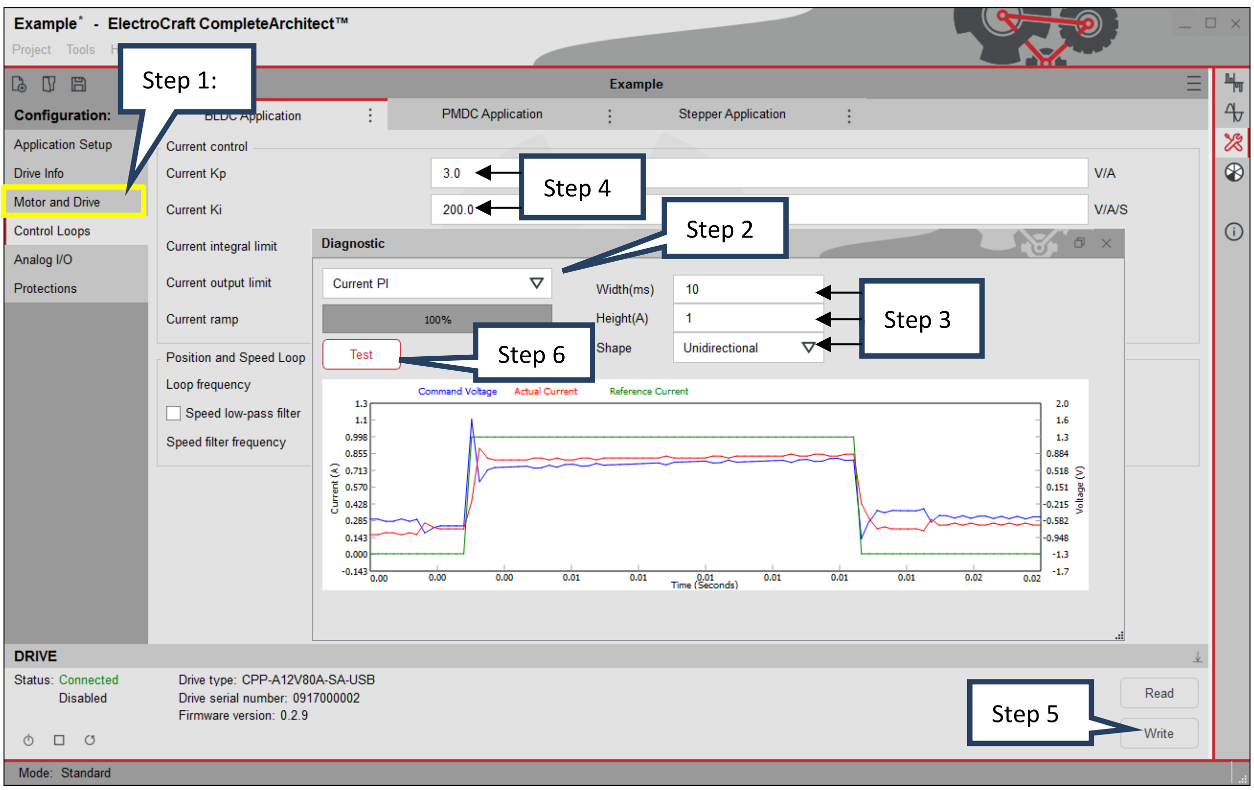



**Figure 66: Critically damped Current Control Loop**

### 8.4.5 Speed Loop Tuning

Speed loop tuning:

Step 1: Select *Speed* under *Drive operation mode* section in *Motor and Drive* group.
Step 2: In the Diagnostic window, select *Speed PI* from the dropdown list.
Step 3: Select the required *Width* in milliseconds (default 1000 ms), *Height* in RPMF (default 1000 RPM) and *Shape* of the reference waveform from the dropdown list.
Step 4: Enter the *Speed Kp* and *Ki* values in the *Control Loops* group.
Step 5: Click *Write* for the parameters to be written into drive.
Step 6: Click *Test* and wait until the progress bar gets to 100%.

Repeat steps 4 to 6 if the drive needs better tuning. An example of critically damped system tuned using the software is shown in Figure 67.

