ELECTROCRAFT

CompletePower™ Plus
UNIVERSAL DRIVE

CPP-A24V80A-SA-CAN
CPP-A40V24A-SA-CAN
Drive User Manual

ElectroCraft CompletePower™ Plus Universal Servo Drive

ElectroCraft document number 198-0000084

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001	05/6/2022	Initial Release	Document created.
002	11/3/2022	Release	9.1: Fixed section reference typo. 10.1.1: Removed section reference (not needed). 10.1.2: Updated diagram to match table. 10.1.2: Updated note regarding termination. 10.1.3: Updated diagram to show correct pins for J8. 10.1.3: Added note for factory setting for CAN Enable. 10.1.4: Updated factory setting for Axis-ID. 10.1.4: Added note regarding CAN Reference Manual.

Read This First

About This Manual

This document is a Drive User Manual for CPP-A24V80A-SA-CAN & CPP-A40V24A-SA-CAN. This document covers the drive hardware including technical data, connectors and wiring diagrams needed for installation. The physical shape and size of the CPP-A24V80A-SA-CAN drive is same as a CPP-A40V24A-SA-CAN, so all pictures that show CPP-A24V80A-SA-CAN in this document also applies to CPP-A40V24A-SA-CAN (and vice versa).

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1 Product Safety Precautions

READ THIS <u>ENTIRE</u> SECTION BEFORE ATTEMPTING TO USE THE CPP-A24V80A-SA-CAN 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 5 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 13 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 13 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 5 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 5, 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. Use twisted-pair wires for CAN-H & CAN-L. See sections 5.4.8 & 5.4.9 for pinout information.

7. 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.

- Power interface cable that supply power to the drive should not exceed 3m (9.84ft) in length.

- Motor cables should not exceed 10m (32.8ft) in length without consulting factory. For best results use ElectroCraft series cables.

- 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.

- 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.

- The J5 I/O port requires an external ferrite located close to the mating connector, with cable passing once through the ferrite. Fair-Rite – 0431176451 or equivalent is required for compliance.

- Re-install cover for the micro USB type B port (when not in use). The USB enclosure port must be covered by non-conductive rubber plug, tape or label.

1.6 Life Support Policy

READ THIS <u>ENTIRE</u> SECTION BEFORE ATTEMPTING TO USE THE CPP-A24V80A-SA-CAN 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-A24V80A-SA-CAN or CPP-A40V24A-SA-CAN 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-A24V80A-SA-CAN or CPP-A40V24A-SA-CAN 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 Introduction to ElectroCraft CompleteArchitect™ PC Software

ElectroCraft CompleteArchitect™ is a Windows®-based software tool used for setup, configuration, system diagnostics and motion control management. CompleteArchitect™ 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-A24V80A-SA-CAN or CPP-A40V24A-SA-CAN drives. The result will be an "Application" containing all the configuration information required to operate the motor with the drive. Please refer to the CompleteArchitect™ user manual document number 198-0000021 for full documentation support to properly configure and operate the drive.

When connecting a PC to the drive via USB it is recommended that an USB isolator is used. The isolator is connected inline between the PC (upstream) and drive (downstream) and can transfer both data and power. This isolator will act to protect the host PC from damage that can come from noise, voltage spikes, surges, or ground loops. Many commercially available isolators are available, contact ElectroCraft for further details.

Windows® is a registered trademark of the Microsoft Corporation.

3   Product Overview

This manual describes the installation and operation of the CPP-A24V80A-SA-CAN digital servo-amplifier manufactured by ElectroCraft Inc.

3.1   Key Features

Features of CPP-A24V80A-SA-CAN & CPP-A40V24A-SA-CAN drives:
- +12 to +80 VDC power supply input for CPP-A24V80A-SA-CAN
- 24 Amps Continuous, 60 Amps Peak (2 seconds) for CPP-A24V80A-SA-CAN
- +12 to +24 VDC power supply input for CPP-A40V24A-SA-CAN
- 40 Amps Continuous, 100 Amps Peak (2 seconds) for CPP-A40V24A-SA-CAN
- 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.
- High Speed CAN Communication up to 1Mbps
- Drive status diagnostics.
- +/-10V Analog command input.
- Digital step and direction input.
- +/-10V Analog output (configurable).
- Encoder mode for low speed performance.
- Capture digital input for Encoder location.
- Digital output to signal to engage eBrake
- BLDC and PMDC 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-A24V80A-SA-CAN or CPP-A40V24A-SA-CAN can be configured by the software through USB even when there is no power supply provided.

3.2   Simplified System Block Diagram

Overall system of CPP-A24V80A-SA-CAN is shown in Figure 1. The drive is configured using the configuration software to operate the motor according to its application.
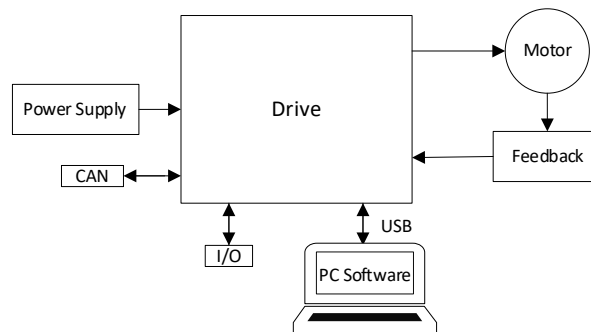
Figure 1: Overall drive system block diagram

