ELECTROCRAFT

CompletePower™ Plus
UNIVERSAL DRIVE

CPP-A06V48A-SA-USB
CPP-B06V48A-SA-USB
Technical Reference

ElectroCraft CompletePower™ Plus Universal Servo Drive

ElectroCraft document number: 198-0000019

Record of Revisions:

Revision	Date	Description	Comments
001	01/30/2018	Initial release	Document created
002	07/12/2018	Additional motor types supported	PMDC and Stepper motor
003	02/20/2019	New drive model added Closed-loop stepper added	CPP-B06V48A-SA-USB

Read This First

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About This Manual

This document is a technical reference manual for CPP-A06V48A-SA-USB and CPP-B06V48A-SA-USB drives. This document covers the drive hardware including technical data, connectors and wiring diagrams needed for installation. The physical shape and size of the CPP-A06V48A-SA-USB drive is the same as the CPP-B06V48A-SA-USB, all pictures that show CPP-A06V48A-SA-USB in this document also applies to CPP-B06V48A-SA-USB. The generic model number CPP-x06V48A-SA-USB is used throughout this manual when referring to both the CPP-A06V48A-SA-USB and CPP-B06V48A-SA-USB models.

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1 Product Safety Precautions

READ THIS <u>ENTIRE</u> SECTION BEFORE ATTEMPTING TO USE THE CPP-x06V48A-SA-USB DRIVE! GIVE SPECIAL ATTENTION TO ALL BOLD PRINT ITEMS.

 WARNING!

ElectroCraft products are not authorized for use in safety critical applications. To operate the drive safely, these minimum precautions MUST be followed to insure proper performance without injury to the operator and damage to motor or drive. **FAILURE TO OBSERVE THESE SAFETY PRECAUTIONS COULD RESULT IN <u>SERIOUS BODILY INJURY</u>, INCLUDING DEATH IN EXTREME CASES.**

1.1 Operation

1. Do not touch any of the connector pins on connectors J1 (Supply Input) or J2 (Motor Output) when power has been applied. Bare wires from adjacent connector pins must never be allowed to touch one another.

2. J1 pin 3 must be connected to an external earth ground. Follow wiring procedures carefully.

3. Read ElectroCraft Life Support Policy in section 1.6 for application limitations.

4. Follow precautionary guidelines as referenced in section 12 of this manual with regard to proper installation of an optional external brake resistor.

5. Do not operate the drive in an explosive area or near explosive or flammable materials.

6. Do not use the drive in environments where it is likely to be exposed to strong and/or frequent static discharge.

7. Conduct trial operations on the servo drive alone with the motor shaft disconnected from the load to avoid any unexpected motion. Motor shaft should be uncoupled and free to rotate without coming in contact with user or any stationary object during set up and preliminary operation.

8. Under no circumstances should a phase output from the control be connected to anything other than a passive inductive/resistive motor load. Short circuit protection for the drive is limited to momentary conditions only! Repetitive short circuits on any of the output pins of J2 may cause permanent damage to the drive.

9. Never touch any moving parts while the motor is running. Failure to observe this warning may result in injury.

10. Excessive speed and current can destroy some motors and possibly injure the user. Check the motor manufacturer's specifications to ensure that the maximum current and voltage for your drive model, does not exceed motor limitations.

11. Whenever the drive is disabled for any reason or unpowered, the motor will be in free spinning/coast mode. The user is responsible to analyze the application (especially in case of servomotor for a vertical axis) and take precautionary safety measures.

12. Provide an appropriate stopping device on the machine side to ensure safety. Failure to observe this warning may result in injury.

13. Do not parallel multiple motors off the same drive.

14. Do not make any extreme adjustments or settings changes of parameters. Failure to observe this caution may result in injury due to unstable operation.

15. Avoid plugging connector J1 into the drive while live power is applied to the connecting cables. Ignoring this precaution will cause electrical arcing at the connector pins, which can cause permanent connector damage. ElectroCraft recommends using a disconnect switch ahead of J1 if the drive must be disconnected often.

16. Do not remove the connectors on ports J1 through J6 from the drive while the motor is operating.

17. Do not service or modify this product. Only authorized personnel must perform disassembly or repair of the drive. Failure to observe warning may result in injury or damage to product.

18. Always operate the drive within the prescribed voltage limits. Any attempt to operate outside these bounds may result in damage to the drive.

19. Safe use of this product depends on factors specific to the end application. These factors are outside of ElectroCraft knowledge and control. The installer of this servo drive must have a thorough knowledge of safety precautions and practices relevant to the specific application of this drive. In particular the installer should consider the risks associated with erroneous or non-operation of the servo drive in the application and mitigate them appropriately.

1.2 Storage and Transportation

1. Do not store or install the product in the following places:
   a. Locations subject to temperature outside of the range specified.
   b. Locations subject to humidity outside the range specified.
   c. Locations subject to condensation as the result of changes in temperature.
   d. Locations subject to corrosive or flammable gases and liquids.
   e. Locations subject to dust, salts, or electrically conductive contaminants.
   f. Locations subject to exposure to water, oil, or chemicals.
   g. Locations subject to shock or vibration.

   Failure to observe this caution may result in fire, electric shock, or damage to the product.

2. Do not hold the product by the cables or motor shaft while transporting it. Failure to observe this caution may result in injury or malfunction.

1.3 Environmental Protection

Waste electrical products should not be disposed of with household waste. Please recycle where facilities exist. Check with your Local Authority or retailer for recycling.

1.4   Installation

1. Take appropriate and sufficient countermeasures when installing systems in the following locations.
   a. Locations subject to static electricity or other forms of noise.
   b. Locations subject to strong electromagnetic fields and magnetic fields.
   c. Locations subject to possible exposure to radioactivity.
   d. Locations close to power supplies including power lines.
   Failure to observe this caution may result in damage to the product.

2. Keep any external shunt/brake resistor away from flammable materials. Read section 12 carefully for more shunt/brake resistor installation details.

3. Never use this product in an environment subject to liquids, corrosive chemicals or gases; or combustibles; or where foreign materials can fall onto or collect inside the drive. Failure to observe this caution may result in electric shock or fire.

4. Do not place any objects on the product. Failure to observe this warning may result in damage to the product.

5. Do not cover the drive or prevent air from escaping or entering through the vents. Failure to observe this caution may cause internal elements to deteriorate resulting in malfunction or fire.

6. Provide the specified clearance between the drive and other devices. Provide sufficient space around the drive for cooling by natural convection or provide cooling fans to prevent excessive heat. See section 4 for details. Failure to observe this caution may result in fire or malfunction.

1.5   Wiring

1. Verify **ALL** wiring **BEFORE** applying power to the drive and motor. Motor may spin or oscillate uncontrollably if improperly wired. Drive may be damaged or improper wiring may prevent drive from operation.

2. J1 pin 3, PE, MUST always be connected to an appropriate external Protective Earth ground in accordance with local electrical codes. Improper grounding may result in electric shock and damage the drive.

3. Securely connect the power supply terminals and motor output terminals. Failure to observe this caution may result in fire.

4. Do not bundle or run power and signal lines together in the same duct. Keep power and signal lines separated.

5. Use twisted-pair shielded wires or multi-core twisted pair shielded wires for signal and encoder feedback lines.

6. Always use the specified power supply voltage. An incorrect power supply may result in damage to the drive.

Installation requirements for EMC CE compliance:

For EMC compliance, correct cable selection and wiring practices are mandatory. The following contains installation instructions necessary for meeting EMC requirements.

- Shielded cables are mandatory for the motor, power and control cabling to the drive. The power and motor cables must be bonded to earth at both ends and the control bonded to earth at one end. The shield of the cable must be grounded at the closed ground point with the least amount of resistance

- Motor cables should not exceed 10m (32.8ft) in length. For best results use Electrocraft series cables.

- Segregate the drive power wiring and motor phase cables from the control wiring and feedback cabling. When using shielded cables for the power wiring, provide a grounded 360 degree clamp termination at both ends. Provide for a large contact area between shields and the mounting plate.

1.6   Life Support Policy

READ THIS ENTIRE SECTION BEFORE ATTEMPTING TO USE THE CPP-x06V48A-SA-USB DRIVE!

ElectroCraft products are not authorized for use as critical components in life support devices or systems without the express written approval from ElectroCraft, Incorporated.

1. Life support devices or systems are intended for surgical implant into the body, or support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the User's Manual and in the labeling, can be reasonably expected to result in a significant injury to the user.

2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

1.7   Checking Product on Delivery

When your package arrives, inspect the shipping box and the unit carefully, and save ALL packing materials. Compare the packing slip against all items included in the shipping box. Any shortages or other inspection problems should be reported to ElectroCraft immediately.

The following procedure is used to check products upon delivery. Check the following items when your CPP-x06V48A-SA-USB is delivered.

- Verify that the model number marked on the nameplate of the drive(s) is the correct model ordered.
- Check the overall appearance. Check for damage or scratches that may have occurred during shipping.

If any damage is noted, or if the unit is the wrong type, contact your ElectroCraft sales representative immediately.

Your CPP-x06V48A-SA-USB has arrived carefully packaged from ElectroCraft, in an antistatic bag. As you unseal this bag, inspect the contents carefully. There should not be any loose or damaged parts inside.

Never attempt to operate or power-up the drive if there is any visible external damage or if there are loose materials inside the chassis. While unpacking, if you discover any loose or damaged parts, notify ElectroCraft within two working days.

ElectroCraft recommends that all packing materials be saved in the event that the drive needs to be returned. Always place the drive in the same antistatic bag used in the original shipment. Anti-static filler material should always be placed around the drive so that it cannot shift inside the box. Extreme care should be exercised when placing packing material around all external connectors to prevent mechanical stress damage.

All material to be returned to ElectroCraft must have a Return Material Authorization (RMA) tracking number assigned before shipment. This can be obtained by contacting ElectroCraft. Any product returned without this number will be rejected by ElectroCraft.

Always insure your shipment for the proper replacement value of its contents. ElectroCraft will not assume responsibility for any returned goods that have been damaged outside of our factory because of improper packaging or handling. All goods shipped to ElectroCraft must be shipped FREIGHT PREPAID.

2   Product Overview

This manual describes the installation and operation of the CPP-x06V48A-SA-USB digital servo-amplifier manufactured by ElectroCraft Inc.

2.1   Key Features

Features of CPP-x06V48A-SA-USB drive:
- +12 to +48 VDC power supply input.
- 6 Amps Continuous, 6 Amps Peak for CPP-B06V48A-SA-USB or 15 Amps Peak CPP-A06V48A-SA-USB (2 seconds).
- 2 and 4 quadrant modes.
- Sinusoidal and Trapezoidal commutation modes.
- 20 kHz, 40 kHz and 80 kHz of programmable PWM frequency options.
- Current, Speed, Position and Position with Speed modes of operation.
- USB Communication.
- Drive status diagnostics.
- +/-10V Analog command input.
- Digital step and direction input.
- +/-10V Analog output (configurable).
- Encoder mode for low speed performance.
- BLDC, PMDC and Stepper motor control.
- Halls only operation mode for BLDC motor.
- IxR speed feedback estimator mode for PMDC motor.
- Integrated circuit for brake regeneration.
- +/- Travel limit inputs.
- Configurable ramp for current and speed.
- 97% efficiency at full load.
- Selectable software protection options.
- Windows®-based set-up and tuning utility software included.

