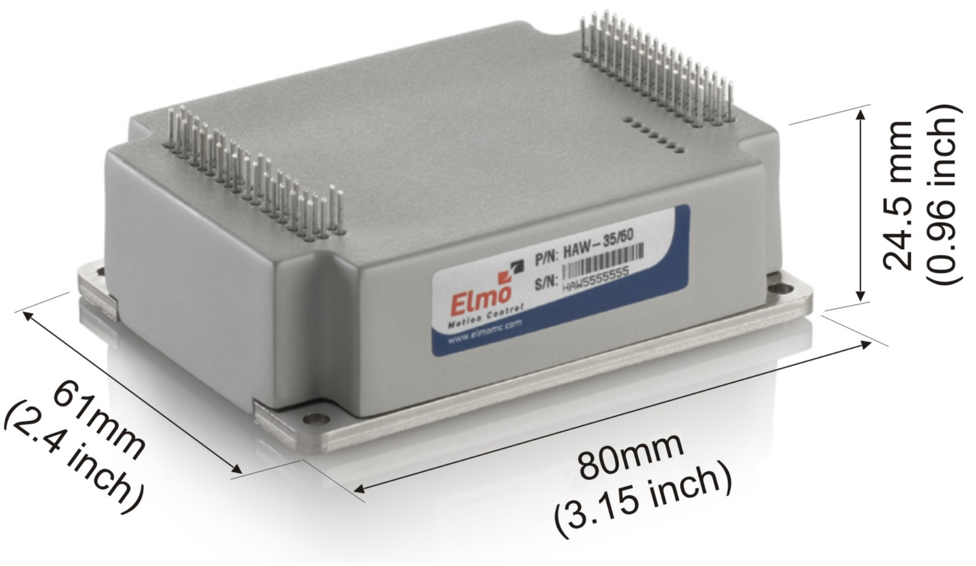
ExtrIQ Line

Hawk
Digital Servo Drive
Installation Guide



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Elmo
Motion Control

www.elmomc.com

Notice

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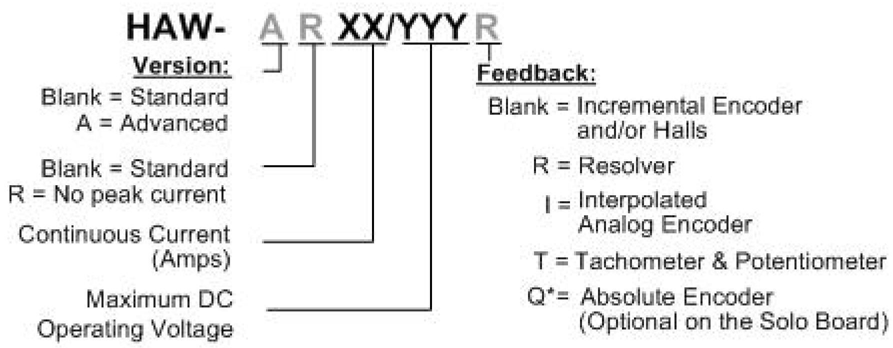
Catalog Number



Related Products

Evaluation Board	**Catalog Number**: EVA-WHI/GUI/BEL
Evaluation Board User Manual	MAN-EVLBRD-WHI-BEL-GUI.pdf (available on our web site)

Revision History

Version	Date	Details
1.0	May 2008	Initial release
1.1	June 2009	MTCR 05-009-53: Updated Section 3.8.3; added Sections 3.15 and 3.16
1.2	July 2010	MTCR 03-010-02: Updated Section 3.4, Figure 22 and Section 4.1.8
1.3	September 2012	Formatted according to the new template "Metronome" was replaced by the "Composer" software.
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Elmo Worldwide

Head Office

Elmo Motion Control Ltd.
60 Amal St., P.O. Box 3078, Petach Tikva 4951360
Israel

Tel: +972 (3) 929-2300 • Fax: +972 (3) 929-2322 • info-il@elmomc.com

North America

Elmo Motion Control Inc.
42 Technology Way, Nashua, NH 03060
USA

Tel: +1 (603) 821-9979 • Fax: +1 (603) 821-9943 • info-us@elmomc.com

Europe

Elmo Motion Control GmbH
Hermann-Schwer-Strasse 3, 78048 VS-Villingen
Germany

Tel: +49 (0) 7721-944 7120 • Fax: +49 (0) 7721-944 7130 • info-de@elmomc.com

China

Elmo Motion Control Technology (Shanghai) Co. Ltd.
Room 1414, Huawen Plaza, No. 999 Zhongshan West Road, Shanghai (200051)
China