3.3 Hall Sensor Feedback

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.
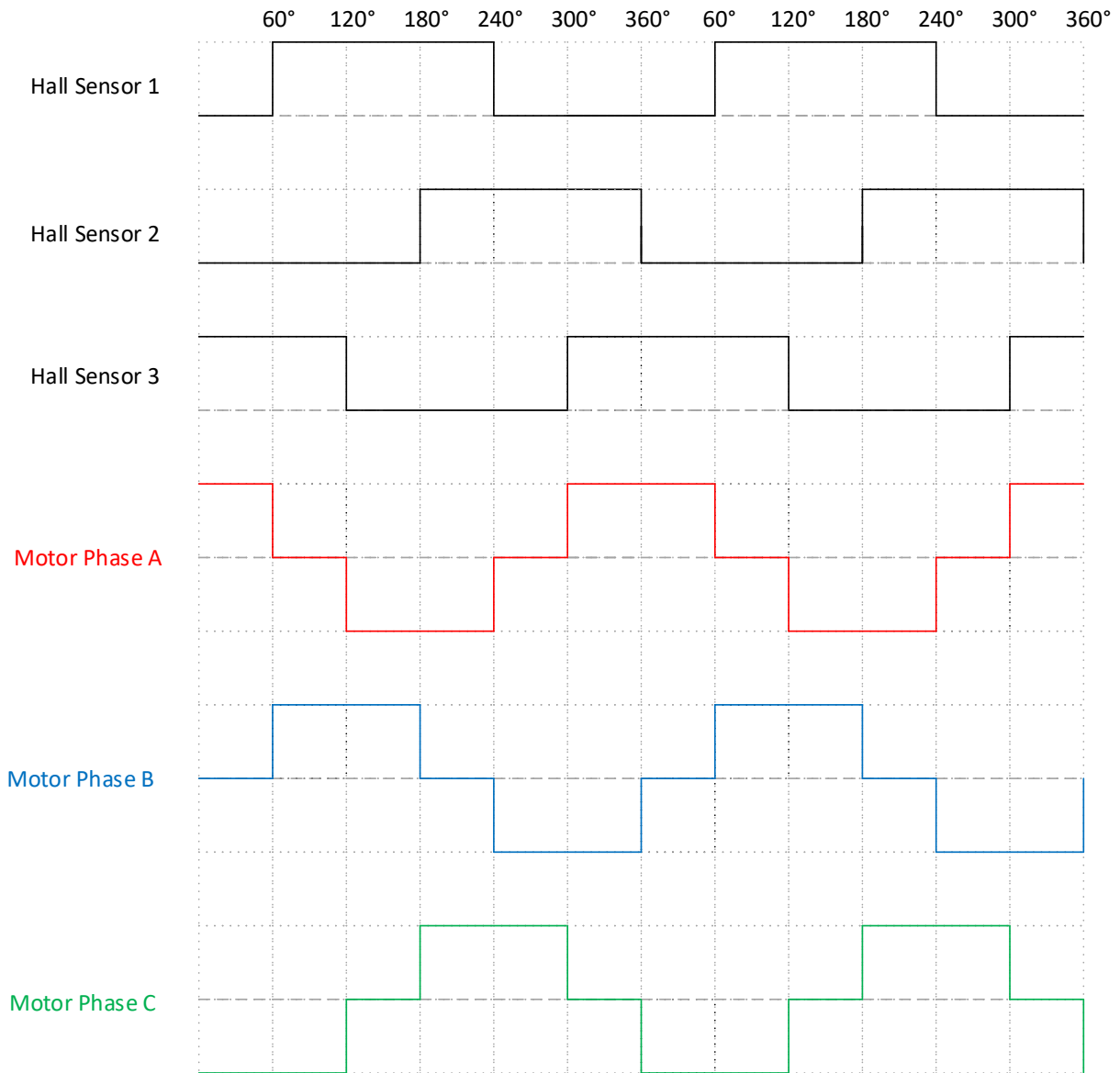
Figure 2: Trapezoidal Commutation with Hall sensor feedback
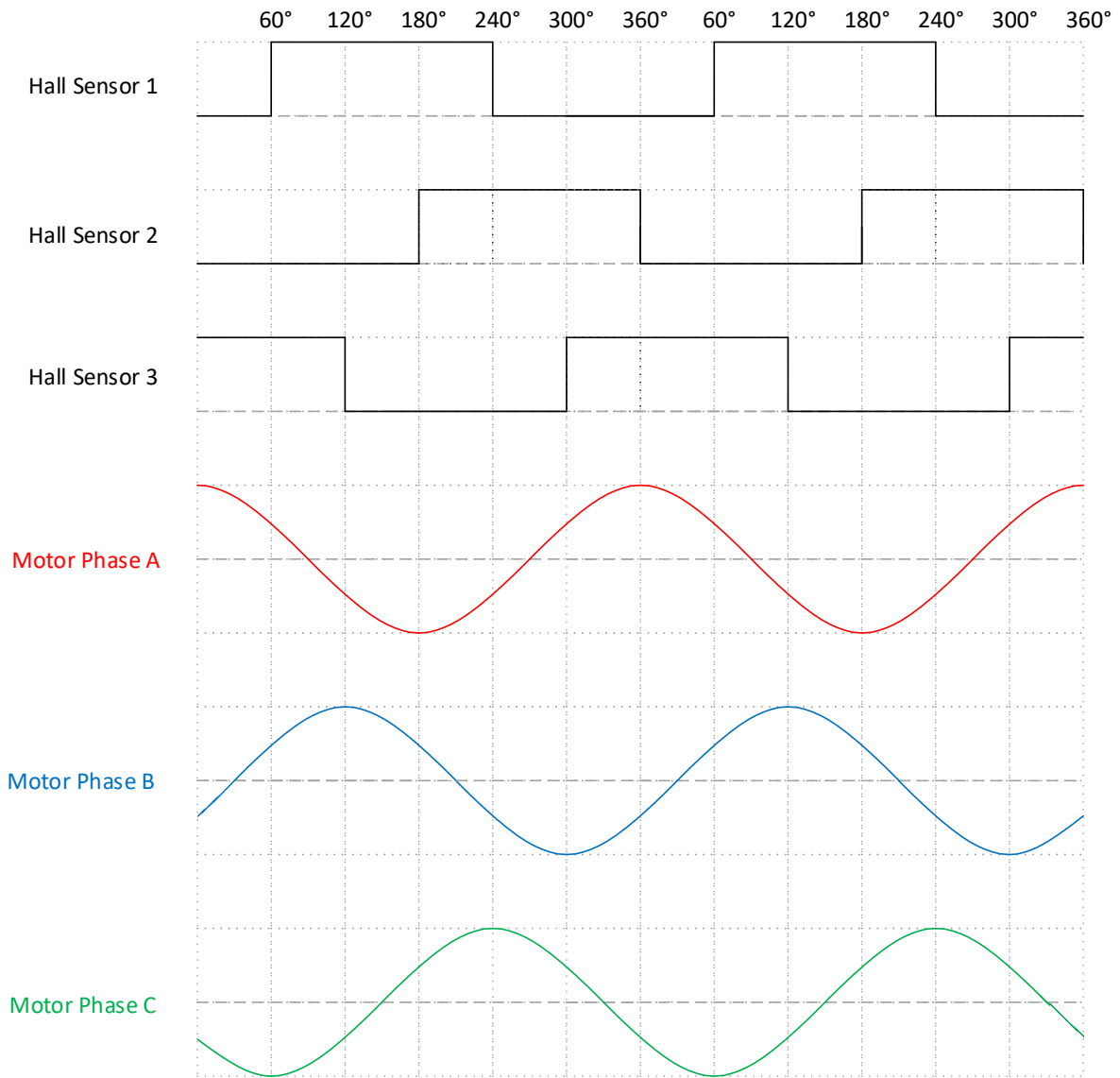
Figure 3: Sinusoidal commutation with Hall sensor feedback

3.4 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 configuration software. Encoder feedback signal is shown in Figure 4.
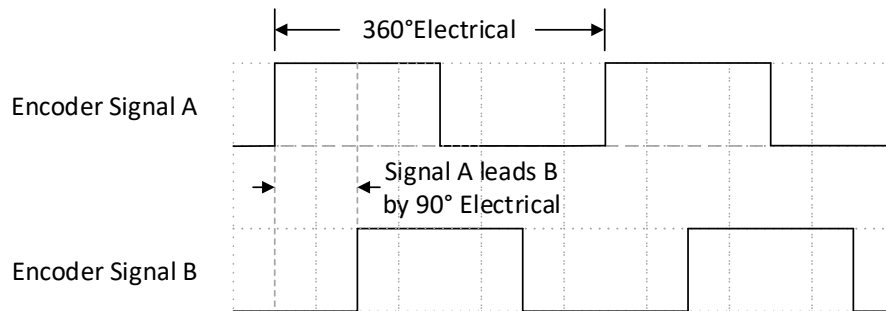
Figure 4: Encoder feedback signal

3.5 Motor and Sensor Configurations

	Brushless Motor	PMDC Motor
Hall Sensors	Yes	No
Encoder + Halls	Yes	No
Encoder Only	No	Yes
IxR Estimator	No	Yes
None	No	Yes

3.6 Identification Labels

Figure 5: Drive with identifying label

3.7 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 14 for LED flash codes and possible causes.

4 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.

4.1 Physical Specifications

Parameter	Conditions	Typical	Units
Weight	Without mating connectors	250	g
Dimensions	Length x Width x Height (Without mating connectors)	144.91 x 95.34 x 29.03	mm
		5.7 x 3.75 x 1.14	Inch

4.2 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

4.3 Electrical Specifications

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

4.3.1 DC Supply Input for CPP-A24V80A-SA-CAN

Parameter	Conditions		Min.	Typical	Max.	Units
Supply Voltage	Operating Range		12	-	80	VDC
	Absolute maximum		10.5	-	90	
Supply Current	Operating at maximum load and speed		-	24	60	A
	Idle condition. No external connections.	@ 12VDC	-	127	-	mA
		@ 80VDC	-	24	-	

4.3.2 DC Supply Input for CPP-A40V24A-SA-CAN

Parameter	Conditions		Min.	Typical	Max.	Units
Supply Voltage	Operating Range		12	-	24	VDC
	Absolute maximum		10.5	-	90	
Supply Current	Operating at maximum load and speed		-	40	100	A
	Idle condition. No external connections.	@ 12VDC	-	146	-	mA
		@ 24VDC	-	74	-	

4.3.3 +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

4.3.4   Motor Output

Parameter	Conditions		Min.	Typical	Max.	Units
Output Phase Current	CPP-A24V80A-SA-CAN	Continuous [1]	-24	-	24	A
		Peak Current [2]	-60	-	60	
	CPP-A40V24A-SA-CAN	Continuous [1]	-40	-	40	
		Peak Current [2]	-100	-	100	
	Peak Duration maximum (See I²t section 4.5)		-	2	-	s
PWM Frequency	Configured by software		20	-	80	kHz

(1) With no additional heat sink.
(2) Values are peak of Sine.

4.3.5   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

4.3.6   Encoder Inputs

Parameter	Conditions		Min.	Typical	Max.	Units
Input Voltage	Single ended	Logic "low" operating	0	-	1.5	V
		Logic "high" operating	3.5	-	5	
	Differential (RS422)	High-threshold	-	-	0.2	
		Low-threshold	-0.2	-	-	
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		125	-	-	ns
	Differential		125	-	-	ns
Input Impedance	Differential		-	120	-	Ω

4.3.7 Digital Input

Parameter	Conditions		Min.	Typical	Max.	Units
Input Voltage	Capture, Enable, Brake, Limit+, Limit-	Logic High	2.3	-	24	V
		Logic Low	0	-	1	
		Absolute maximum	-	-	26	
	Step, Direction	Logic High	1.5	-	-	V
		Logic Low	-	-	0.5	
		Absolute maximum	-12	-	12	
Sinking and Sourcing Current	Capture, Enable, Brake, Limit+, Limit-	Logic Low Sourcing	-	-	33	μA
		Logic High Sinking	-	-	2	mA
	Step, Direction	Logic Low Sourcing	-	-	33	μA
		Logic High Sinking	-	-	0.2	mA
Input Frequency	Capture, Enable, Brake, Limit +, Limit -	Frequency	-	-	2	kHz
		Pulse Width	200	-	-	μs
	Step, Direction (Push-Pull Driver)	Frequency	-	-	1	MHz
		Pulse Width[1]	400	-	-	ns

(1) **Note:** The drive registers a step pulse on the rising edge of the input pulse.