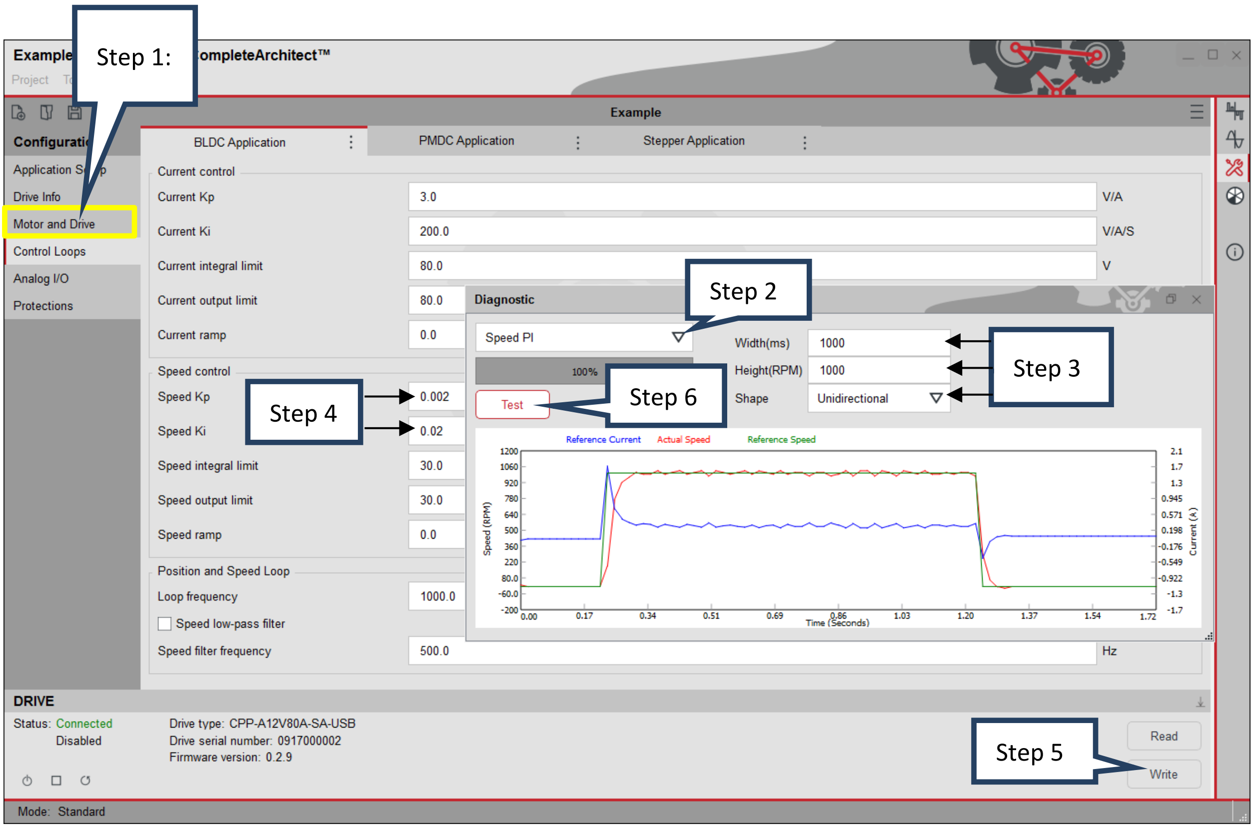



**Figure 67: Critically damped Speed Control Loop**

### 8.4.6 Position Loop Tuning

Position loop tuning:

Step 1: Select *Position* under *Drive operation mode* section in *Motor and Drive* group. Make sure *Reverse spin* is not checked in *Motor and Drive* group.

Step 2: In the Diagnostic window, select *Position* from the dropdown list.

Step 3: Select the required *Width* in milliseconds (default 1000 ms), *Distance* in IU (Internal Units = Encoder counts, default 1000). *Shape* of the reference waveform is always unidirectional (not user selectable).

Step 4: Enter the *Position Kp*, *Ki and Kd* values in the *Control Loops* group.

Step 5: Click *Write* for the parameters to be written into drive.

Step 6: Click *Test* and wait until the progress bar gets to 100%.

Repeat steps 4 to 6 if the drive needs better tuning. An example of critically damped system tuned using the software is shown in Figure 68.