Note: The CPP-x06V48A-SA-USB drive can be configured by the software through USB even when there is no power supply provided.

2.2   Simplified System Block Diagram

Overall system of CPP-x06V48A-SA-USB is shown in Figure 1. The drive is configured using the software to operate the motor according to its application.
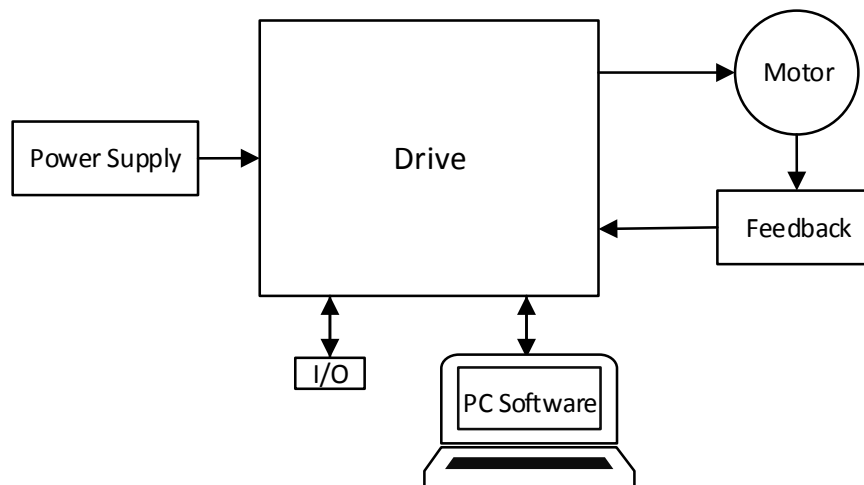
Figure 1: Overall drive system block diagram

2.3   Hall Sensor Feedback for BLDC motor

Drive is capable of operating the BLDC motor using trapezoidal (6-step) commutation with hall sensor feedback as shown in Figure 2 and sinusoidal commutation with hall sensor feedback as shown in Figure 3.
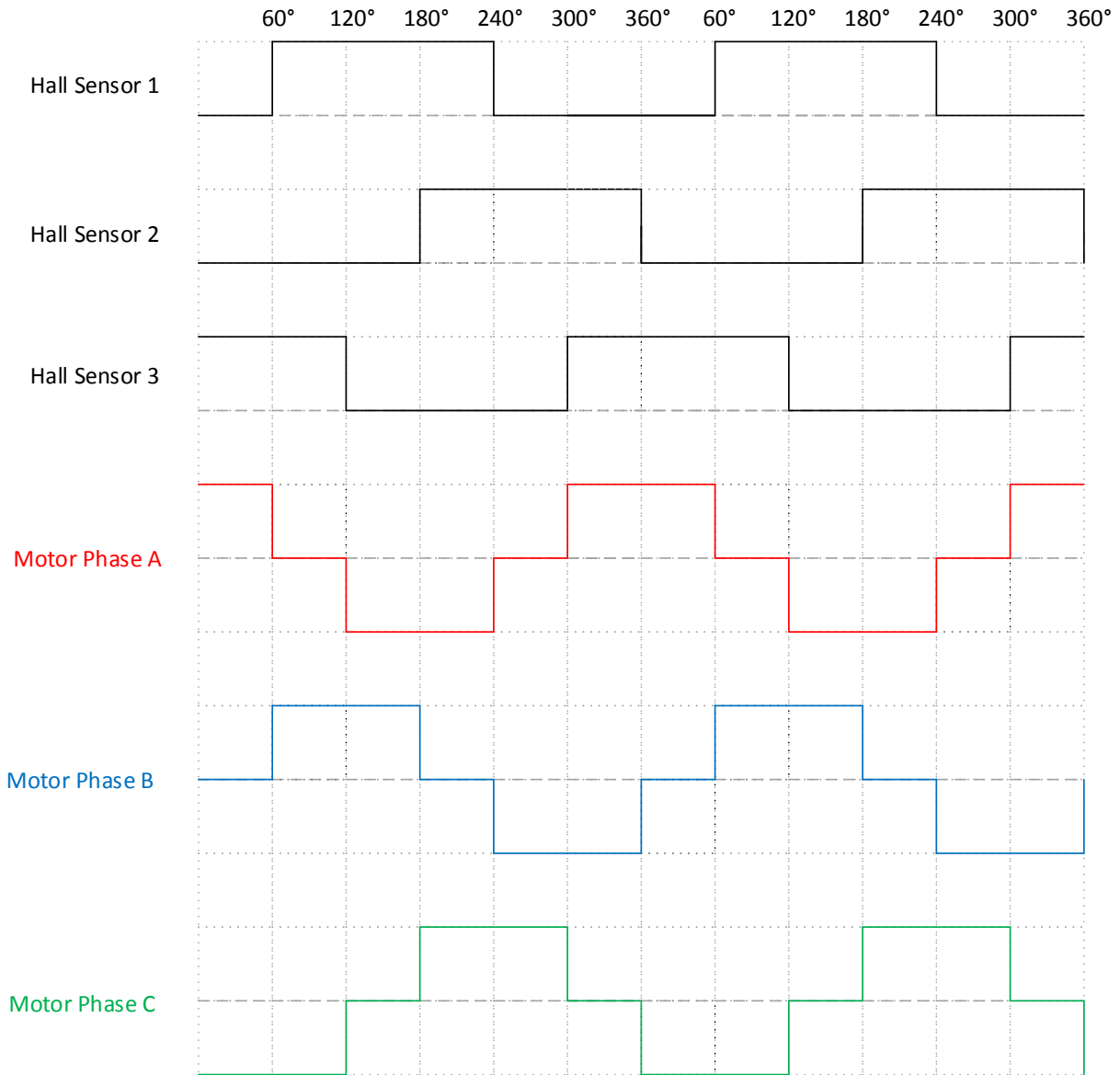
Figure 2: Trapezoidal Commutation with Hall sensor feedback
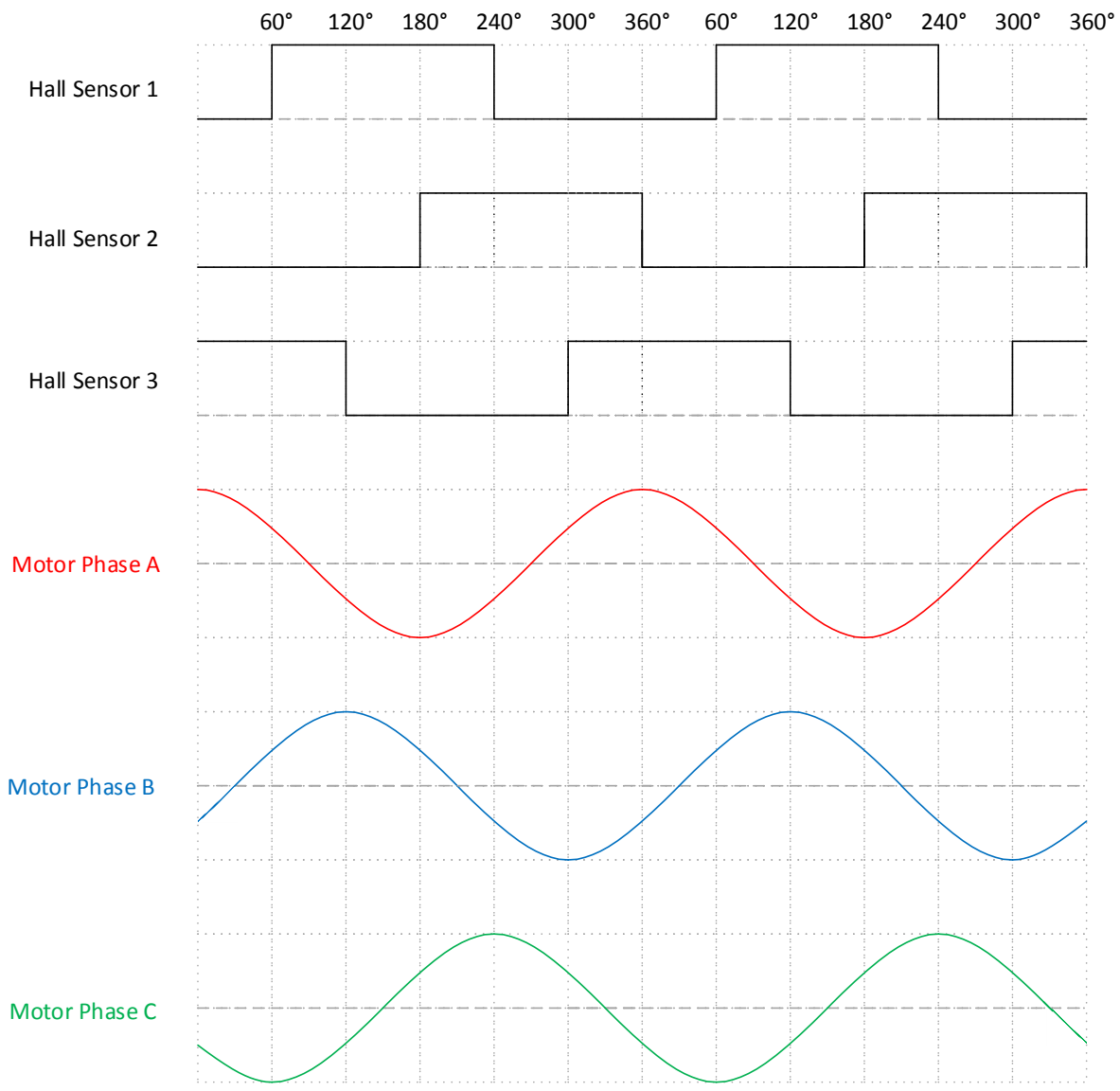
Figure 3: Sinusoidal commutation with Hall sensor feedback