4.3.8 Digital Output

Parameter	Conditions		Min.	Typical	Max.	Units
Output Voltage	Ready, Fault	Operational range	0	5	24 [1]	V
		Absolute Max	-	-	28 [1]	
	eBrake	Operational range	0	-	48 [1]	
		Absolute Max	-	-	53 [1]	
Sourcing Current [2]	Ready, Fault, eBrake		-	7	-	mA
Sinking Current	Ready, Fault		-	-	2.4	A
	eBrake		-	-	1.0	
External Load Impedance [3]	Ready, Fault		10	-	-	Ω
	eBrake		48	-	-	

(1) **Note:** When voltage is applied externally.
(2) **Note:** When output is "OFF," and output pin is pulled to min operational voltage externally.
(3) **Note:** When output is "ON," and output pin is pulled up to max operational voltage externally.

4.3.9 Analog Input

Parameter	Conditions	Min.	Typical	Max.	Units
Input Voltage	Operational range	-10	-	10	V
	Absolute maximum	-12	-	12	
Input Impedance		100	-	-	kΩ

4.3.10 Analog Output

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

4.3.11 USB Communication

Parameter	Conditions	Type
USB Interface	USB micro type B female	USB 2.0b

4.3.12 CAN

Parameter	Conditions		Min.	Typical	Max.	Units
CAN Enable Out Output Voltage	Internal Supply	Operational Range	4.95	5.1	5.25	V
	External Supply	Absolute Maximum	-	-	5.25	
CAN Enable Out Output Current	Sinking	Absolute Maximum	-	-	200	mA
CAN Enable In+ Input Voltage	CAN Enable In- pulled to GND	Logic High	3.3	-	-	V
		Logic Low	-	-	1	
		Absolute maximum	-48	-	48	

4.4 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 temperature derating for different PWM frequencies in the ambient temperature range of 0 to 40°C and supply voltage of 80VDC is shown in Figure 6, when mounted according to ElectroCraft recommendations as specified in section 5.1. Improved derating can be achieved by limiting the supply voltage. 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.
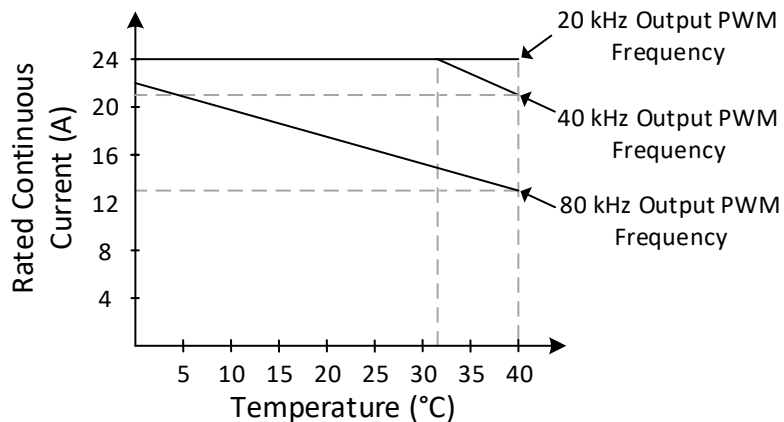

Figure 6: Drive temperature derating at 80VDC

4.5　Peak Current Fold-back (I²t)

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 I²t algorithm with a programmable peak current (I_P), rated current (I_R) and I²t 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. The drive will not supply current above the peak current value.

The I²t algorithm integrates up towards the limit whenever the output current exceeds the continuous I²t current value and integrates down when the output current is below the continuous I²t current value. When the I²t algorithm limit is reached, the output current is reduced and limited to the continuous I²t current limit value. The I²t time limit allowed by the software is computed using the equation given below.

$$I^2t \ algorithm \ limit = ((I_P)^2 - (I_R)^2) \ x \ T_P$$

Where, for A24V80A:
I_P = Peak phase current set by user (maximum of 60 A)
I_R = Rated phase current of 24 A
T_P = I²t time, in ms
I²t algorithm limit = 6048000 (preset)

Where, for A40V24A:
I_P = Peak phase current set by user (maximum of 100 A)
I_R = Rated phase current of 40 A
T_P = I²t time, in ms
I²t algorithm limit = 16800000 (preset)

The I²t time limit that the software allows is 2 seconds for a peak current and beyond that the drive limits the current to the I²t continuous current set in the configuration software. The allowable I²t time limit increases when the desired peak current value reduces.

Result of the I²t algorithm at maximum peak current and continuous current is shown in Figure 7.
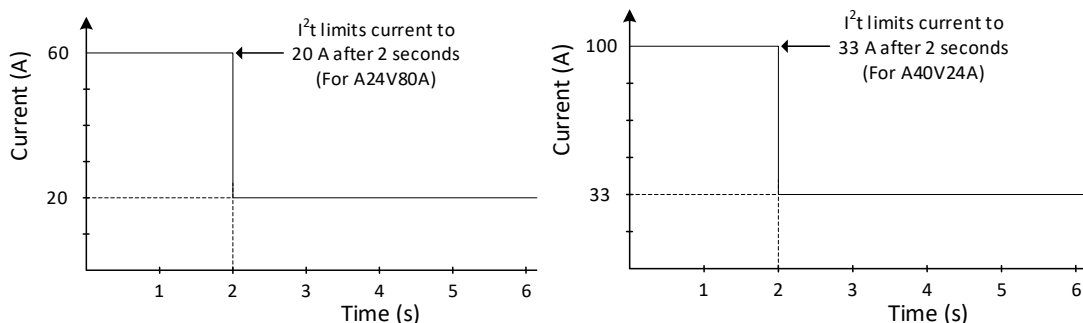

Figure 7: I²t Algorithm Example

The I²t 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 I²t time limit of 30 seconds.

5 Hardware Installation

5.1 Mechanical Mounting

The drive is intended to be mounted at least on a 300 mm (12 in) x 300 mm (12 in) metallic support which is not connected to any other heat generating source and must act as a cooling heat sink. Use the provided mounting holes and the recommended mating connectors, as referenced in section 5.3. Provide at least 125 mm (5 in) of clearance between drives or units and at least 250 mm (10 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.

5.2 Dimensions
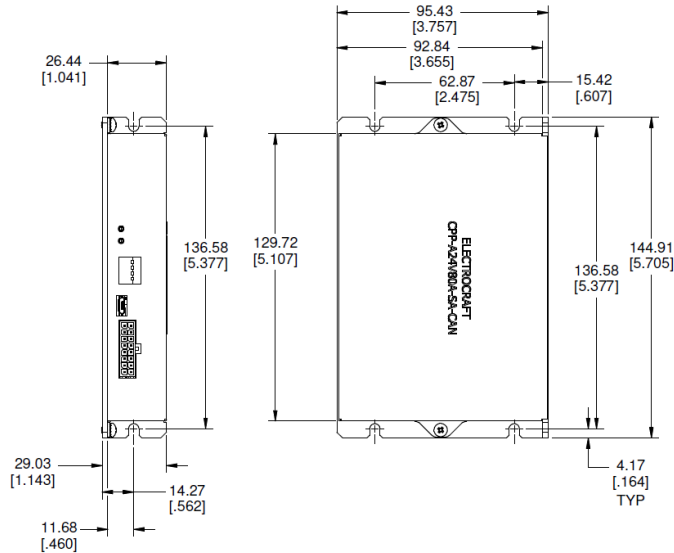
Figure 8: Drive dimensions (for both CPP-A24V80A-SA-CAN & CPP-A40V24A-SA-CAN)

5.3 Mating Connectors

Connector	Connector Name	Manufacturer	Mating Connectors P/N	Crimp Pin P/N
J1	Supply	Phoenix	1804933*	N/A
		FCI / Amphenol	20020516-M051B01LF	
			ET0501500000G	
J2	Motor	Phoenix	1804920*	N/A
		FCI / Amphenol	20020516-M041B01LF	
			ET0401500000G	
J3	Hall	Molex	43025-0800	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
J7	CAN Input	Amp	RJ45	N/A
J8	CAN Output	Amp	RJ45	N/A
-	Crimp tool for J3, J4, J5	Molex	0638190000	N/A

*Phoenix parts listed must be used only for applications less than or equal to 20A continuous current.