**Figure 68: Critically damped Position Control Loop**

## 8.4.7 Position with Speed Loop Tuning

Position with Speed loop tuning:

Step 1: Select *Position with Speed* under *Drive operation mode* section in *Motor and Drive* group. Make sure *Reverse spin* is not checked in *Motor and Drive* group.

Step 2: In the Diagnostic window, select *Position with Speed* from the dropdown list.

Step 3: Select the required *Width* in milliseconds (default 1000 ms), *Distance* in IU (Internal Units = Encoder counts, default 1000). *Shape* of the reference waveform is always unidirectional (not user selectable).

Step 4: Enter the *Position Kp*, *Ki and Kd* values in the *Control Loops* group.

Step 5: Click *Write* for the parameters to be written into drive.

Step 6: Click *Test* and wait until the progress bar gets to 100%.

Repeat steps 4 to 6 if the drive needs better tuning. An example of critically damped system tuned using the software is shown in Figure 69.

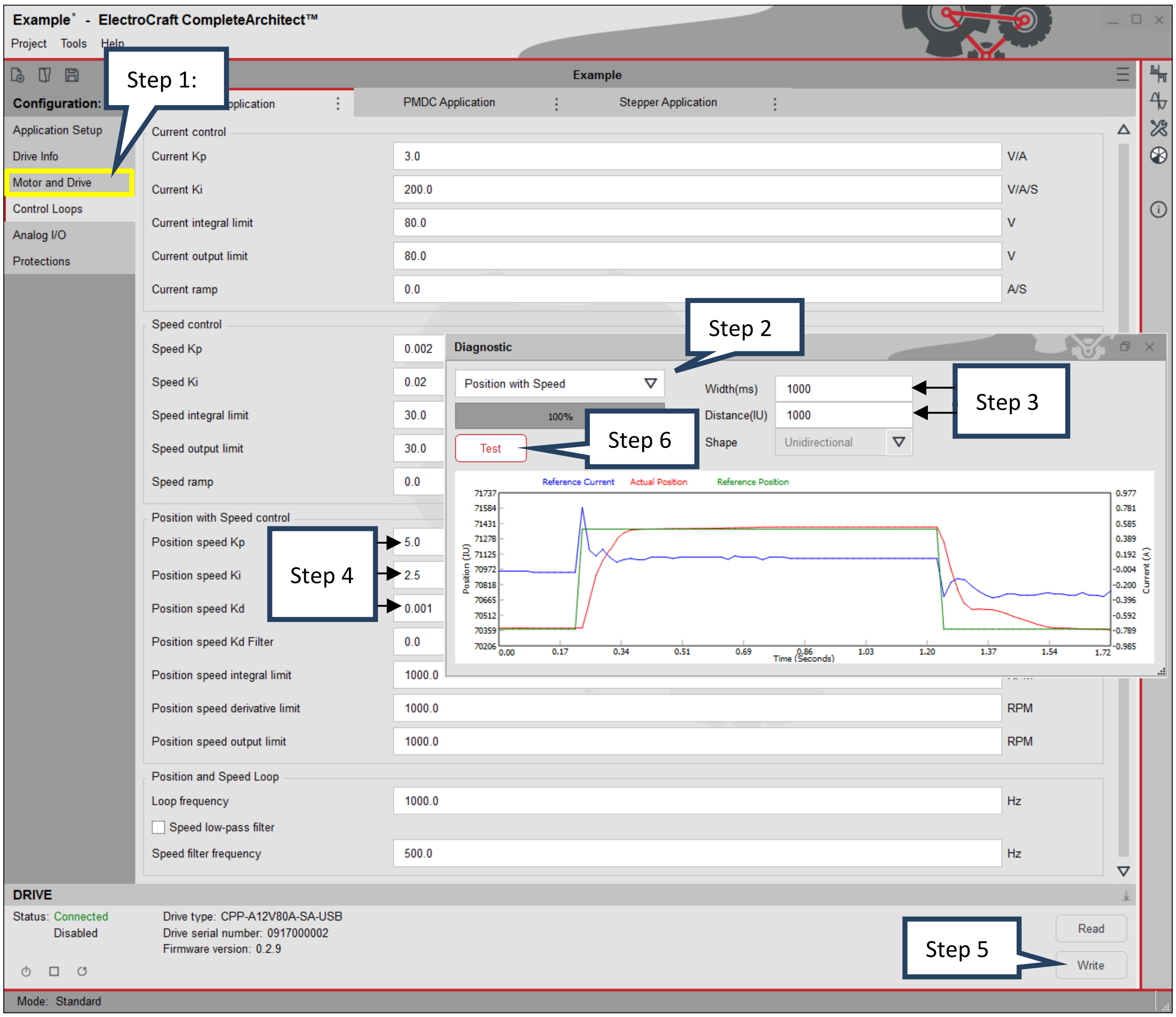
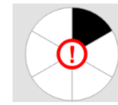