2.4   Stepper motor Phase Current Waveforms for Different Step values

The drive is capable of operating the stepper motor in open-loop and closed-loop configurations from full step to 256 microsteps per step at a maximum step rate of 1MHz @ 50% ± 10%. The phase current wave forms for full step, quarter step and 256 microsteps per step is shown in Figure 4.
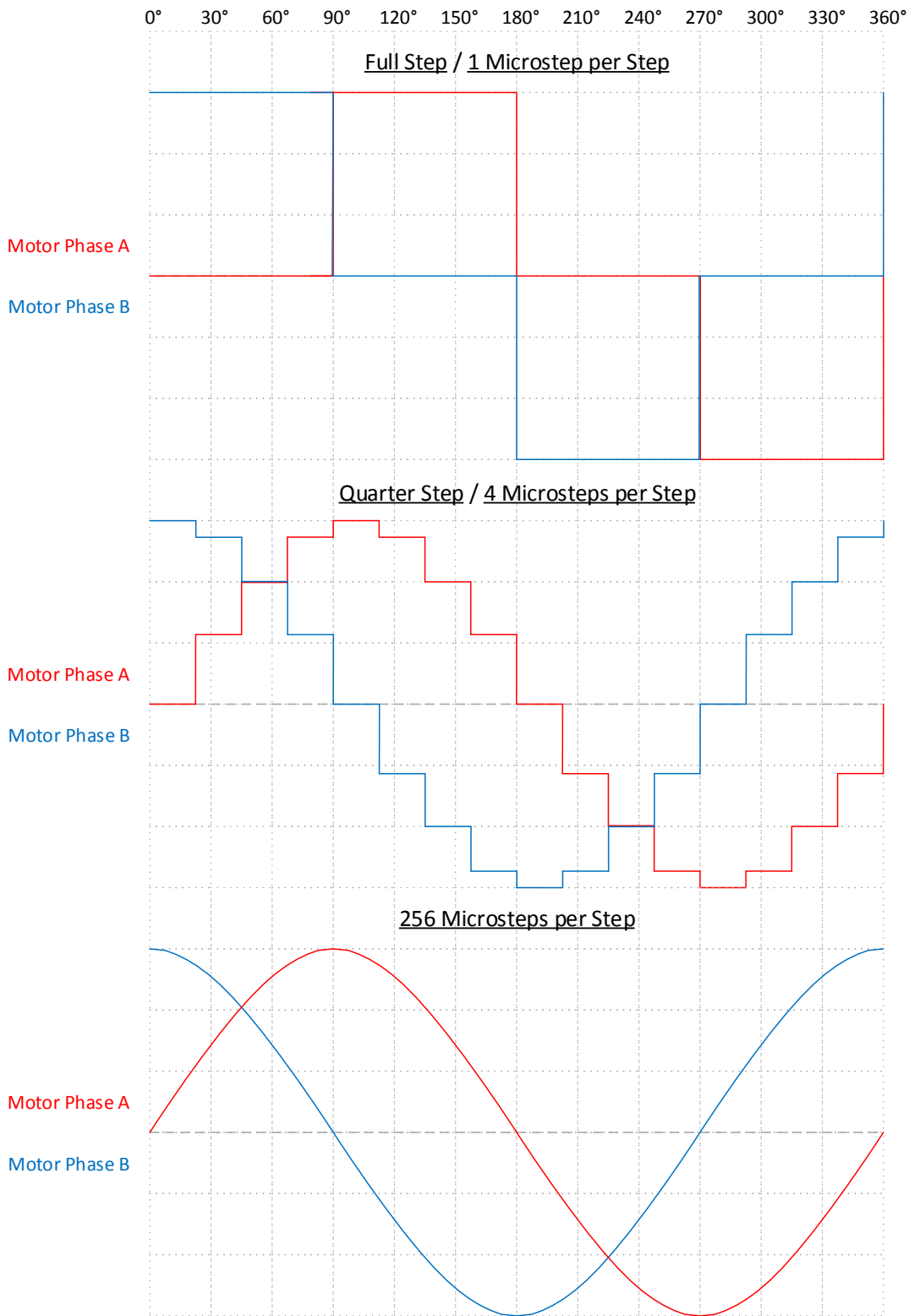
Figure 4: Stepper motor Phase Current Waveform

2.5 Encoder Feedback

Drive counts the encoder lines in a positive direction, when encoder signal A leads encoder signal B by 90° electrical and vice-versa. This function can be reversed using the PC software. Encoder feedback signal is shown in Figure 5.
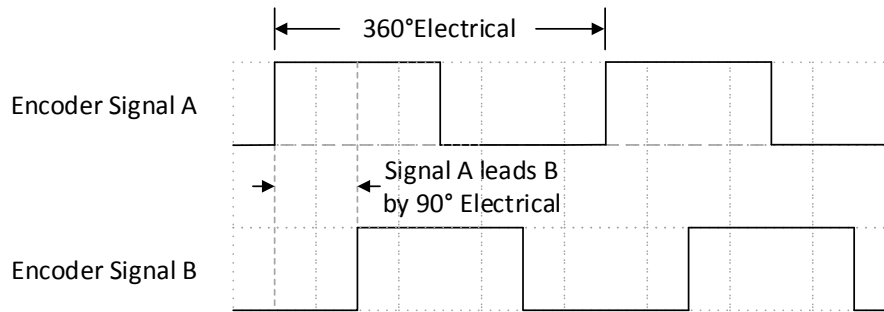
Figure 5: Encoder feedback signal

2.6 Motor and Sensor Configurations

	Brushless Motor	PMDC Motor	Stepper Motor
Hall Sensors	Yes	No	No
Encoder + Halls	Yes	No	No
Encoder Only	No	Yes	Yes
IxR Estimator	No	Yes	No
No Feedback	No	Yes	Yes

2.7 Identification Labels

Identification label with **ElectroCraft** serial number
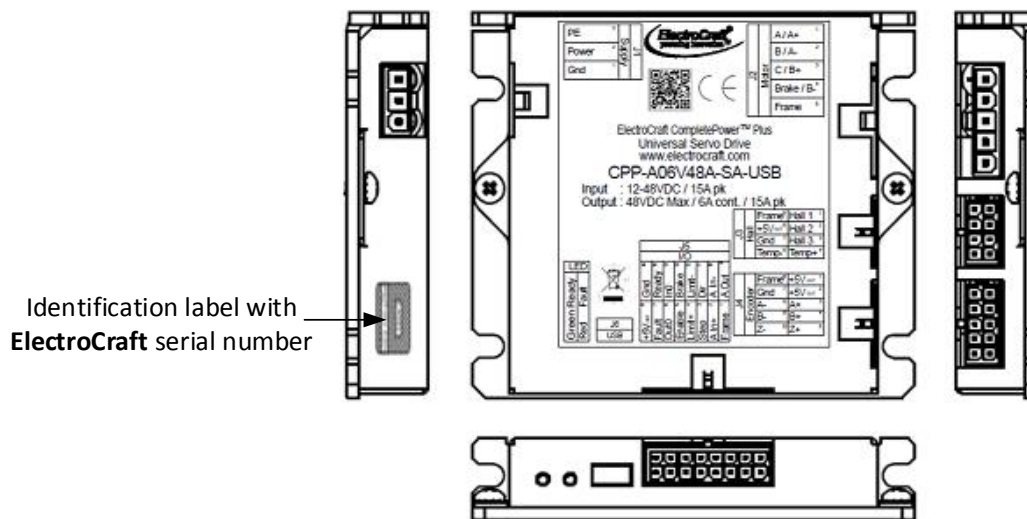
Figure 6: Drive with identifying label

2.8 Status Indicator Lights

In normal operation, the drive is either in an "Enabled" state or in a "Disabled" state. When power is first applied, the green LED will be On indicating that power has been applied. The Red LED should be Off, meaning no errors or faults. The Enable input is used to switch between "Enabled" and "Disabled" states. Refer to section 13 for LED flash codes and possible causes.

3   Drive Specifications

Using the drive outside the specified absolute maximum ratings will damage the drive. Using the drive outside normal operating specifications may not guarantee a reliable operation.

3.1   Physical Specifications

Parameter	Conditions	Typical	Units
Weight	Without mating connectors	115	g
Dimensions	Length x Width x Height (without mating connectors)	88.9 x 77.1 x 16.4	mm
		3.5 x 3.03 x 0.64	Inch

3.2   Environmental Specifications

Parameter	Conditions	Min.	Typical	Max.	Units
Ambient Temperature	Operating Range	0	-	40	°C
	Storage Range	-20	-	85	
Ambient Humidity	Non-condensing	5	-	95	%RH

3.3   Electrical Specifications

All ratings at ambient temperatures = 0 to 40°C and PWM frequency of 20 kHz (unless otherwise noted).

3.3.1   DC Supply Input

Parameter	Conditions		Min.	Typical	Max.	Units
Supply Voltage	Operating Range		12	-	48	VDC
	Absolute maximum		10.5	-	54	
Supply Current	Operating at maximum load and speed	CPP-A06V48A-SA-USB	-	6	15	A
		CPP-B06V48A-SA-USB	-		6	
	Idle condition. No external connections.	@ 12VDC	-	115	-	mA
		@ 48VDC	-	35	-	

3.3.2   +5VDC Supply Output

Parameter	Conditions	Min.	Typical	Max.	Units
Output Voltage	Operating Range	5	5.1	5.2	VDC
Output Current	Total combined current on all connectors	-	-	250	mA

3.3.3   Motor Output

Parameter	Conditions		Min.	Typical	Max.	Units
Output Phase Current	Continuous with no additional heatsink		-6	-	6	A*
	Peak Current	CPP-A06V48A-SA-USB	-15	-	15	
		CPP-B06V48A-SA-USB	-6		6	
	Peak Duration maximum (Applies only for CPP-A06V48A-SA-USB model, see I²t section 3.5)		-	2	-	s
PWM Frequency	Configured by software		20	-	80	kHz

* Values are peak of Sine

3.3.4   Hall Sensor Inputs

Parameter	Conditions	Min.	Typical	Max.	Units
Input Voltage	Operating Range	0	-	5.5	V
	Logic "low" operating	0	-	1	
	Logic "high" operating	2.3	-	5	
Sourcing Current	Logic "low" with internal 2.2K pull up to +5V	-	-	2.3	mA

3.3.5   Encoder Inputs

Parameter	Conditions		Min.	Typical	Max.	Units
Input Voltage	Single ended	Logic "low" operating	0	-	1	V
		Logic "high" operating	2.3	-	5	
	Differential (RS422)	High-threshold	-	-	0.1	
		Low-threshold	-0.1	-	-	
Sinking and Sourcing Current	Single ended	Logic "low", Sourcing	-	8	-	mA
		Logic "high", Sinking	-	8	-	
Input Frequency	Single ended		-	-	4	MHz
	Differential		-	-	4	
Minimum Pulse Width	Single ended and Differential		125	-	-	nS
Input Impedance	Differential		-	120	-	Ω

3.3.6   Digital Input

Parameter	Conditions		Min.	Typical	Max.	Units
Input Voltage	Logic High		2.3	-	24	V
	Logic Low		0	-	1	
	Absolute maximum		-	-	26	
Sinking Current	Operational range when logic High		-	-	5	mA
Sourcing Current	Operational range when logic Low		-	-	33	µA
Input Frequency	Step, Direction	Frequency	-	-	1	MHz
		Pulse Width	400	-	-	nS
	In 0, Enable, Brake, Limit +, Limit -	Frequency	-	-	2	kHz
		Pulse Width	200	-	-	µS

Note: The drive registers a step pulse on the rising edge of the input pulse.