5.4 Connector Locations and Pin Numbers

5.4.1 Connector Layout

Figure 9: Drive connector layout (for both CPP-A24V80A-SA-CAN & CPP-A40V24A-SA-CAN)

5.4.2 J1 Supply Connector Pinout
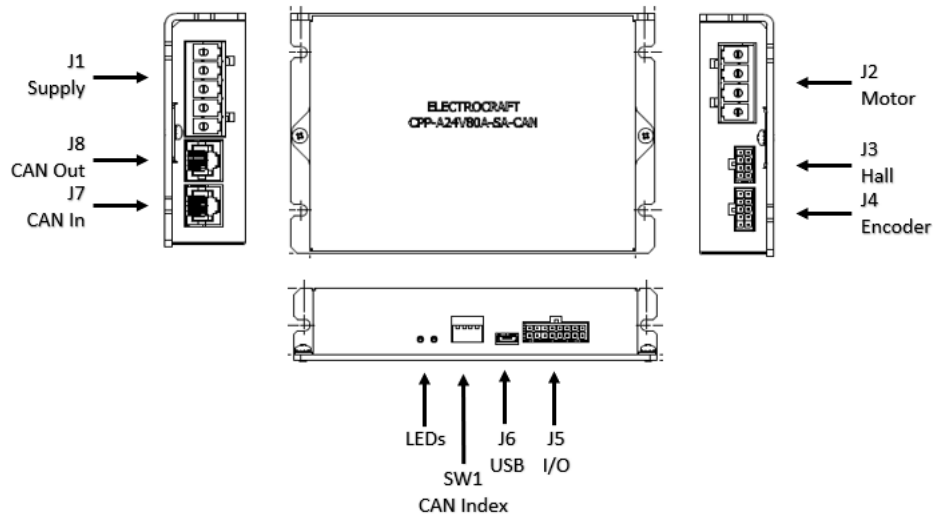
Pin #	Name	I/O	Description
1	Gnd	Input	DC Power Input – Power supply return
2	Power	Input	DC Power Input – Power supply
3	Brake Res+	Output	DC Power Output – Braking Resistor
4	Brake Res-	Input	Return path for Braking Resistor
5	PE	-	Connected to drive chassis

5.4.3 J2 Motor Connector Pinout

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

5.4.4 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.

5.4.5   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.

5.4.6   J5 I/O Connector Pinout

Pin #	Name	I/O	Description
1	Frame	-	Connected to drive chassis
2	A In1+	Input	Analog Input1 (+); Differential analog input.
3[1]	Step	Input	Step; Digital input
	A In2+	Input	Analog Input2 (+); Differential analog input.
4	Limit+	Input	Limit Switch, Positive Direction; Digital input.
5	Enable	Input	Enable, Digital input.
6	eBrake	Output	Digital output
7	Fault	Output	Fault; Digital output.
8	+5V_{OUT}	Output	+5 Volts DC Power; Internally generated.
9	A Out	Output	Analog Output
10	A In1-	Input	Analog Input1 (-); Differential analog input.
11[1]	Dir	Input	Direction; Digital input. User selectable polarity
	A In2-	Input	Analog Input2 (-); Differential analog input.
12	Limit-	Input	Limit Switch, Negative Direction; Digital input.
13	Brake	Input	Brake; Digital input.
14	Capture	Input	Digital input.
15	Ready	Output	Ready; Digital Output.
16	Gnd	-	Digital Ground; Return for digital I/O pins.

(1) **Note:** Pins 3 & 11 are configurable in CompleteArchitect™ to be either digital or analog inputs.

5.4.7   J6 USB Communications Connector Pinout

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

5.4.8   J7 CAN Communications Input Pinout

Pin #	Name	I/O	Description
1	CAN-H	In/Out	CAN high differential signal
2	CAN-L	In/Out	CAN low differential signal
3	GND	-	CAN GND (digital GND)
4	EN In+	Input	Isolated, digital input high side for CAN enable
5	EN In-	Input	Isolated, return for Enable In+.
6	Shield	-	CAN Shield (pass thru to J8 pin 6)
7	GND	-	CAN GND (digital GND)
8	CAN V+	-	Pass thru (no connection).

5.4.9   J8 CAN Communications Output Pinout

Pin #	Name	I/O	Description
1	CAN-H	In/Out	CAN high differential signal
2	CAN-L	In/Out	CAN low differential signal
3	GND	-	CAN GND (digital GND)
4	+5V$_{OUT}$	Output	+5 Volts DC Power; Internally generated.
5	EN Out	Output	Digital output for CAN enable
6	Shield	-	CAN Shield (pass thru to J7 pin 6)
7	GND	-	CAN GND (digital GND)
8	CAN V+	-	Pass thru (no connection).

6   Connecting Power
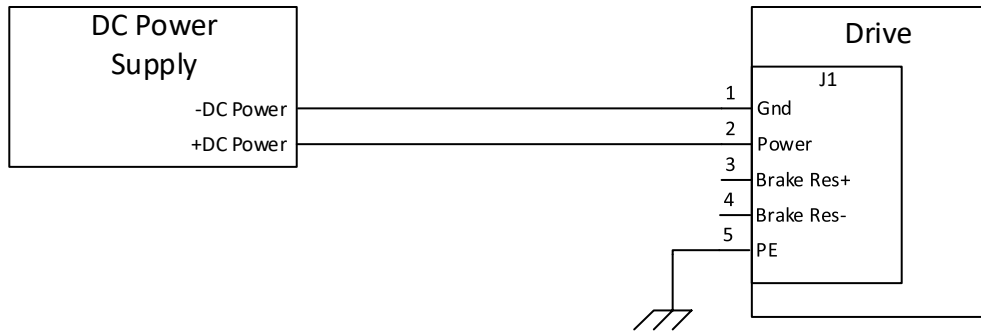
6.1   Power supply

Figure 10: Power supply connection to the drive

7   Connecting Motors

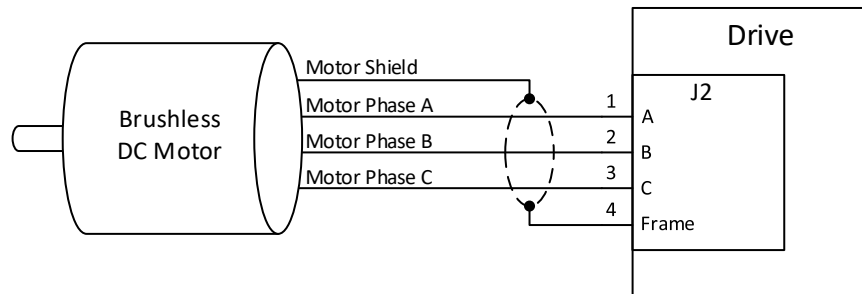## 7.1   Brushless DC Motor

Figure 11: Brushless DC motor connection to the drive

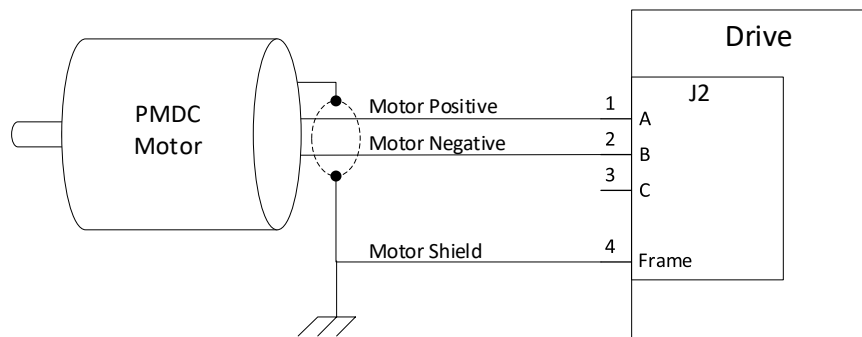## 7.2   Permanent Magnet DC (PMDC) Motor

Figure 12: Permanent Magnet DC motor connection to the drive

8   Connecting Motor Feedback Devices

8.1   Hall Sensors

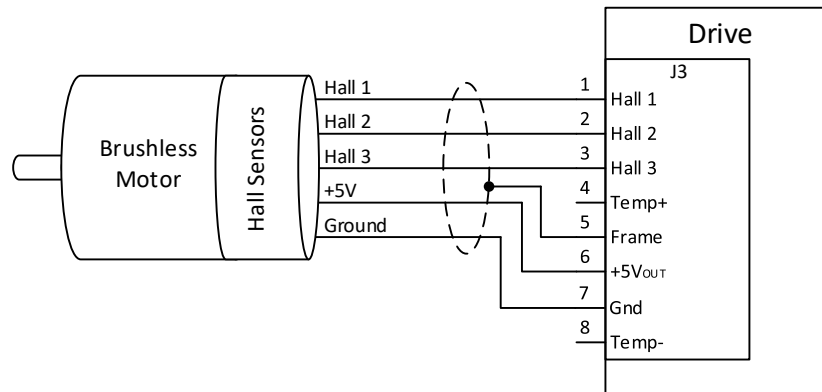### 8.1.1   Hall Sensor Connections

Figure 13: Hall sensor connection to the drive

8.1.2   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.
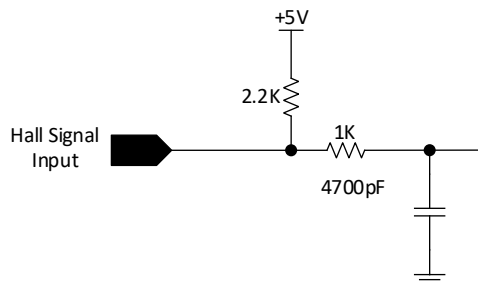