**Figure 69: Critically damped Position with Speed Control Loop**

## 8.5 Drive I/O Monitor

The Drive I/O Monitor tool displays the Digital input, Digital output, Analog input, Hall sensor states and Encoder states with position counter. In the event that an invalid hall state is detected a red ! in circle will be displayed.



To open this tool, select *Tools -> Drive I/O Monitor* or select the icon from the toolbar.

***Digital Inputs*** – This section displays the physical state (High-1 or Low-0) of digital inputs.

***Digital Outputs*** – This section displays the physical state (High-1 or Low-0) of digital outputs.

***Analog Input*** – This section displays the analog input which is scaled according to *Analog I/O* configuration group's parameter settings. If the analog input is not used for the selected *drive operation mode*, then it is disabled on the *Drive I/O Monitor.*

***Hall Sensors*** – This section displays the status of hall sensor inputs. For a BLDC motor it will show the status of the inputs. Even though Stepper and PMDC motors do not have hall sensors, the display is still active and will report the status of the inputs.

***Encoder*** – This section displays the status of encoder inputs. The scaling of the dial (counts per rotation) is based on the user entered encoder *Lines per rev* value. Encoder is active only if the encoder checkbox on the *Motor and Drive* configuration group is checked.

An example of I/O monitor is shown in Figure 70.


**Figure 70: Drive I/O Monitor**

## 8.6 User Motor Database Manager

The purpose of this window is to add a user's custom motor into the software database.

Select *Tools -> User Motor DB Manager* from the menu to open the User Motor Database tool, the window shown in Figure 71 will appear.

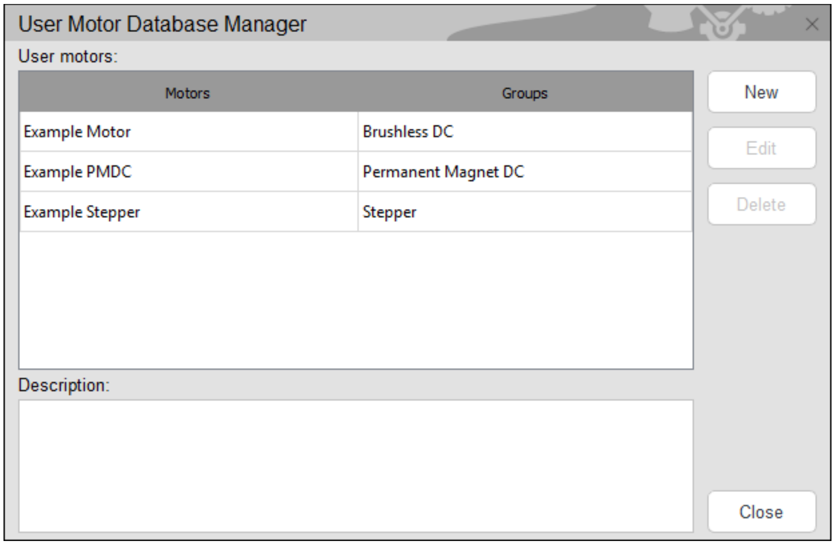



**Figure 71: User Motor Database Manager Window**

### 8.6.1 Add New Motor to the Database

- Select *New* in the *User Motor Database Manager* window and select the desired motor type from the list and click *OK* as shown in Figure 72. Brushless DC motor is selected to demonstrate this tool.