3.3.7   Digital Output

Parameter	Conditions	Min.	Typical	Max.	Units
Output Voltage	Operational range	0	5	24	V
	Absolute Max			28	
Load impedance	With external pull up to max operational range voltage	150	-	-	Ω
	Absolute Max	112	-	-	

3.3.8   Analog Input

Parameter	Conditions	Min.	Typical	Max.	Units
Input Voltage	Operational range	-10	-	10	V
	Absolute maximum	-12	-	12	
Sinking and Sourcing Current	At operational range	-0.2	-	0.2	mA

3.3.9   Analog Output

Parameter	Conditions	Min.	Typical	Max.	Units
Output Voltage	Operational range	-10	-	10	V
Load impedance	Connected to ground	10	-	-	kΩ

3.3.10   USB Communications

Parameter	Conditions	Type
USB on the drive	USB mini type B female	USB 2.0 compatible communications interface

3.4   De-rating

The drive is protected against overheating. The protection mechanism employed is to shut off current to the motor when the drive internal temperature reaches the maximum limit. The thermal performance of the drive is dependent on the application and the environmental conditions. This section provides guidance for application of the drive within the recommended operating conditions referenced in this manual. However, thermal performance of the drive is dependent on the specifics of the application and the environmental conditions.

The drive does not have any temperature or output PWM frequency derating in the ambient temperature range of 0 to 40°C when mounted according to ElectroCraft recommendations as specified in section 4.1. Operating the drive outside ElectroCraft recommendations or in a closed box and stagnant air may limit maximum performance. Use of additional heatsinking or forced air may be required. For applications outside ElectroCraft recommendations or in ambient temperature outside the limit of 0 to 40°C, please contact ElectroCraft.

3.5   Peak Current Fold-back (I^2t)

This feature applies only for CPP-A06V48A-SA-USB model only. Currents higher than rated continuous current may be required to achieve high momentary torques. The drive and motor can withstand these higher peak currents for a limited time. To protect the drive and motor, the drive will limit the time operated with peak current. The protection is implemented as an I^2t algorithm with a programmable peak current (I_P), rated current (I_R) and I^2t time which is the peak current time (T_P). The values of peak current and continuous current (I_C) are entered in the drive configuration software. Rated current of the drive is set at 6A. The drive will not supply current above the peak current value.

The I^2t algorithm integrates up towards the limit whenever the output current exceeds the continuous I^2t current value and integrates down when the output current is below the continuous I^2t current value. When the I^2t algorithm limit is reached, the output current is reduced and limited to the continuous I^2t current limit value. The I^2t time limit allowed by the software is computed using the equation given below.

$$I^2t \text{ algorithm limit} = ((I_P)^2 - (I_R)^2) \times T_P$$

Where, I_P = Peak phase current set by user (maximum of 15A)
   I_R = Rated phase current of 6A
   T_P = I^2t time, in mS
   I^2t algorithm limit = 378000 (preset)

The I^2t time limit that the software allows is 2 seconds for a peak current of 15A and beyond that the drive limits the current to the I^2t continuous current set in the software. The allowable I^2t time limit increases when the desired peak current value reduces.

Result of the I^2t algorithm at maximum peak current of 15A and continuous current of 5A is shown in Figure 7.
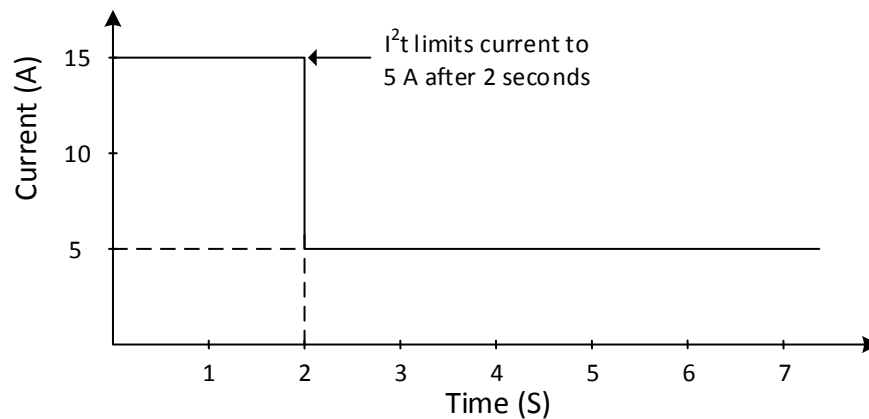

Figure 7: I^2t algorithm example

The I^2t time limit is computed by the software and any time value entered within the time limit computed is accepted by the software. If the entered time value is longer than the computed time limit, the software defaults to the computed time limit. Additionally there is a preset maximum I^2t time limit of 30 seconds.

4 Hardware Installation

4.1 Mechanical Mounting

Use the provided mounting holes and recommended mating connectors, as referenced in section 4.3. Provide at least 25 mm (1 in) of clearance between drives and at least 100 mm (4 in) of clearance above and below each drive when installing, for full rated operation of the drives or as needed for unimpeded natural convection. Install the drive using the slots provided which can accommodate up to M4 or #8 screw.
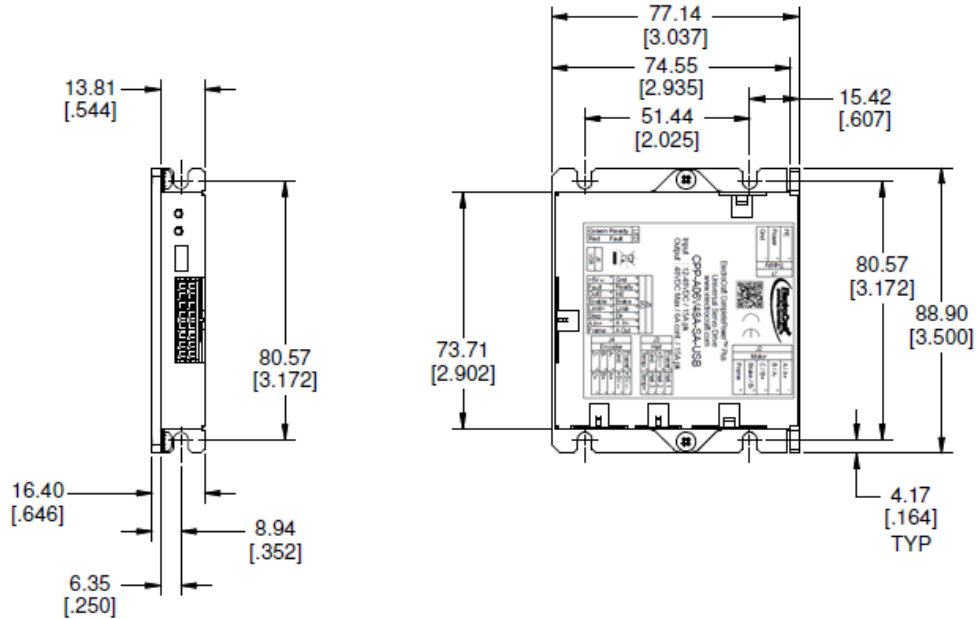
4.2 Dimensions

Units: mm [in]

Figure 8: Drive dimensions

4.3 Mating Connectors

Connector	Connector Name	Manufacturer	Mating Connectors P/N	Crimp Pin P/N
J1	Supply	Molex	39014030	39-00-0039
J2	Motor	Molex	39014050	
J3	Hall	Molex	430250800	43030-0007
		Adam Tech	DMT-2-08	DMT-B-C-F-T-R
J4	Encoder	Molex	43025-1000	43030-0007
		Adam Tech	DMT-2-10	DMT-B-C-F-T-R
J5	I/O	Molex	43025-1600	43030-0007
		Adam Tech	DMT-2-16	DMT-B-C-F-T-R
J6	USB	N/A	Miniature USB Type B - Male	N/A
-	Crimp tool for J1, J2	Molex	57026-5000	N/A
-	Crimp tool for J3, J4, J5	Molex	0638190000	N/A

4.4 Connector Locations and Pin Numbers

4.4.1 Connector Layout
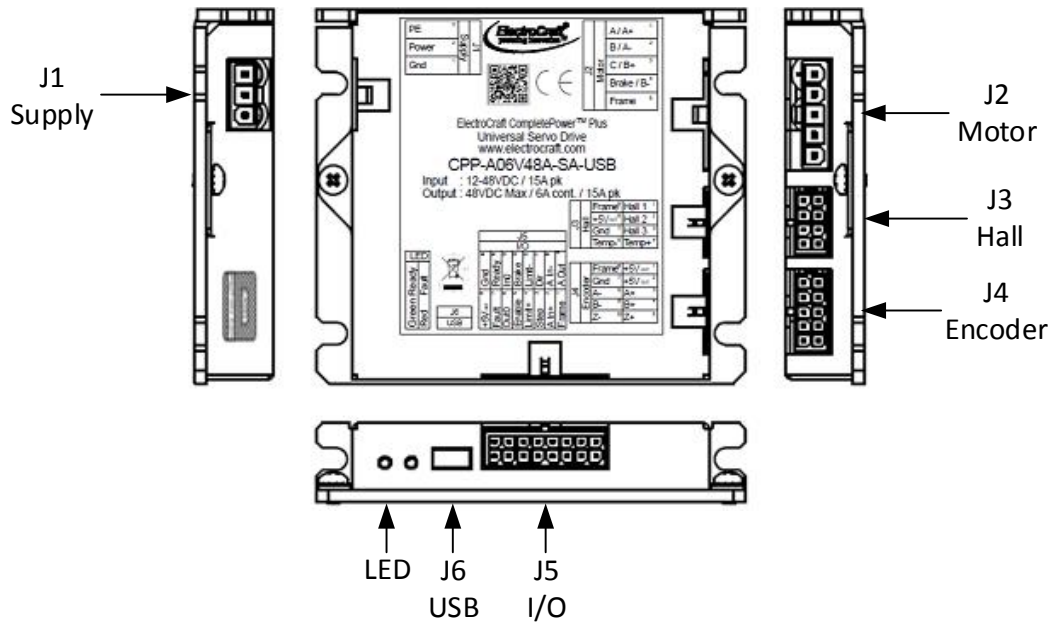
Figure 9: Drive connector layout

4.4.2 J1 Supply Connector Pinout

Pin #	Name	I/O	Description
1	Gnd	Input	DC Power Input – Power supply return
2	Power	Input	DC Power Input – Power supply
3	PE	-	Connected to drive chassis

4.4.3 J2 Motor Connector Pinout

Pin #	Name	I/O	Description
1	A / A+	Output	BLDC Phase A / Stepper Phase A+ / PMDC +
2	B / A-	Output	BLDC Phase B / Stepper Phase A- / PMDC -
3	C / B+	Output	BLDC Phase C / Stepper Phase B+
4	Brake / B-	Output	Braking Resistor / Stepper Phase B-
5	Frame	-	Connected to drive chassis

4.4.4 J3 Hall Connector Pinout

Pin #	Name	I/O	Description
1	Hall 1	Input	Hall Signal A; Internal pull up to +5Vdc.
2	Hall 2	Input	Hall Signal B; Internal pull up to +5Vdc.
3	Hall 3	Input	Hall Signal C; Internal pull up to +5Vdc.
4	Temp+	Input	Motor Temperature Sensor Positive; Analog input.
5	Frame	-	Connected to drive chassis
6	+5V$_{OUT}$	Output	+5 Volts DC Power; Internally generated.
7	Gnd	-	Digital Ground; Return for hall signals.
8	Temp-	Input	Motor Temperature Negative; Return for Motor Temperature Sensor.