Figure 14: Hall sensor signal input circuit

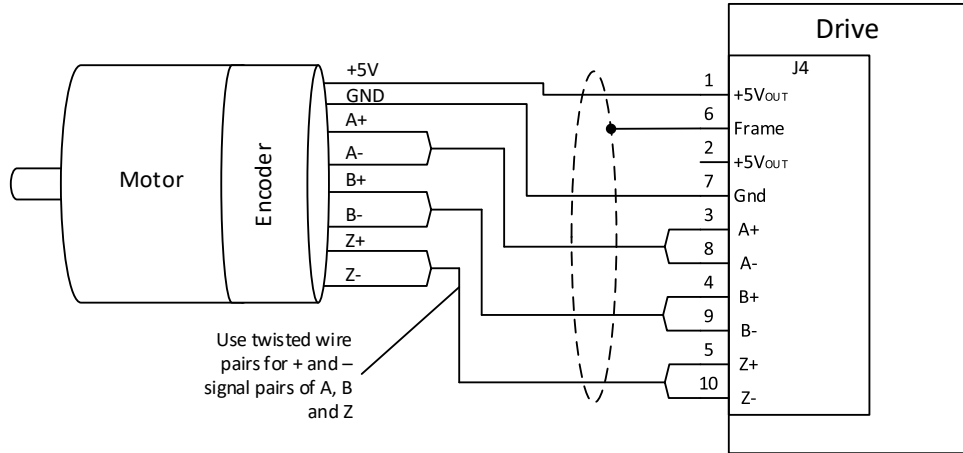## 8.2   Incremental Encoder

8.2.1   Differential Encoder

Figure 15: Differential encoder connection to the drive
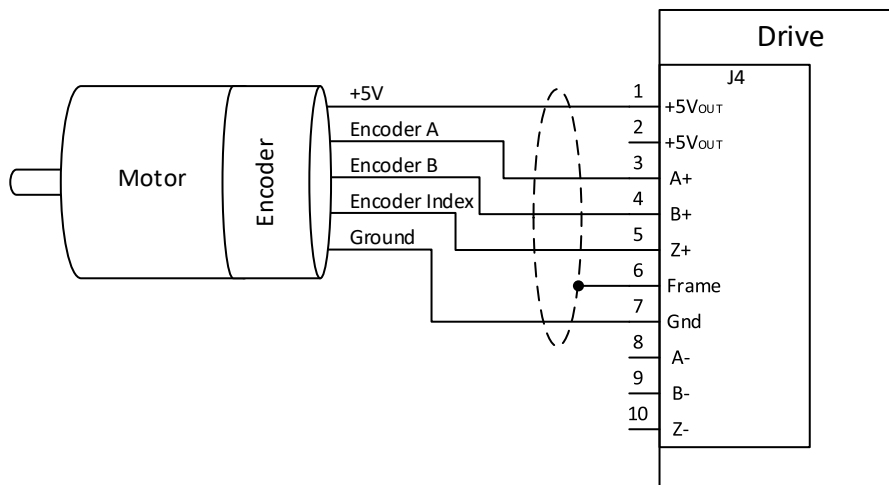
8.2.2   Single-Ended Encoder

Figure 16: Single-ended encoder connection to the drive

8.2.3 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.
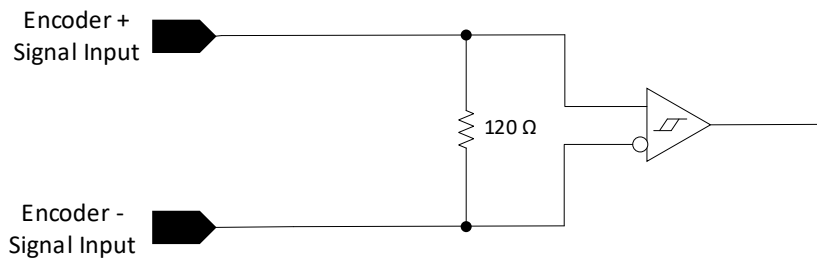
Figure 17: Encoder signal-ended input circuit

Note: For single ended encoder feedback, use signals A+, B+, Z+ and leave signals A-, B-, Z- unconnected as shown in section 8.2.2. Select 'Single Ended Encoder' in the drive configuration software.

8.3 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.

8.4   Motor Temperature Sensor

A motor over-temperature protection function is provided by the drive. The actual motor temperature is dependent upon the temperature sensor installed in the motor. The drive is designed to be compatible with any motor equipped with a thermistor temperature sensor. There are five different options available for motor temperature sensing, all of which are configurable in CompleteArchitect™. Select the temperature sensor that is installed in the motor.

1. Normally Open (NO)
2. Normally Closed (NC)
3. Threshold Level
4. Negative Temperature Coefficient (NTC)
5. Positive Temperature Coefficient (PTC)

The sensor should be isolated from any voltage sources (the drive provides the necessary pull-up source) and the low side of the sensor should be wired back to pin 8 on connector J3. See section 8.4.1 for connection information.

Normally Open (NO) Temperature Sensing
In this instance the sensor is normally open. Once the temperature threshold is reached, the sensor will close and pull the sensing pin (J3 pin 4) low. This can be enabled in CompleteArchitect™ and doesn't require to set any thresholds.

Normally Closed (NC) Temperature Sensing
In this instance the sensor is normally closed and holds the sensor pin (J3 pin 4) low. Once the temperature threshold is reached the sensor will open, and the sensing pin will be pulled high internally. This can be enabled in CompleteArchitect™ and doesn't require to set any thresholds.

Threshold Level Temperature Sensing
A custom configurable threshold set in CompleteArchitect™. Consult factory.

Negative Temperature Coefficient (NTC) Temperature Sensing
An NTC sensor is a resistive element whose resistance decreases with temperature.

The values of R_{25} and $B_{25/Tref}$ are inherent to the NTC sensor being applied. Their values and tolerances will typically be included in an NTC datasheet.

- The value of R_{25} must be chosen in the range of 5kΩ to 50kΩ.
- The B value can vary with temperature, so the user should consider the temperature threshold for the application when choosing the appropriate B value and its tolerance.

CompleteArchitect™ includes options for entering R_{25}, B value and the temperature threshold for the NTC sensor that is to be used.

Positive Temperature Coefficient (PTC) Temperature Sensing
A PTC sensor is a resistive element whose resistance increases with temperature. PTC datasheets will typically specify a temperature threshold (or switching temperature) where resistance will change sharply. The user should choose a PTC with a temperature switching point appropriate for their motor application. Additionally, it is required for this value to be in the range from 0.5 to 2kΩ. This value can be entered as the threshold into CompleteArchitect™.

For both NTC & PTC applications the drive system will have up to 6% error in accuracy for sensing resistance. This error will be increased further by error in the temperature sensor. The user should factor this in when considering the sensor to be used with the drive.

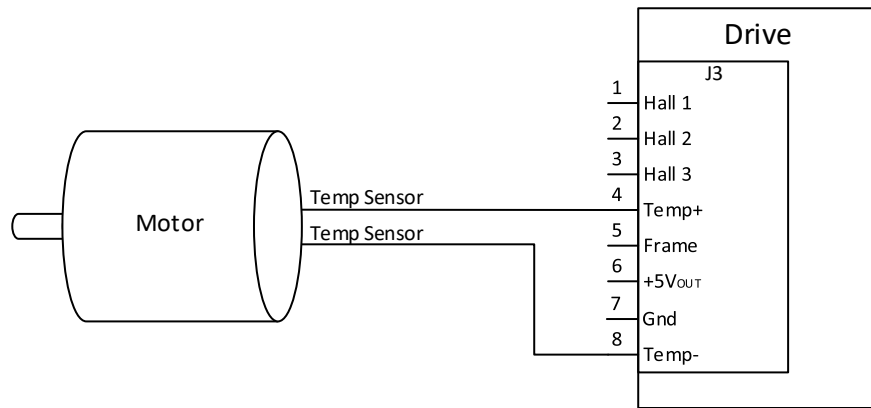### 8.4.1   Temperature Sensor Connections

Figure 18: Temperature sensor connection to the drive
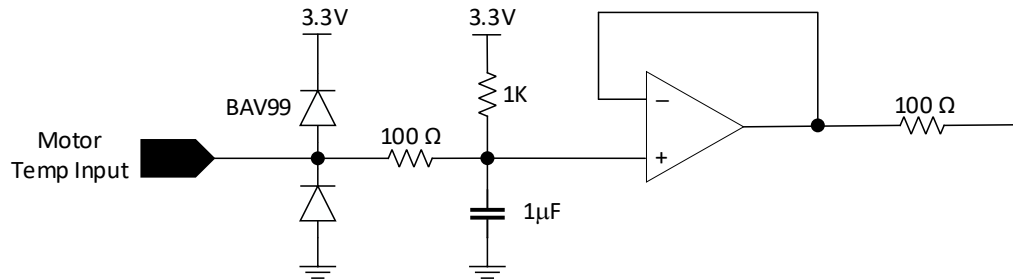
8.4.2   Temperature Sensor Signal Input Circuit