Tel: +86-21-32516651 • Fax: +86-21-32516652 • info-asia@elmomc.com

Asia Pacific

Elmo Motion Control APAC Ltd.
B-601 Pangyo Innovalley, 621 Sampyeong-dong, Bundang-gu, Seongnam-si, Gyeonggi-do, South Korea (463-400)

Tel: +82-31-698-2010 • Fax: +82-31-801-8078 • info-asia@elmomc.com

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Chapter 1: Safety Information

In order to operate the Hawk servo drive safely, it is imperative that you implement the safety procedures included in this installation guide. This information is provided to protect you and to keep your work area safe when operating the Hawk and accompanying equipment.

Please read this chapter carefully before you begin the installation process.

Before you start, ensure that all system components are connected to earth ground. Electrical safety is provided through a low-resistance earth connection.

Only qualified personnel may install, adjust, maintain and repair the servo drive. A qualified person has the knowledge and authorization to perform tasks such as transporting, assembling, installing, commissioning and operating motors.

The Hawk servo drive contains electrostatic-sensitive components that can be damaged if handled incorrectly. To prevent any electrostatic damage, avoid contact with highly insulating materials, such as plastic film and synthetic fabrics. Place the product on a conductive surface and ground yourself in order to discharge any possible static electricity build-up.

To avoid any potential hazards that may cause severe personal injury or damage to the product during operation, keep all covers and cabinet doors shut.

The following safety symbols are used in this manual:

Warning:
This information is needed to avoid a safety hazard, which might cause bodily injury.

Caution:
This information is necessary for preventing damage to the product or to other equipment.

1.1. Warnings

- To avoid electric arcing and hazards to personnel and electrical contacts, never connect/disconnect the servo drive while the power source is on.
- Power cables can carry a high voltage, even when the motor is not in motion. Disconnect the Hawk from all voltage sources before it is opened for servicing.
- The Hawk servo drive contains grounding conduits for electric current protection. Any disruption to these conduits may cause the instrument to become hot (live) and dangerous.
- After shutting off the power and removing the power source from your equipment, wait at least 1 minute before touching or disconnecting parts of the equipment that are normally loaded with electrical charges (such as capacitors or contacts). Measuring the electrical contact points with a meter, before touching the equipment, is recommended.

1.2. Cautions

- The Hawk servo drive contains hot surfaces and electrically-charged components during operation.
- The maximum DC power supply connected to the instrument must comply with the parameters outlined in this guide.
- When connecting the Hawk to an approved 12 to 195 VDC auxiliary power supply, connect it through a line that is separated from hazardous live voltages using reinforced or double insulation in accordance with approved safety standards.
- Before switching on the Hawk, verify that all safety precautions have been observed and that the installation procedures in this manual have been followed.
- Do not clean any of the Hawk drive's soldering with solvent cleaning fluids of pH greater than 7 (8 to 14). The solvent corrodes the plastic cover causing cracks and eventual damage to the drive's PCBs.

  Elmo recommends using the cleaning fluid Vigon-EFM which is pH Neutral (7).

  For further technical information on this recommended cleaning fluid, select the link:

  http://www.zestron.com/fileadmin/zestron.com-usa/daten/electronics/Product_TI1s/TI1-VIGON_EFM-US.pdf

1.3. Directives and Standards

The Hawk conforms to the following industry safety standards:

Safety Standard	Item
Approved **IEC/EN 61800-5-1, Safety**	Adjustable speed electrical power drive systems
Recognized **UL 508C**	Power Conversion Equipment
In compliance with **UL 840**	Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment
In compliance with **UL 60950-1** (formerly **UL 1950**)	Safety of Information Technology Equipment Including Electrical Business Equipment
In compliance with **EN 60204-1**	Low Voltage Directive 73/23/EEC

The Hawk servo drive has been developed, produced, tested and documented in accordance with the relevant standards. Elmo Motion Control is not responsible for any deviation from the configuration and installation described in this documentation. Furthermore, Elmo is not responsible for the performance of new measurements or ensuring that regulatory requirements are met.

1.4. CE Marking Conformance

The Hawk servo drive is intended for incorporation in a machine or end product. The actual end product must comply with all safety aspects of the relevant requirements of the European Safety of Machinery Directive 98/37/EC as amended, and with those of the most recent versions of standards **EN 60204-1** and **EN 292-2** at the least.