4.4.5   J4 Encoder Connector Pinout

Pin #	Name	I/O	Description
1	+5V$_{OUT}$	Output	+5 Volts DC Power; Internally generated.
2	+5V$_{OUT}$	Output	+5 Volts DC Power; Internally generated.
3	A+	Input	Encoder "A+" Signal; 0 to +5 Volt digital signal.
4	B+	Input	Encoder "B+" Signal; 0 to +5 Volt digital signal.
5	Z+	Input	Encoder "Z+" Signal; 0 to +5 Volt digital signal.
6	Frame	-	Connected to drive chassis
7	Gnd	-	Digital Ground; Return for encoder signals.
8	A-	Input	Encoder "A-" Signal; 0 to +5 Volt digital signal.
9	B-	Input	Encoder "B-" Signal; 0 to +5 Volt digital signal.
10	Z-	Input	Encoder "Z-" Signal; 0 to +5 Volt digital signal.

4.4.6   J5 I/O Connector Pinout

Pin #	Name	I/O	Description
1	Frame	-	Connected to drive chassis
2	A In+	Input	Analog In+; Differential analog input.
3	Step	Input	Step; Digital input.
4	Limit+	Input	Limit Switch, Positive Direction; Digital input.
5	Enable	Input	Enable; Digital input. User selectable polarity.
6	Out0	Output	General purpose; Digital output.
7	Fault	Output	Fault; Digital output.
8	+5V$_{OUT}$	Output	+5 Volts DC Power; Internally generated.
9	A Out	Output	Analog Out; Analog output referenced to analog ground.
10	A In-	Input	Analog In-; Differential analog input.
11	Dir	Input	Direction; Digital input. User selectable polarity.
12	Limit-	Input	Limit Switch, Negative Direction; Digital input.
13	Brake	Input	Brake; Digital input.
14	In0	Input	General purpose; Digital input.
15	Ready	Output	Ready; Digital Output.
16	Gnd	-	Digital Ground; Return for digital I/O pins.

4.4.7   J6 USB Communications Connector Pinout

Pin #	Name	I/O	Description
-	USB	In/Out	USB 2.0 compatible communications interface for drive configuration.

5   Connecting Power

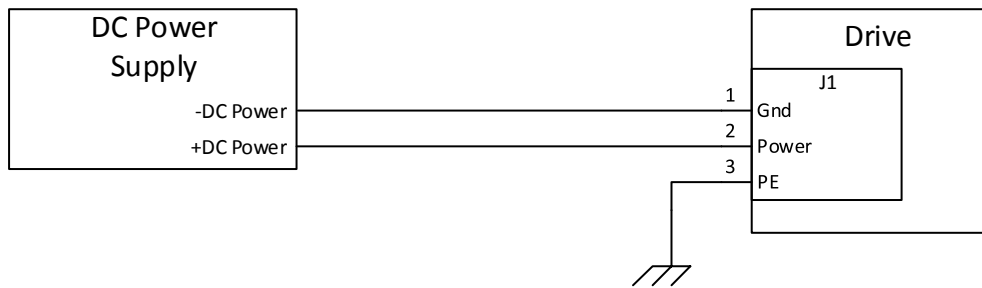## 5.1   Power supply

Figure 10: Power supply connection to the drive

6   Connecting Motors

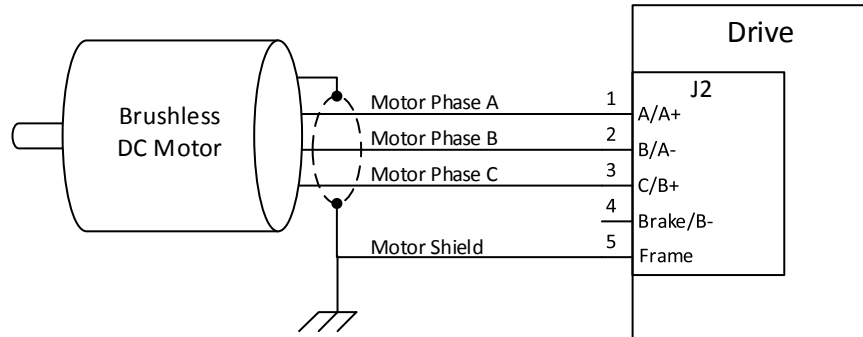## 6.1   Brushless DC (BLDC) Motor

Figure 11: Brushless DC motor connection to the drive
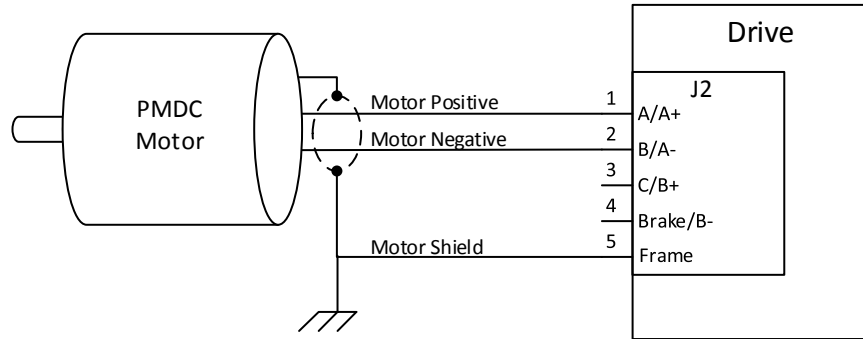
6.2   Permanent Magnet DC (PMDC) Motor

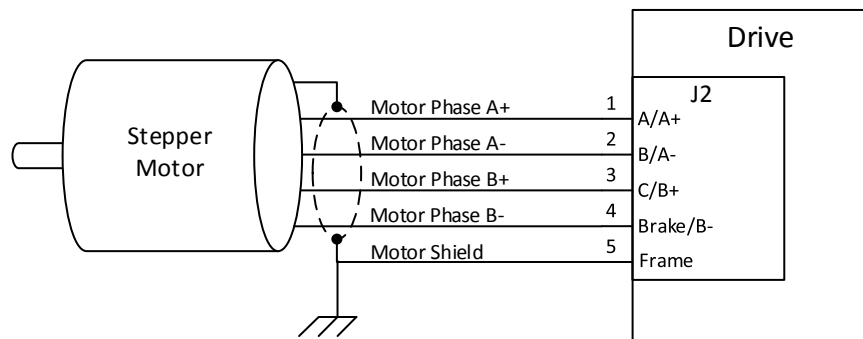**Figure 12: Permanent Magnet DC motor connection to the drive**

6.3   Stepper Motor

Figure 13: Stepper motor connection to the drive

7 Connecting Motor Feedback Devices

7.1 Hall Sensors
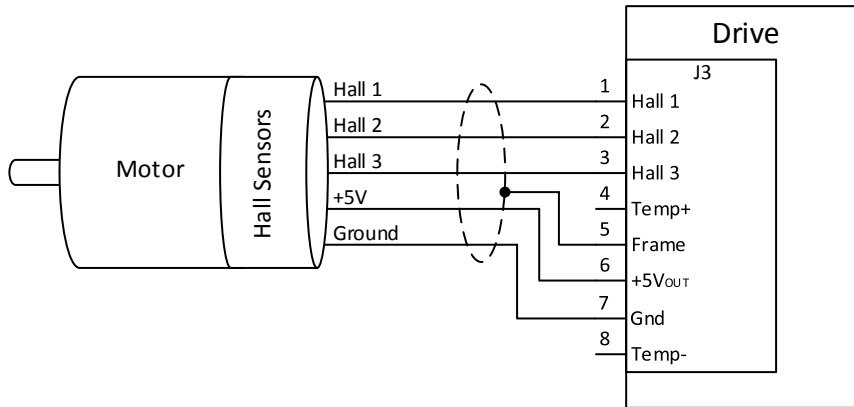
7.1.1 Hall Sensor Connections

Figure 14: Hall sensor connection to the drive

7.1.2 Hall Sensor Signal Input Circuit

The Hall sensor inputs are limited to +5V logic levels. Use the drive supplied +5V to supply power to the motor's hall sensors.
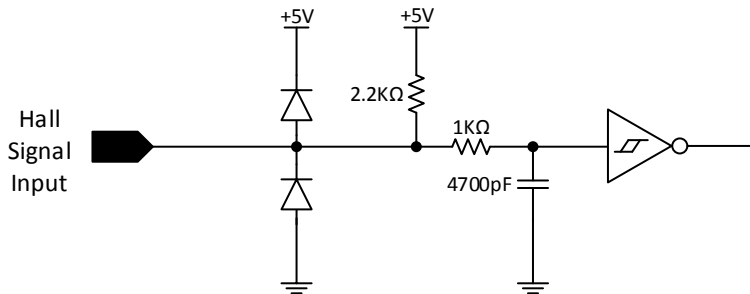

Figure 15: Hall sensor signal input circuit

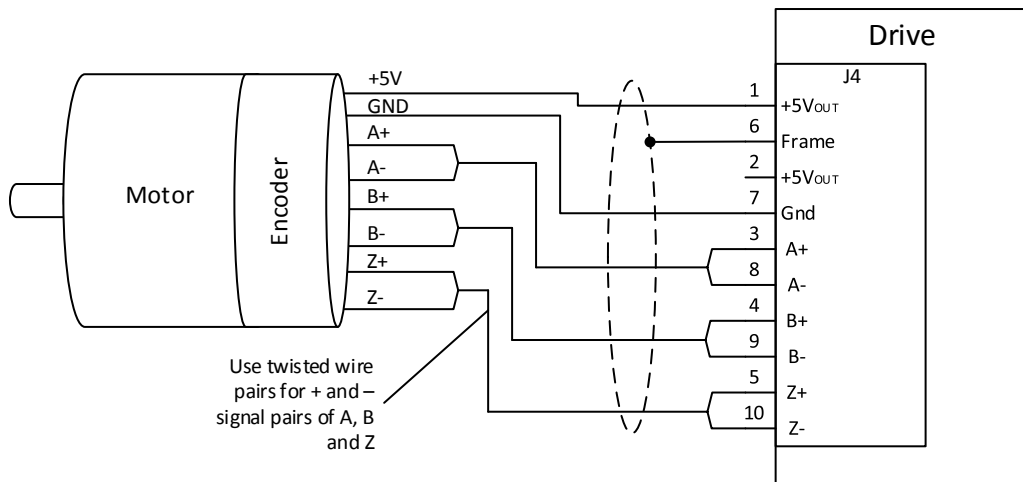## 7.2 Incremental Encoder

7.2.1 Differential Encoder

Figure 16: Differential encoder connection to the drive
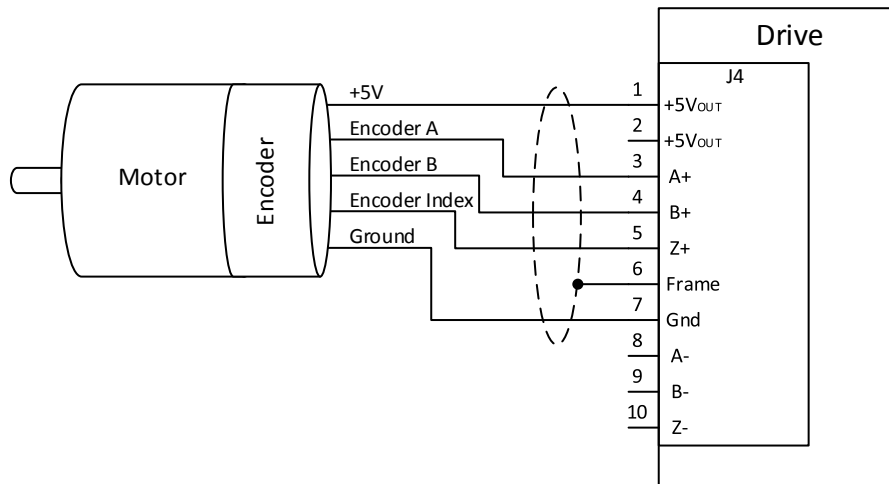
7.2.2   Single-Ended Encoder