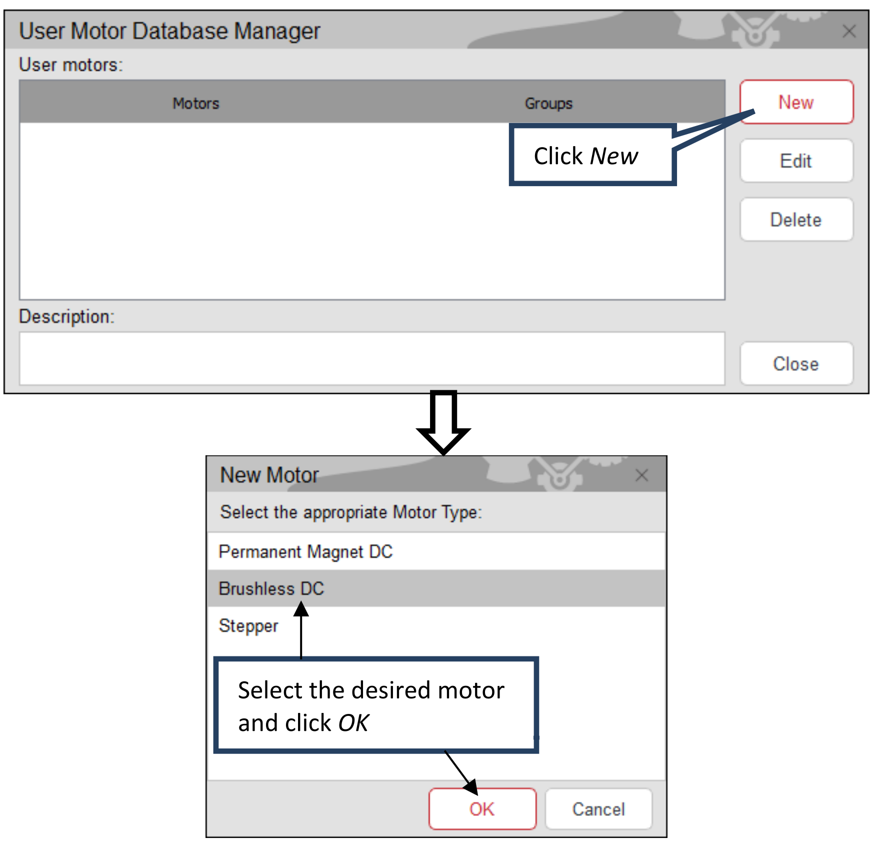



**Figure 72: New Motor Type Selection Window**

- The Motor settings window will appear in which all motor parameters must be entered before clicking the *OK* button to save. See example window in Figure 73. For unknown parameter values refer to the manufactures data sheet and click *OK*.

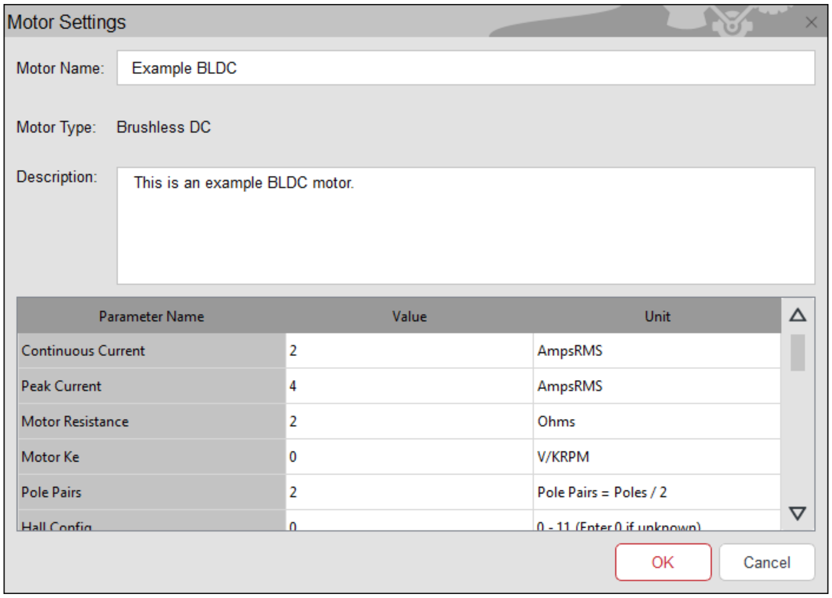



**Figure 73: Motor Settings Window**

- The motor should now be displayed in the *User Motor Database Manager* window as shown in Figure 74. The selected motor appears in red text.