Figure 19: Temperature sensor signal input circuit

9 Connecting I/O

9.1 I/O Functional Description

I/O Pin Name	Type	Functional Description
Frame	-	Shield Connection.
Analog Input Positive 1	Analog Input	-10V to +10V input signal for speed or current command. The scaling of input voltage to motor output is configured in the CompleteArchitect™.
Analog Input Negative 1	Analog Input	-10V to +10V input signal for speed or current command. The scaling of input voltage to motor output is configured in the CompleteArchitect™. 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 CompleteArchitect™.
Step	Digital Input	The rising edge of each input pulse is accepted as one step pulse by the drive.
Analog Input Positive 2	Analog Input	-10V to +10V input signal for use of a secondary feedback. The scaling of input voltage to motor output is configured in the CompleteArchitect™.
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.
Analog Input Negative 2	Analog Input	-10V to +10V input signal for use of a secondary feedback. The scaling of input voltage to motor output is configured in the CompleteArchitect™. For a single ended analog signal connection, this pin should be connected to ground.
eBrake	Digital Output	Open drain output that can be used to engage electromechanical brake. See section 12 for more details.
Capture	Digital Input	When the capture input pin has been triggered, it provides an instantaneous encoder count location. The trigger occurs on a falling edge input. The count location is stored in memory and can be accessed via USB or CAN.
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. This will inhibit the torque in the positive direction.
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. This will inhibit the torque in the negative direction.
+5 Vout	Output	Internally generated +5 volts for customer use. Refer to section **Error! Reference source not found.**.
Ground	-	Referenced to supply ground.

9.2   I/O Connections

Typical examples of using the minimal I/O interfaces for control are shown in figure 21 for BLDC & PMDC motors. Control is also possible over the CAN network with or without the I/O interface. It is also possible to configure the drive to ignore any of the external I/O connections and preset the respective parameter in CompleteArchitect™.

To run the drive in a basic no I/O connection mode, the drive needs to be configured to ignore the enable input, set a fixed direction, and set a fixed speed or torque setting. See the CompleteArchitect™ manual for more details.

9.2.1   Typical I/O Connections for BLDC and PMDC motors
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 20.
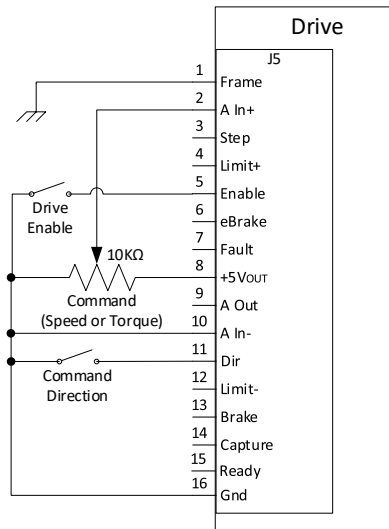

Figure 20: Typical drive I/O connections needed to operate BLDC and PMDC motors

9.3 Digital Inputs and Outputs

9.3.1 Digital Input Circuit

Capture Input

The capture input provides a snapshot of the encoder counts accumulated to that point. It is triggered on a falling edge of the input signal. If a digital interface is used, the capture circuit is compatible with either push-pull or open collector (internal pull-up is present in the drive). It is recommended that for higher frequency capture triggering, a push-pull interface should be used. See section 4.3.7 for more information regarding electrical specifications.
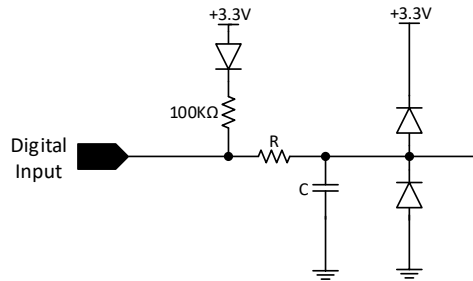

Figure 21a: Digital input circuit for Capture, Enable, Brake and Limit Switch Inputs

For Enable, Brake, Limit Switch Pos, & Limit Switch Neg: R= 20KΩ and C = 4700pF.
For Capture: R=10KΩ and C=5pF.

Step & Direction Inputs

See section 9.1 for functional application regarding step & direction inputs. The states of these pins can be monitored in CompleteArchitect™. There is the option to set the steps per revolution in CompleteArchitect™. The software will divide the Desired Steps per Rev. into the Encoder resolution.

For high frequency stepping a push-pull interface is required. The drive includes a pull-up on the internal circuit and can be interfaced to an open collector for low frequency stepping. See section 4.3.7 for more information regarding electrical specifications.
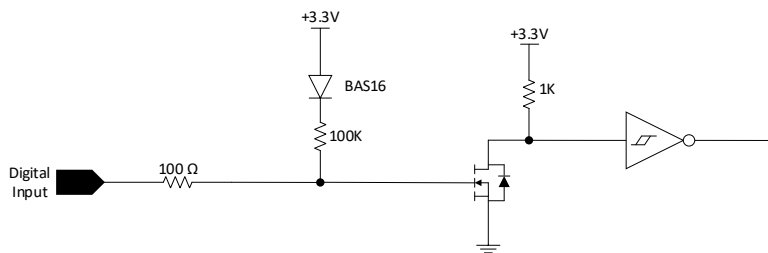

Figure 22b: Digital input circuit for Step & Direction Inputs
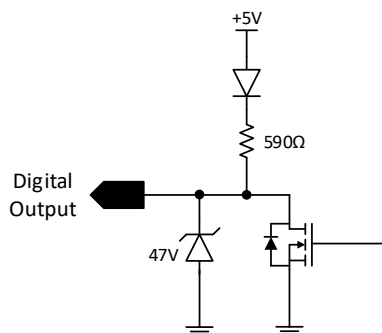
9.3.2 Digital Output Circuit

Figure 23: Digital output circuit

9.4 Analog Inputs and Outputs

9.4.1 Analog Input Circuit

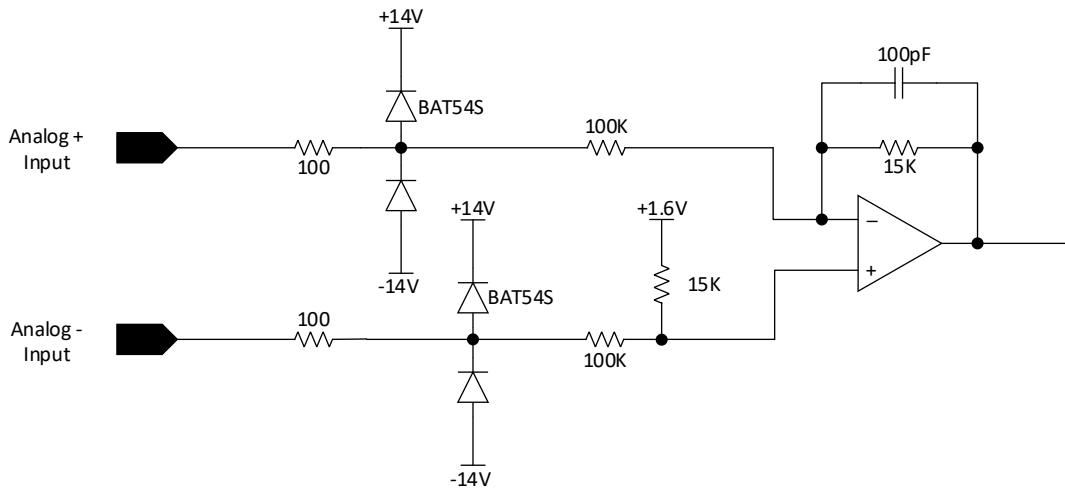The scaling and offset for the analog input are configurable using the drive setup software.

Figure 24: Analog input circuit

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

9.4.2 Analog Output Circuit

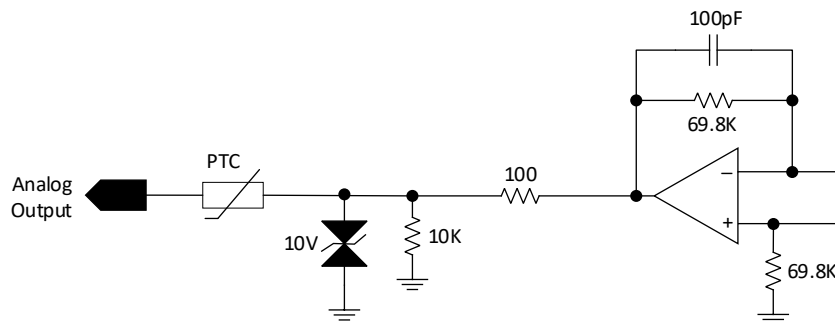The scaling for the analog output is configurable using the drive setup software.

Figure 25: Analog output circuit

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

The primary analog output circuit is limited to pin 9 on connector J5. A secondary analog output circuit is available on pin 6 of J5, however this is factory enabled only and requires a special order.