Figure 17: Single-ended encoder connection to the drive

7.2.3   Encoder Input Circuit

The encoder inputs are limited to +5V logic levels. Use the drive supplied +5V to supply power to the motor's encoder.
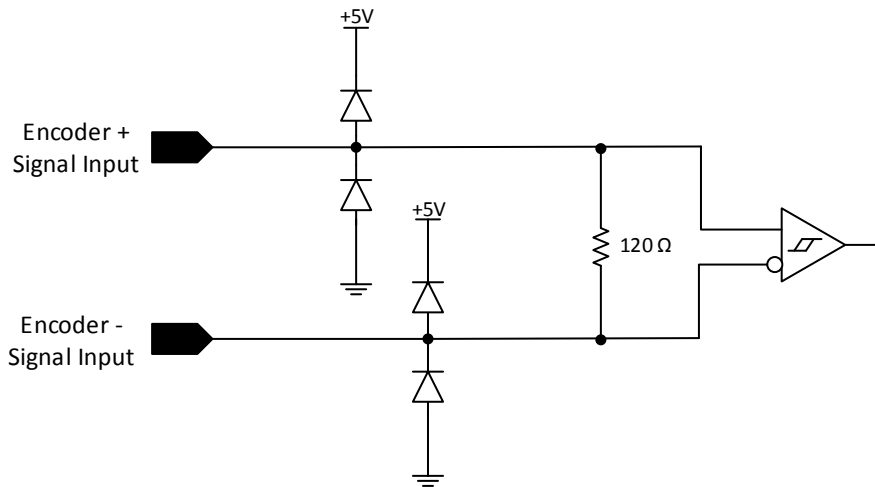
Figure 18: Encoder signal-ended input circuit

Note: For single ended encoder feedback, use signals A+, B+, Z+ and leave signals A-, B-, Z- unconnected as shown in section 7.2.2. *Select 'Single Ended Encoder' in the drive configuration software.*

7.3   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. The drive estimates the speed of the motor using the Motor's Resistance and Ke. Refer CompleteArchitect™ software manual for more information about calibrating the IxR Speed Feedback Estimator.

7.4   Motor Temperature Sensor

A motor over-temperature protection function is provided by the drive. The drive is designed to be compatible with standard Electrocraft motors equipped with a thermistor temperature sensor. However the drive is capable of interfacing with any resistance based temperature sensor that meets the following criteria.

- The resistance of the temperature sensor decreases with increasing temperature.
- The resistance at the maximum motor temperature is 1kΩ (typical).
- The sensor is isolated from any voltage sources (the drive provides the necessary excitation)

This sensor is commonly a thermistor or a normally open temperature switch that closes at the desired shutdown temperature. If motor over temperature function is not used, the connections must be left open. Contact the factory for applications with temperature sensors that do not match these specifications.
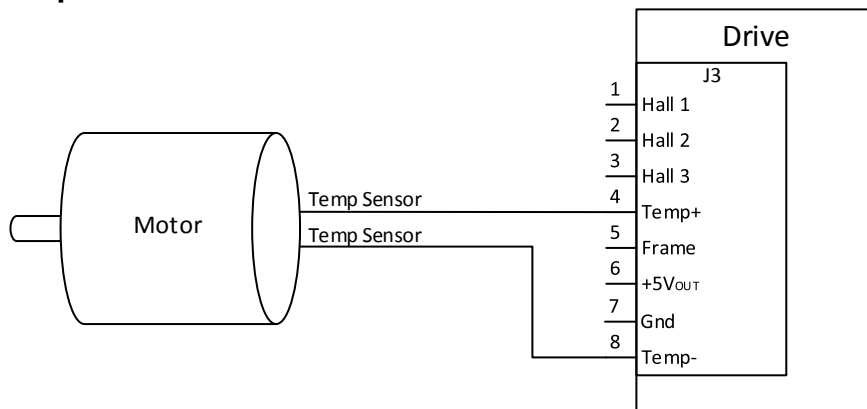
7.4.1   Temperature Sensor Connections

Figure 19: Temperature sensor connection to the drive
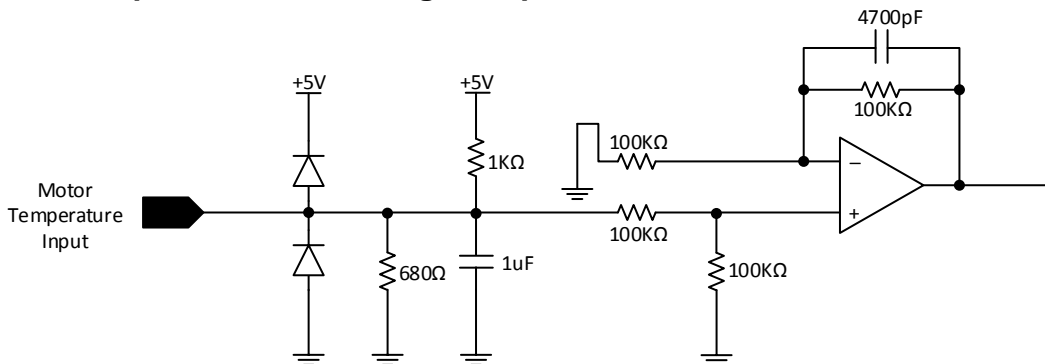
7.4.2   Temperature Sensor Signal Input Circuit

Figure 20: Temperature sensor signal input circuit

8 Connecting I/O

8.1 I/O Functional Description

I/O Pin Name	Type	Functional Description
Frame	-	Shield Connection.
Analog Input Positive	Analog Input	-10V to +10V input signal for speed or current command. The scaling of input voltage to motor output is configured in the setup software.
Analog Input Negative	Analog Input	-10V to +10V input signal for speed or current command. The scaling of input voltage to motor output is configured in the setup software. For a single ended analog signal connection, this pin should be connected to ground.
Analog Output	Analog Output	-10V to +10V output signal which represents the motor speed or current. The scaling of motor output to output voltage is configured in the setup software.
Step	Digital Input	The rising edge of each input pulse is accepted as one step pulse by the drive.
Direction	Digital Input	When the input signal is active low, it reverses the speed or current command. This in turn changes the direction of motor rotation.
Out 0	Digital Output	Unused, do not connect.
In 0	Digital Input	Unused, do not connect.
Fault	Digital Output	Open collector output that pulls to ground when the drive is in a faulted state.
Ready	Digital Output	Open collector output that pulls to ground when the drive is ready.
Enable	Digital Input	Input which enables the drive when an active low signal is applied and disables the drive when a high signal is applied. The signal needs to be kept low for the drive to remain enabled. In case of any drive interruptions or faults, this input should be toggled from high to active low to re-enable the drive.
Brake	Digital Input	Input pin which dynamically brakes the motor when it's active low.
Limit Switch Positive	Digital Input	Input pin which controls the positive current delivered to the motor. When the Limit switch positive is active low, the drive stops delivering positive current to the motor.
Limit Switch Negative	Digital Input	Input pin which controls the negative current delivered to the motor. When the Limit switch negative is active low, the drive stops delivering negative current to the motor.
+5 Vout	Output	Internally generated +5 volts for customer use. Refer to section 3.3.2.
Ground	-	Referenced to supply ground.

8.2   Minimum I/O Connections
8.2.1   Minimum I/O Connections for BLDC and PMDC motors

The drive requires an Enable signal and speed, torque or position command signal to operate. A basic example using a switch for the Enable signal, a potentiometer for analog speed/torque command and a switch to change motor direction is shown in Figure 21.
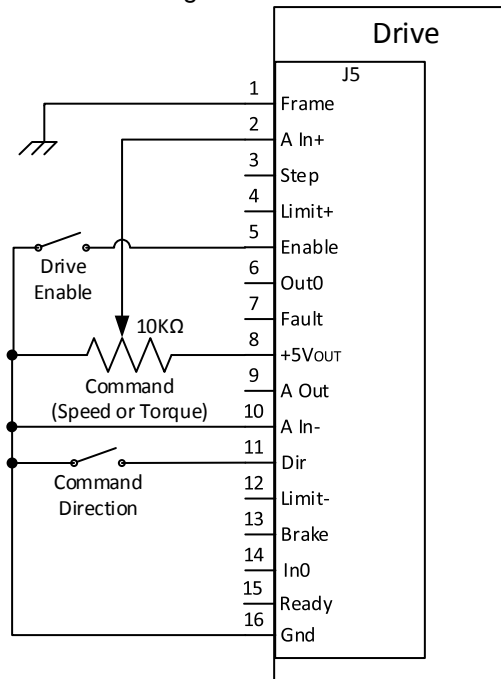
Figure 21: Minimum drive I/O connections needed to operate BLDC and PMDC motor

8.2.2   Minimum I/O Connections for Stepper motor

The drive requires an Enable, Step and Direction digital input signal to operate. A basic example using a switch for the Enable signal and digital pulse input for Step and Direction from a controller is shown in Figure 22.
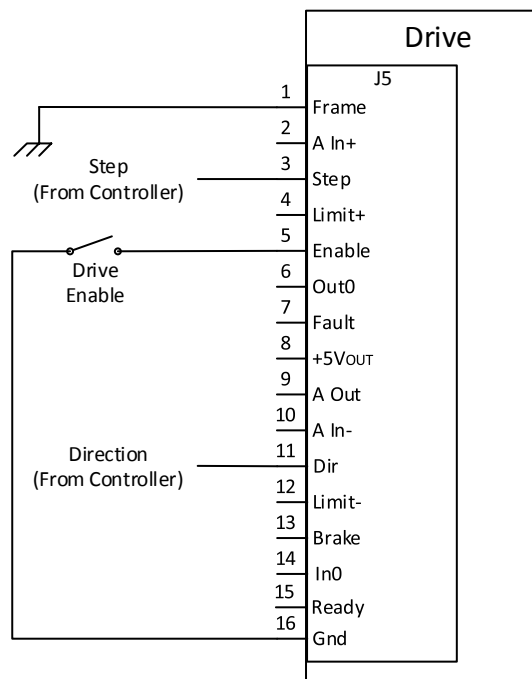
Figure 22: Minimum drive I/O connection needed to operate stepper motor

8.3 Digital Inputs and Outputs

8.3.1 Digital Input Circuit
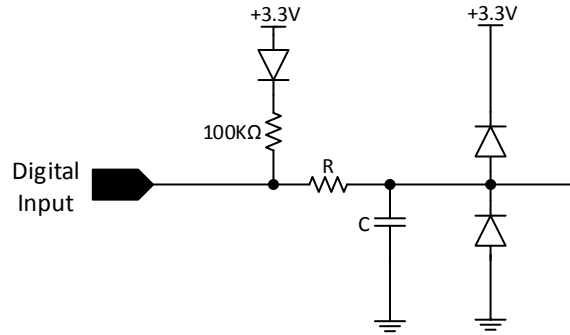
Note: For Step and Direction digital inputs R = 10KΩ and C = 10pF. For In 0, Enable, Brake, Limit Switch Positive and Limit Switch Negative digital inputs R= 20KΩ and C = 4700pF.