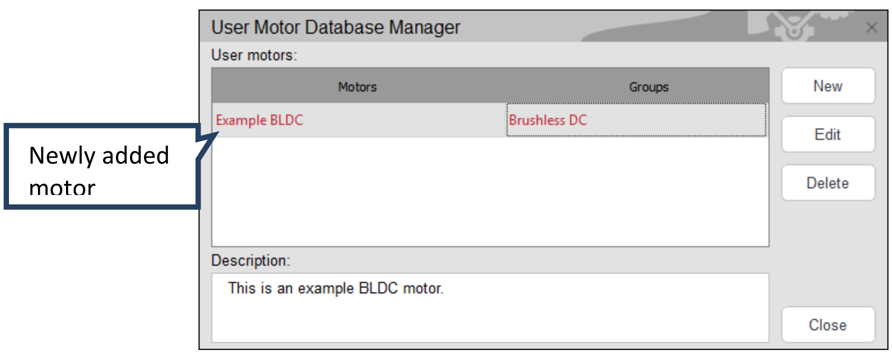



**Figure 74: New Motor Added to Database**

- If the motor was successfully entered into the database, it will be displayed in alphabetical order in the *New Application* window as shown in Figure 75.

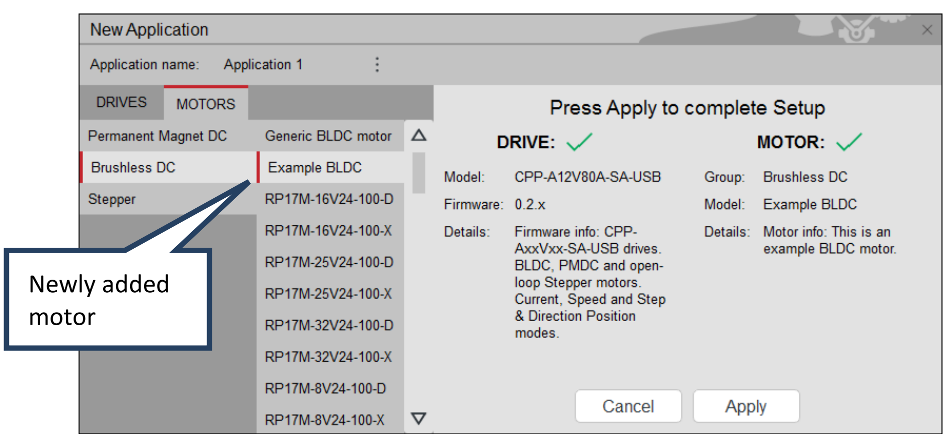



**Figure 75: New Motor displayed while creating new project**

## 8.6.2 Edit or Delete Motor from the Database

Edit a motor in the database:

- Open the *User Motor Database Manager* window and select the motor to be edited and click *Edit* as shown in Figure 76.

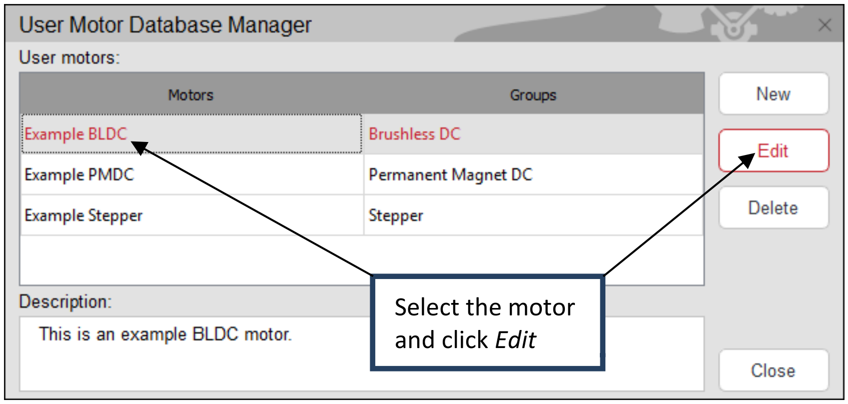



**Figure 76: Edit Motor**

- The Motor Settings window will appear in which all the motor parameters can be edited and click *OK* to finalize changes.