10 Communication

10.1 Connecting CAN

10.1.1 I/O Description

I/O Pin Name	Type	Functional Description
CAN H	In/Out	CAN differential signal High
CAN L	In/Out	CAN differential signal Low
Enable Out	Output	Open drain output that is pulled to GND and can be used to enable next CAN node.
Enable In +	Input	Isolated input that requires pull-up to external supply. Can be configured in CompleteArchitect™ to enable CAN and/or the Drive.
Enable In -	Input	Return for Enable In+.
+5V External	Output	Internally generated +5 volts for customer use.
Shield	-	Pass through for CAN cable shield ground.
Ground	-	Referenced to supply ground.
CAN V+	-	Pass thru (no connection).

10.1.2 CAN Physical Layer Circuit
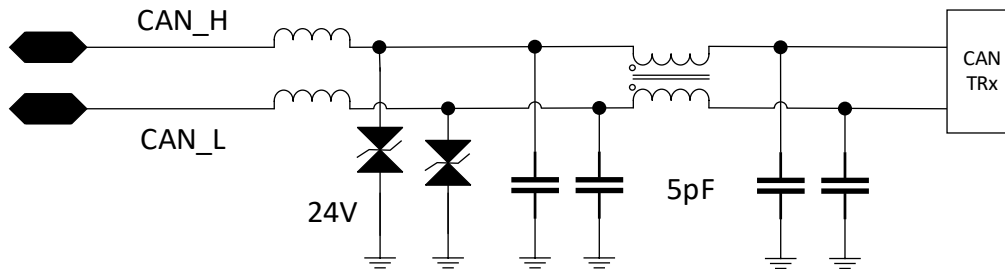

Figure 26: CAN Physical Layer Circuit

Important Note: A termination of 120 Ohms between CAN high and low signals is necessary at each end of the bus for ElectroCraft CAN (it is not required at each axis point). ElectroCraft standard drives do NOT include this termination.

10.1.3 CAN Input & Output Circuits
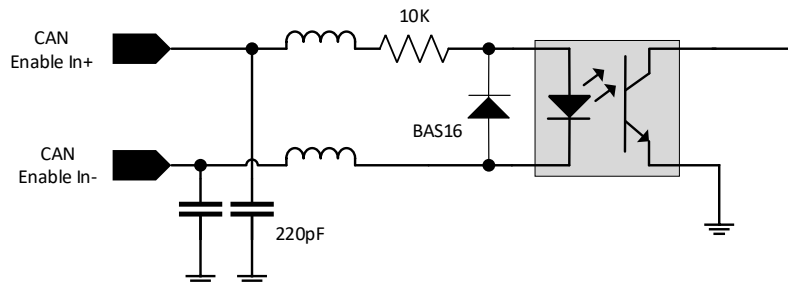
Figure 27: CAN Enable (High and Low) Input Interface
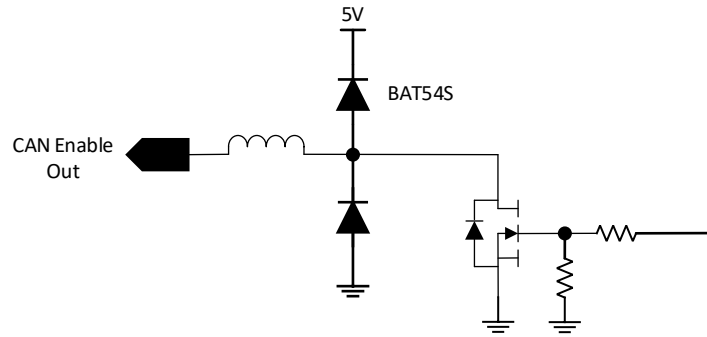
Figure 28: CAN Enable (Low) Output Interface

The CAN enable circuits can be used to daisy chain multiple drives together. This is achieved by connecting the CAN enable output circuit of one drive to the CAN EN- circuit to the next drive. See Figure 29 below. Note that the 5V external supply is provided from the first drive to the second drive for CAN enable high input. The second drive (and subsequent drives) can also be pulled up by an external source. See section 4.3.12 for electrical specifications.

Figure 29: Drive Daisy Chain Operation

10.1.4 CAN Address Settings

The CAN enable input can be configured using CompleteArchitect™ and has the following options:

a) **Not used**: The drive will ignore this input (default factory setting).
b) **Enable CAN**: This will enable the CAN operation. The drive will not transmit or receive any messages on the CAN bus without this input enabled.
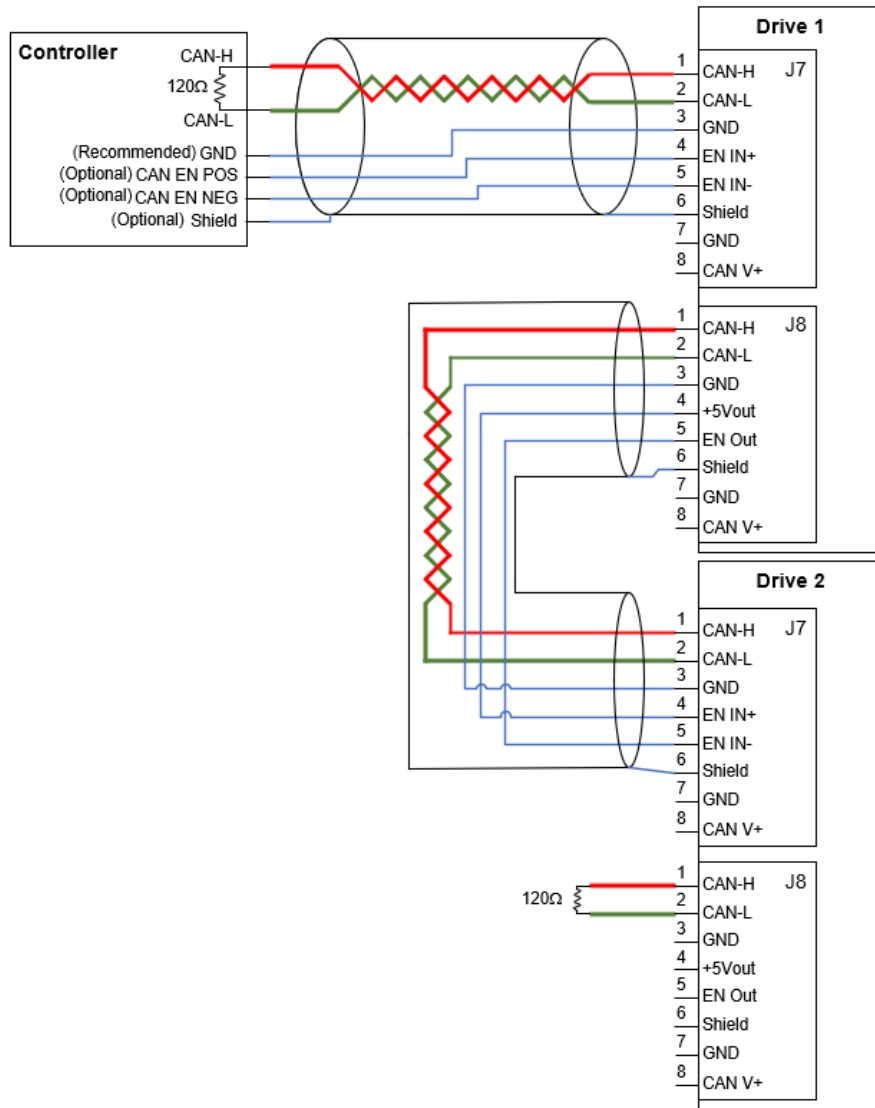c) **Enable Drive**: The input can be used as the drive's enable input instead of the default enable input on the I/O connector.
d) **Enable CAN and Drive**: Use this input to enable both CAN and the drive.

10.1.5 CAN Address Settings

To receive Axis Messages on the CAN bus network, the drive must have a valid non-zero AXIS-ID. The Axis-ID is non-volatile and needs to be set just once. Axis-IDs in the range 1-127 are available.

The AXIS-ID can be set either:
a) Assigned by CompleteArchitect™.
b) In hardware using the Axis-ID 4 position switch on the drive (SW1). Axis-IDs in the range 1-15 are available by this method. See table below.

SW ID	Name	Description
ID1	ADDR0	Hardware CAN Axis-ID bit 0
ID2	ADDR1	Hardware CAN Axis-ID bit 1
ID3	ADDR2	Hardware CAN Axis-ID bit 2
ID4	ADDR3	Hardware CAN Axis-ID bit 3

c) CAN Axis-ID configured in CompleteArchitect™ as a base address plus hardware switches.
d) Dynamically assigned at power up over the CAN bus.

As shipped from the factory, standard ElectroCraft drives are configured with an AXIS-ID of 1. Additional information regarding CAN operation can be found in the ElectroCraft CAN Reference Manual (198-0000088).