Figure 23: Digital input circuit

8.3.2 Digital Output Circuit
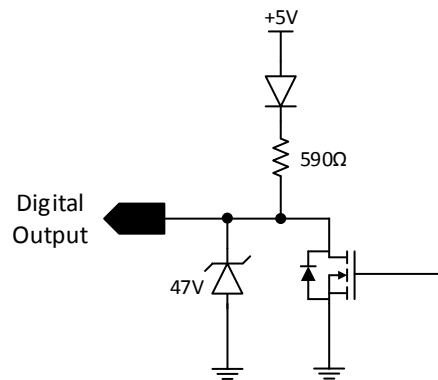
Figure 24: Digital output circuit

8.4   Analog Inputs and Outputs

8.4.1   Analog Input Circuit

The scaling and offset for the analog input is configurable using the drive setup software.

Figure 25: Analog input circuit

Note: For single-ended operation, connect single ended analog input signals to Analog+ and connect Analog– to analog ground.

8.4.2   Analog Output Circuit

The scaling for the analog output is configurable using the drive setup software.

Figure 26: Analog output circuit

Note: The single ended analog output is referenced to ground on J5 pin 16.

9 Communication

9.1 Connecting USB

An *USB Type A Male* to *Mini USB Type B Male* cable is required to connect the drive to the PC software. Insert the *USB Type A Male* connector to the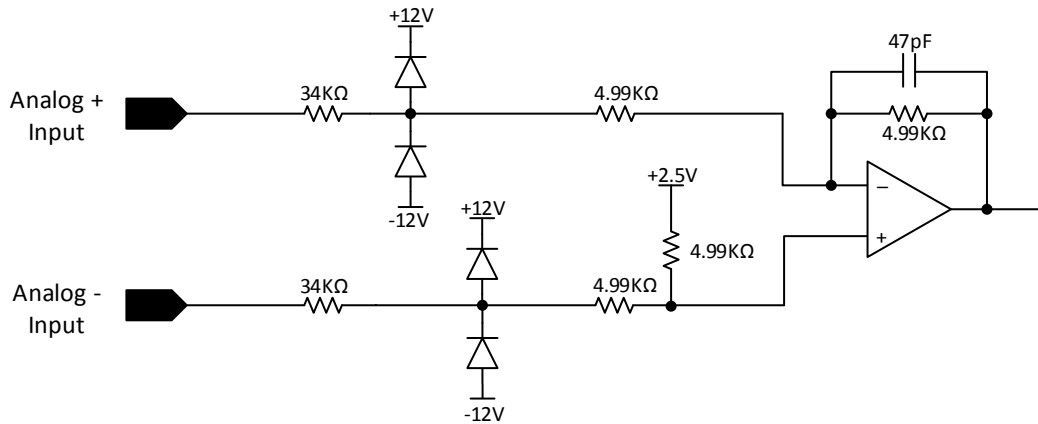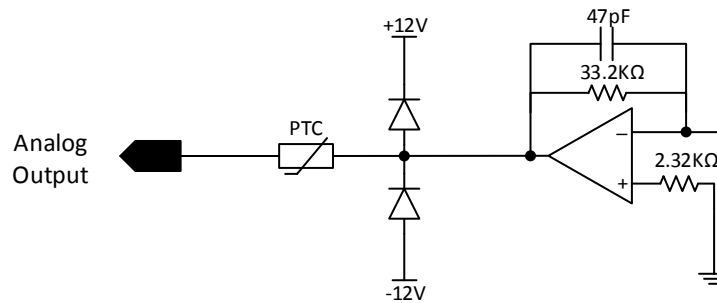 computer and *Mini USB Type B Male* to the drive as shown in Figure 27. Follow steps as specified in the setup software user manual to establish communication between PC software and drive.
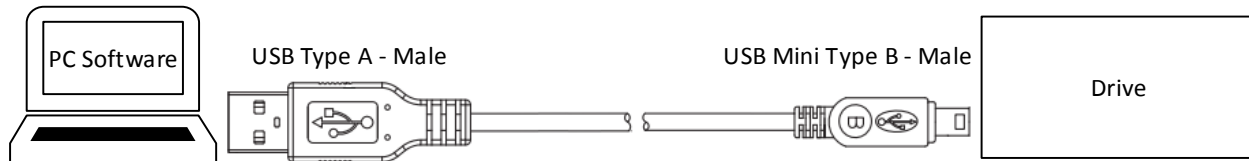

Figure 27: USB cable connection between computer and drive

10 Introduction to ElectroCraft CompleteArchitect™ PC Software

ElectroCraft CompleteArchitect™ is a Windows®-based program used for setup, configuration, system diagnostics and motion control management. The 198-0000021 CompleteArchitect user manual will lead the user through a step-by-step Wizard to create the correct configuration and information required for the user to run a particular motor with CPP-x06V48A-SA-USB drive. The result will be an "Application" containing all of the configuration information required to operate the motor with the drive. Please refer to the CompleteArchitect user manual for full documentation support to properly configure and operate the drive.

Windows® is a registered trademark of the Microsoft Corporation.

11 First Time Operation

To get started, proceed as follows:

1. Install ElectroCraft CompletePower™ Plus Universal Drive Configuration Tool onto user PC and open the software window.

2. Connect I/O, motor phase and feedback wires to the drive. Make sure the Enable switch is in the OFF position.

3. Supply required power to the drive (within the voltage and current range as specified in section 3) to operate the motor.

4. Establish communications between drive and PC software using the USB cable.

5. Use the configuration software to configure the drive settings. Refer to section 10 for details on Software settings.

If the drive does not function, refer to Troubleshooting section 13.

12 Adding an External Brake Resistor

12.1 Caution Statement

⚠️ **CAUTION!**

WHEN THIS PRODUCT USES THE OPTIONAL EXTERNAL BRAKE RESISTOR OR THE BRAKING ASSEMBLY, PRECAUTIONS MUST BE FOLLOWED TO PREVENT A POSSIBLE FIRE HAZARD.

Never mount the braking resistor or braking assembly where it can make contact with flammable materials, flammable liquid and/or flammable chemicals. Never use the drive, either with or without a brake resistor or braking assembly of any type, in an explosive atmosphere. Never place the braking resistor or braking assembly in the proximity of flammable materials that could melt or drop upon the brake resistor or braking assembly body.

12.2 Brake Resistor Theory of Operation

During motor deceleration, the motor behaves as a generator i.e. mechanical energy is converted into electrical energy. A braking resistor is used to dissipate this energy as heat.

The brake resistor is connected to the drive as shown in section 12.5. The user specifies the brake resistor On and Off voltage in the drive configuration software. During motor deceleration, when the bus voltage rises up to the brake resistor On voltage, the drive connects the braking resistor across the positive terminal of the supply input and ground. This causes current to flow through the resistor and reduce the bus voltage. When the bus voltage decreases to the brake resistor Off voltage, the drive disconnects the brake resistor circuit. This cycle repeats until the system dissipates enough energy beyond which the bus voltage doesn't rise up to brake resistor On voltage.

The resistor On time is the time taken for the bus voltage to drop from the brake resistor On voltage to Off voltage. The drive is designed such that if the resistor On time is greater than 3 seconds, it triggers a fault condition in the drive and the drive turns off its motor outputs. The Figure 28 shows the behavior of bus voltage in coordination with braking resistor's On and Off time.
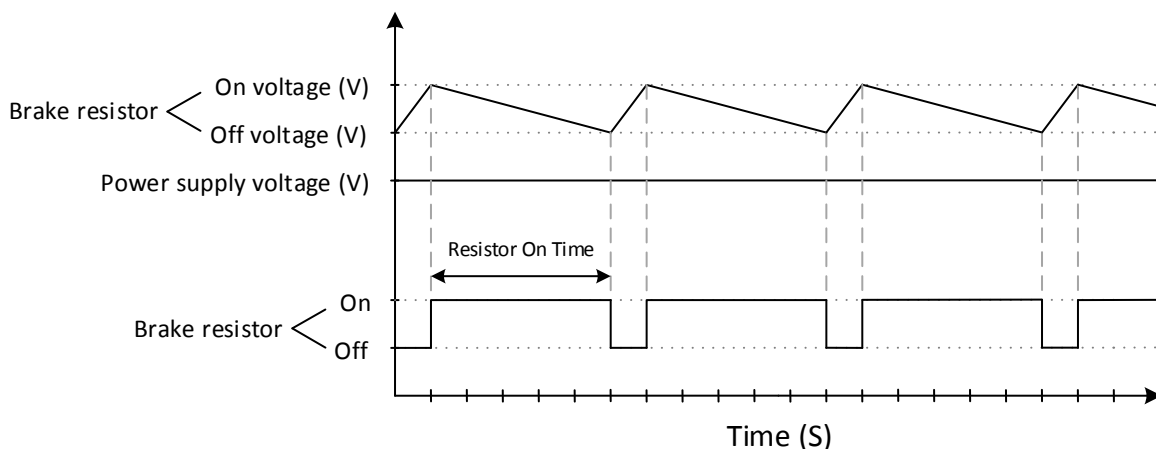
Figure 28: Brake resistor operation graph

It is important to use an external temperature sensitive device (switch or fuse) installed in close proximity to the brake resistor. The device opens when the braking resistor gets too hot to prevent overheating. The drive faults due to shunt overpower when the braking resistor is disconnected from the drive while braking. The user supplied temperature sensitive device must be rated to a current equal or more than the maximum deceleration current. Refer section 12.5 for wiring an external temperature sensitive switch to the drive.

12.3 Selecting External Brake Resistor

For properly sizing the resistor, a complex calculation requiring detailed information about the application and load is needed. This data is often not known or difficult to obtain, so ElectroCraft has provided the following guideline as a starting point which has proven sufficient in the majority of applications. If further support is needed or this recommendation does not provide the required performance please contact ElectroCraft.