Delete a motor from user motor database:

- Open the *User Motor Database Manager* window and select the motor to be deleted and click *Delete.* Click *OK* in the information window as shown in Figure 77: Delete Motor. This will delete the selected motor from the user motor database.

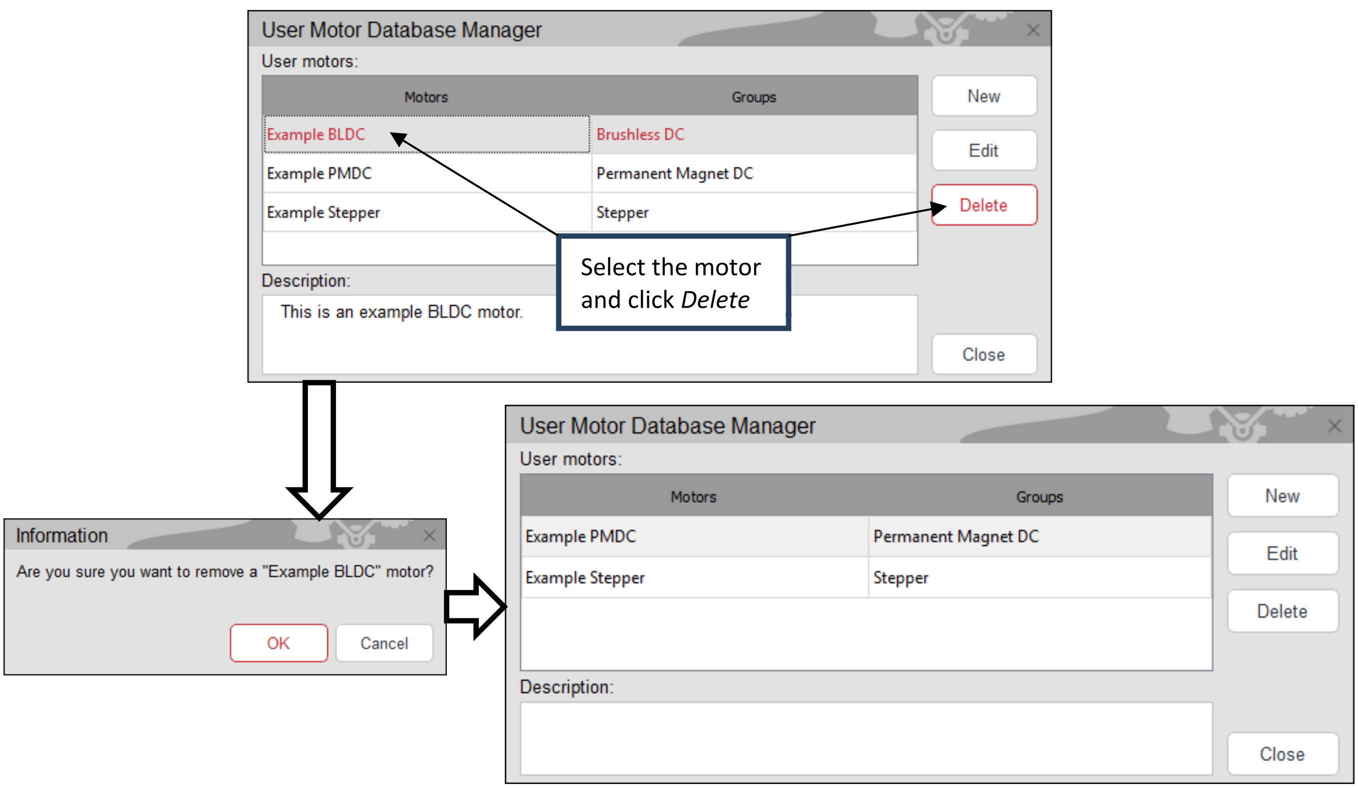



**Figure 77: Delete Motor**

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