10.2 Connecting USB

An USB Type A Male to Micro 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 Micro USB Type B Male to the drive as shown in Figure 30. Follow steps as specified in CompleteArchitect™ user manual to establish communication between PC software and drive.
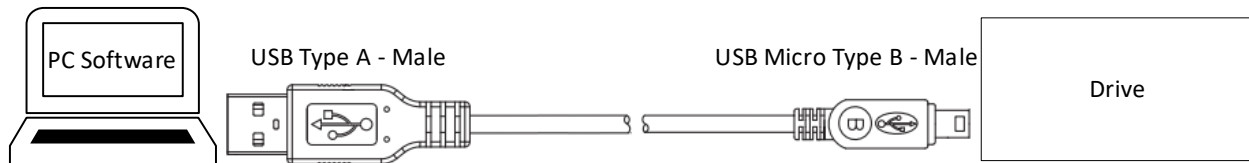

Figure 30: USB cable connection between computer and drive

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 4) 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 2 for details on Software settings.

If the drive does not function, refer to Troubleshooting section 14.

12   eBrake Control

The drive includes an output circuit that can be used to control an external electromechanical brake. There are two options for this, as indicated below:

- **Option 1:** For high current applications, a relay or switch can be driven by the output.
- **Option 2:** For low current applications, the eBrake can be driven directly by the output.
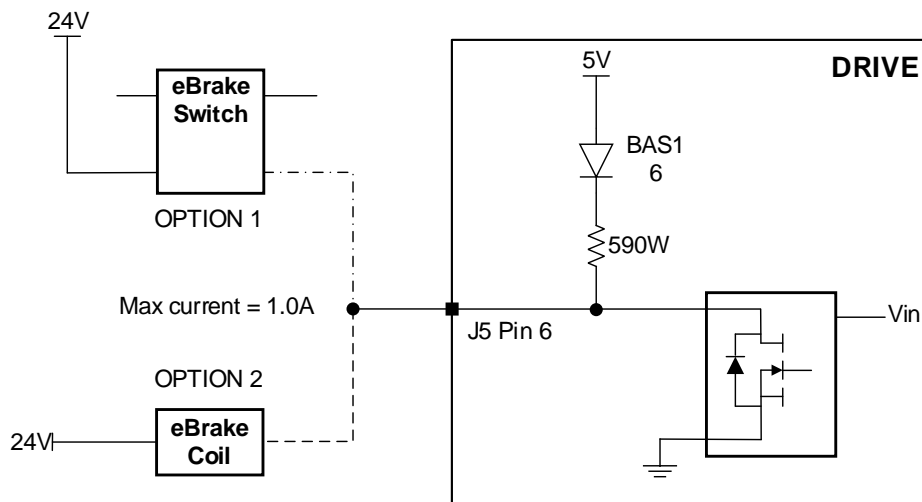

Figure 31: eBrake Control Interface

Control parameters for the eBrake output are configurable in CompleteArchitect™.

The user should consider the use case for the electromechanical brake and consult product requirements for voltage, current and timing specifications. See section 4.3.8 for electrical specifications for eBrake output circuit.

13   Adding an External Brake Resistor

13.1   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.

13.2   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 13.5. 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. Figure 32 shows the behavior of bus voltage in coordination with braking resistor's On and Off time.
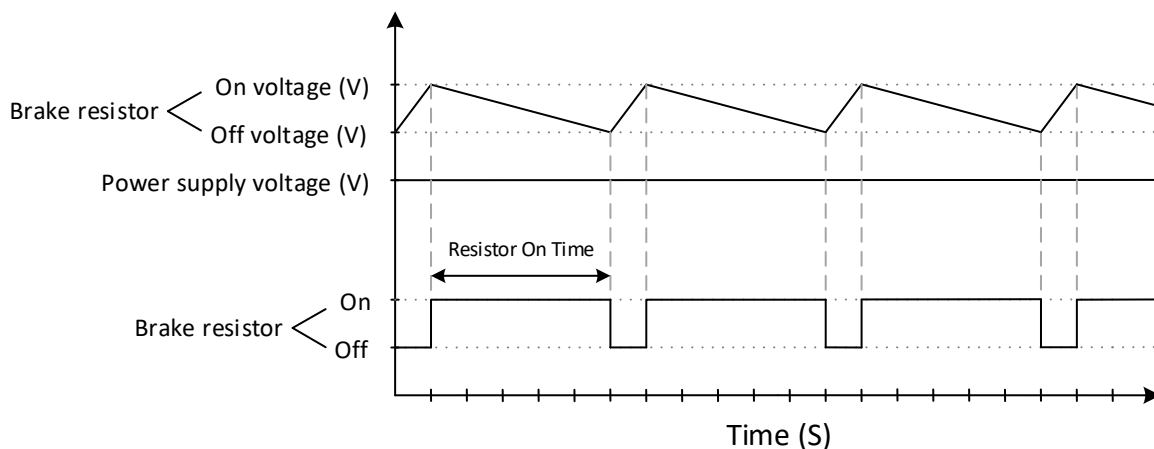
Figure 32: Brake resistor operation graph

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 13.5 for wiring an external temperature sensitive switch to the drive.

13.3 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.

13.3.1 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 24 A. 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)
24	12	0.5
	24	1
	48	2
	60	2.5
	80	3.33

The resistance value for appropriate power supply voltage (when brake resistor On and Off voltages are set according to section 13.3.2) 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 14 for drive fault codes) indicates that the resistor is not dissipating enough power. A lower value resistor or lower deceleration current may be required.

13.3.2 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 48 V and motor deceleration current of 24 A is as follows:

$$Maximum\ Power\ value = (48 + 4)\ x\ 24 = 1248\ Watts$$

The power rating of the braking resistor **need not** be the maximum 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 48 V and motor deceleration current of 24 A, so a 2 ohm resistor is picked (according to section 13.3.1). 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	52	Volts
Deceleration current	24	Amps

$$Duty\ Cycle = 4/10 = 0.4$$
$$Average\ Power\ value = 52\ x\ 24\ x\ 0.4 = 500\ Watts$$

Therefore, in this example a 500 Watts resistor will be able to handle the braking power of 1248 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.

$$Duty\ Cycle = 4/10 = 0.4$$
$$Average\ Power\ value = 500\ Watts$$

A 500 watts resistor will not handle 1248 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 13.5), 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.

13.4 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 100 µF per each ampere deceleration current across J1 pin 1 and pin 2 as shown in section 13.5. For example, the application given in section 13.3.2 has a deceleration current of 24 A, so it will need a 2400 µF 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 100 µF per each ampere deceleration current could result in an overvoltage fault condition and may result in damage to the drive.

13.5 Connecting External Brake Resistor and Bulk Capacitor

The braking resistor and bulk capacitor wiring is shown in Figure 33.

Temperature Sensitive Device Connection: The user supplied temperature sensitive device is connected in series with the brake resistor as shown in Figure 33. 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 33 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.
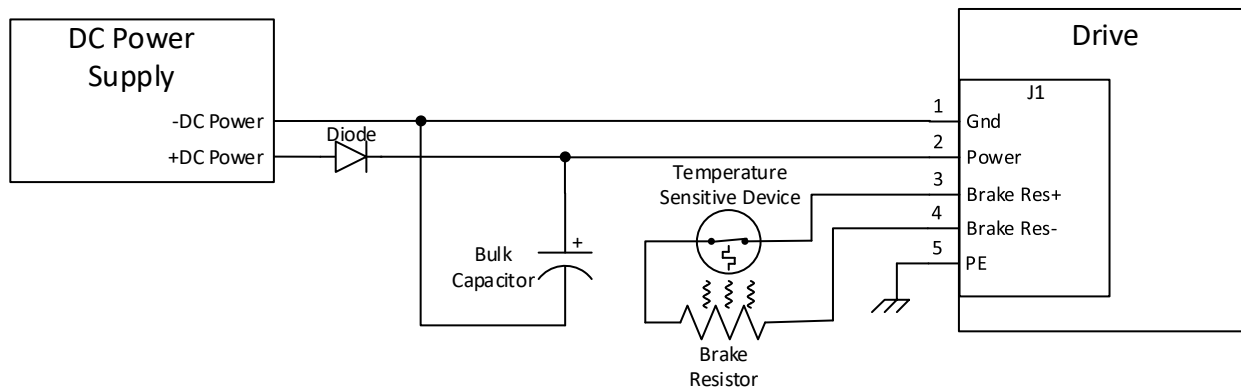

Figure 33: External brake resistor and bulk capacitor connection to the drive

The ElectroCraft Braking Module is designed for this purpose and is compatible with both CPP-A24V80A-SA-CAN and CPP-A40V24A-SA-CAN. Refer section 13.6 for application information.

13.6 ElectroCraft Braking Module Assembly

Figure 34: 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-A24V80A-SA-CAN (or CPP-A40V24A-SA-CAN) 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.

14   Troubleshooting

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

- Input voltage is 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 14.1 and 14.2 details the status LED flash codes and suggested recovery steps.

14.1   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.

14.2 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.