12.3.1 Calculating resistance value of the braking resistor

The resistance value of the braking resistor and the power supply voltage will determine the rate at which energy is dissipated in it. The minimum resistance can be calculated from the following equation.

$$Minimum\ Resistance\ value = \frac{Supply\ Voltage}{Maximum\ deceleration\ current\ of\ the\ motor}$$

The next nearest resistor higher than the calculated value should be selected.

The table below gives the minimum resistance values for standard power supply voltages at drive continuous current of 6A. Use the equation above to calculate the maximum resistance value for other supply voltage and drive continuous current/deceleration current.

Deceleration Current (A)	Power Supply Voltage (Vdc)	Minimum Resistance value (Ω)
6	12	2
	24	4
	48	8

The resistance value for appropriate power supply voltage (when brake resistor On and Off voltages are set according to section 12.3.2) in the above table is a good starting point. Increase the resistance value for lower deceleration current.

Drive faults due to Shunt Overpower or Bus Overvoltage (refer section 13 for drive fault codes) indicates that the resistor is not dissipating enough power. A lower value resistor or lower deceleration current may be required.

12.3.2 Calculating power value of the braking resistor

The power rating of a braking resistor decides its maximum heat capacity. A brake resistor with large heat capacity can dissipate large amount of energy without the temperature of the resistor element exceeding the operational (safe) temperature rating.

Maximum Power value = Resistor On voltage x Maximum deceleration current of the motor

The On voltage and Off voltage of the brake resistor is programmed into the drive by the user via the PC configuration software. Brake resistor On and Off voltages are calculated as given below:

Brake resistor On voltage = Power supply output voltage + 4 volts
Brake resistor Off voltage = Power supply output voltage + 2 volts

An example to calculate the maximum power of a braking resistor with a power supply voltage of 24V and motor deceleration current of 6A is as follows:

Maximum Power value = (24 + 4) x 6 = 168 Watts

The power rating of the braking resistor **need not** be the maximum power value, as the value of power dissipated across the resistor depends on the duty cycle of braking.

Duty Cycle = Time in Braking / Total cycle Time

Calculation for average power value of the braking resistor using duty cycle is as follows:

Average Power value = Resistor On voltage x Maximum deceleration current of the motor x Duty Cycle

For example, consider an application with power supply voltage of 24V and motor deceleration current of 6A, so a 4 ohm resistor is picked (according to section 12.3.1). The load accelerates for 6 seconds and brakes for 4 seconds, which gives a total cycle time of 10 seconds. Example parameters are referenced in the table below:

Parameter	Value	Unit
Total cycle Time	10	Seconds
Time in Braking	4	Seconds
Volts during braking	28	Volts
Deceleration current	6	Amps

Duty Cycle = 4/10 = 0.4
Average Power value = 28 x 6 x 0.4 = 68 Watts

Therefore, in this example a 68 Watts resistor will be able to handle the braking power of 168 watts for 4 seconds and cools down for 6 seconds as long as the maximum current of the resistor is not exceeded and the thermal sensitive switch does not trip.

Considering the same application as referenced in the above example but the "Total cycle Time" is 10 minutes and "Time in Braking" is 4 minutes.

Duty Cycle = 4/10 = 0.4
Average Power value = 68 Watts

A 68 watts resistor will not handle 168 watts of braking power for 4 minutes. The brake resistor will get too hot and it will trip the user supplied temperature sensitive switch (refer to section 12.5), in turn disconnecting the braking resistor from the drive. The drive will then fault due to shunt overpower or bus over voltage after the braking resistor is disconnected from the drive while braking. Hence, the Average power value of the resistor also gets affected by the duration of the braking time. The selected power rating for any external brake resistor is application dependent. Usually a heavy-duty wire wound resistor will work best.

12.4 Minimum external bulk capacitance

A bulk capacitor is used to delay the bus voltage rising up to the brake resistor On voltage during braking. This increases the braking resistor Off time, in turn giving more time for the brake resistor to cool. The capacitor must be rated to a voltage equal or higher than the brake resistor On voltage (set in the configuration software).

ElectroCraft recommends connecting a capacitor of 50µF per each ampere deceleration current across J1 pin 1 and pin 2 as shown in section 12.5. For example, the application given in section 12.3.2 has a deceleration current of 6A, so it will need a 300µF capacitor. This recommendation has proven sufficient in the majority of applications. If further support is needed or this recommendation does not provide the required performance please contact ElectroCraft.

WARNING!

Installing capacitance value lesser than 50µF per each ampere deceleration current could result in an overvoltage fault condition and may result in damage to the drive.

12.5 Connecting External Brake Resistor and Bulk Capacitor

The braking resistor and bulk capacitor wiring is shown in Figure 29.

Temperature Sensitive Device Connection: The user supplied temperature sensitive device is connected in series with the brake resistor as shown in Figure 29. Generally the temperature sensitive device should be mounted in contact with the surface of the brake resistor or very close to it for an effective operation.

Optional Diode connection: Adding a diode between the positive terminal of the power supply and J1 pin 2 of the drive as shown in Figure 29 will protect the power supply from any back fed overvoltage while braking. The diode is sized by the application's maximum reverse voltage and forward current.
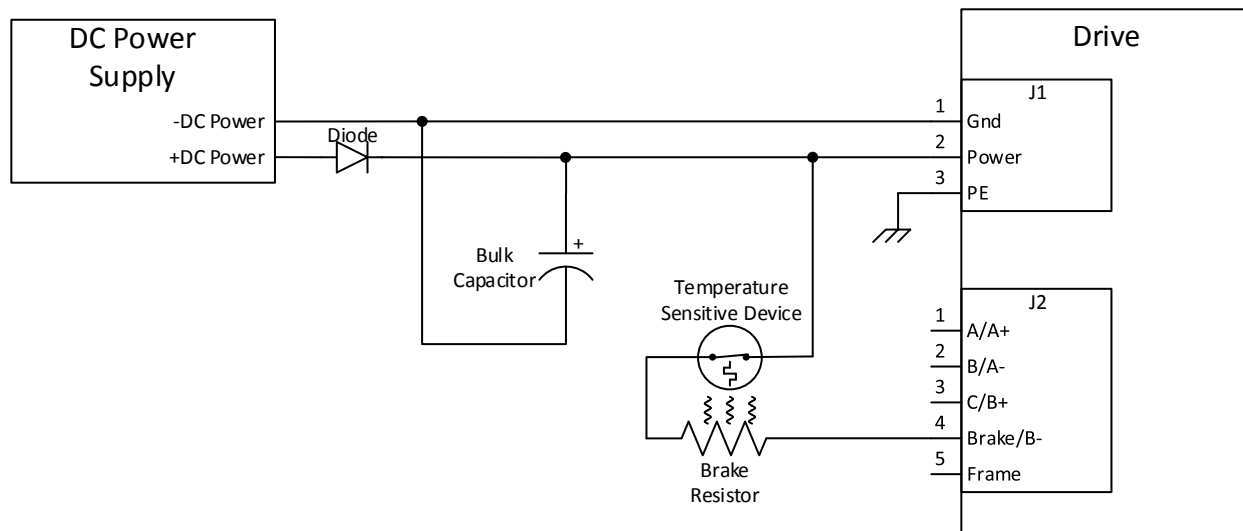

Figure 29: External brake resistor and bulk capacitor connection to the drive

The ElectroCraft Braking Module is designed for this purpose and is compatible with CPP-x06V48A-SA-USB. Refer section 12.6 for application information.

12.6 ElectroCraft Braking Module Assembly

Figure 30: ElectroCraft braking module

A Braking Module is used to divert regenerative energy from the motor and servo drive into the braking resistor during deceleration. The braking module will turn On when the drive side voltage increases 2 to 3 VDC above the power supply input voltage and shunt the excess voltage to ground through the internal braking resistor preventing overvoltage faults in the servo drive. A blocking diode in the Braking Module prevents the excess voltage from feeding back to the power supply. As the drive "regenerates", the module will cycle On and Off to dispose of the excess energy through the brake resistor. Care should be taken to ensure the brake resistor is not mounted next to any flammable material, as it could get hot. This braking module will also allow the user to attach a high wattage braking resistor externally.

The braking module is designed to be connected between the CPP-x06V48A-SA-USB connector J1 and the power supply. For full and complete data including proper connection information please refer to the ElectroCraft Braking Module datasheet available at ElectroCraft website.

13 Troubleshooting

If the drive does not function as expected, check the following parameters:

- Input voltage within drive and motor range.
- Motor and I/O connections are wired correctly to the drive.
- Verify the configuration parameters were written into the drive successfully.

The table given in section 13.1 and 13.2 details the status LED flash codes and suggested recovery steps.

13.1 Status LED (Red)

Flash Code	Description	Possible cause	Result	Recovery method
ON (Steady)	Drive hardware or Software error. Processor is inoperable.	• Processor fault.	Drive outputs are disabled.	• Disconnect power from the drive for 30 seconds for drive to reset and internal components to discharge. Then re-apply power to drive.
OFF	No Errors / Faults.	• Drive is operational.	Drive is operational.	• Use the 'Enable' input to enable or disable the drive outputs.
Flicker (fast blinking)	Invalid configuration.	• Drive has not been configured.	Drive outputs are disabled.	• Use configuration software to write a valid configuration into the drive.
1	Over Current	• Output current was detected as too high.	Drive outputs are disabled.	• Check motor wires for shorts. • Verify current loop tuning for stable operation.
2	Voltage Fault or Shunt Overpower	• Drive power is above/below operational limits. • Braking resistor is turned ON for more than 3 seconds. • No Braking resistor available in the circuit or the resistor is too small for the energy dissipated. • Braking resistor turn ON/OFF limits are set too low.	Drive outputs are disabled.	• Verify voltage of power supply. • Verify braking resistor is properly sized and installed. • Verify braking resistor turn On/Off levels are above the power supply input voltage.
3	Motor Feedback Fault	• Hall / Commutation signal Fault. • Encoder Fault. • Incorrect Hall and Encoder parameters entered in the software.	Drive outputs are disabled.	• Verify hall / commutation signals are present and working correctly. • Verify encoder signals are present and working correctly. • Verify Motor Pole Pairs, Hall sensor configuration and Encoder resolution/options.
4	System Fault	• Drive Over Temperature • Motor Over Temperature • Motor Over Speed • Motor Control Error	Drive outputs are disabled.	• Verify temperature of drive or motor. • Check for overload conditions. • Check for mechanical conditions that would cause an over speed condition.

Note: Detailed status information can be obtained using the drive configuration software.

13.2 Power LED (Green)

Flash Code	Description	Possible Cause	Result	Recovery Method
ON	Power Indicator	Drive is powered.	Required for drive to operate.	N/A
OFF	Power Indicator	Drive is not powered.	Drive will not operate.	• Apply power to power input of drive. • Verify input power is within acceptable range. • Check wires for possible short circuit. • Verify internally generated +5Vdc power is not overloaded by I/O or motor feedback devices.