According to Annex III of Article 13 of Council Directive 93/68/EEC, amending Council Directive 73/23/EEC concerning electrical equipment designed for use within certain voltage limits, the Hawk meets the provisions outlined in Council Directive 73/23/EEC. The party responsible for ensuring that the equipment meets the limits required by EMC regulations is the manufacturer of the end product.

1.5. Warranty Information

The products covered in this manual are warranted to be free of defects in material and workmanship and conform to the specifications stated either within this document or in the product catalog description. All Elmo drives are warranted for a period of 12 months from the date of shipment. No other warranties, expressed or implied — and including a warranty of merchantability and fitness for a particular purpose — extend beyond this warranty.

Chapter 2: Introduction

This installation guide describes the Hawk servo drive and the steps for its wiring, installation and power-up. Following these guidelines ensures maximum functionality of the drive and the system to which it is connected.

2.1. *ExtrIQ* Product Family

Elmo Motion Control's ***ExtrIQ*** product family is a set of durable motion control products for applications operating under extreme environmental conditions. The products are capable of withstanding the following extreme conditions:

Feature	Operation Conditions	Range
Ambient Temperature Range	Non-operating Conditions	-50 °C to +100 °C (-58 °F to 212 °F)
	Operating conditions	-40 °C to +70 °C (-40 °F to 160 °F)
Temperature Shock	Non-operating conditions	-40 °C to +70 °C (-40 °F to 160 °F) within 3 min
Altitude	Non-operating conditions	Unlimited
	Operating conditions	-400 m to 12,000 m (-1312 to 39370 feet)
Maximum Humidity	Non-operating conditions	Up to 95% non-condensing humidity at 35 °C (95 °F)
	Operating conditions	Up to 95% non-condensing humidity at 25 °C (77 °F), up to 90% non-condensing humidity at 42 °C (108 °F)
Vibration	Operating conditions	20 Hz to 2000 Hz, 14.6g
Mechanical Shock	Non-operating conditions	±40g; Half sine, 11 msec
	Operating conditions	±20g; Half sine, 11 msec

ExtrIQ products have a high power density in the range of 50 W to 65,000 W and current carrying capacity of up to 140 A (280 A peak). ***ExtrIQ*** has been tested using methods and procedures specified in a variety of extended environmental conditions (EEC) standards.

Based on Elmo Motion Control's innovative ***ExtrIQ*** core technology, they support a wide range of motor feedback options, programming capabilities and communication protocols.

2.1.1. Drive Description

The Hawk series of digital servo drives is designed to deliver "the highest density of power and intelligence". The Hawk delivers up to **4.8 kW of continuous power** or **8.0 kW of peak power** in a 119. 6 cc (6.95 in^3) package (80 x 24.5 x 61 mm or 3.15" x 0.965" x 2.4").

The Hawk is designed for OEMs. It operates from a DC power source in current, velocity, position and advanced position modes, in conjunction with a permanent-magnet synchronous brushless motor, DC brush motor, linear motor or voice coil. It is designed for use with any type of sinusoidal and trapezoidal commutation, with vector control. The Hawk can operate as a stand-alone device or as part of a multi-axis system in a distributed configuration on a real-time network.

The Hawk drive is easily set up and tuned using Elmo's *Composer* software tools. This Windows-based application enables users to quickly and simply configure the servo drive for optimal use with their motor. The Hawk, as part of the *ExtrIQ* product line, is fully programmable with Elmo *Composer* motion control language.

Power to the Hawk is provided by a 12 to 195 VDC isolated DC power source (not included with the Hawk). A "smart" control-supply algorithm enables the Hawk to operate with only one power supply with no need for an auxiliary power supply for the logic.

If backup functionality is required for storing control parameters in case of power-loss, an external 12 to 195 VDC isolated supply should be connected (via the +VL terminal on the Hawk) providing maximum flexibility and backup functionality when needed.

Note: This backup power supply can operate from any voltage source within the 12 to 195 VDC range. This is much more flexible than a standard 24 VDC power supply requirement.

If backup power is not needed, two terminals (VP and VL) are shorted so that the main power supply will also power the control/logic supply. In this way there is no need for a separate control/logic supply.

The Hawk is a PCB mounted device which enables efficient and economic implementation.

The Hawk is available in two models:

- The Standard Hawk is a basic servo drive which operates in current, velocity and position modes including Follower and PT & PVT. It operates simultaneously via RS-232 and CAN DS 301, DS 305, DS 402 communications and features a third-generation programming environment.
- The Advanced Hawk includes all the motion capabilities and communication options included in the Standard model, as well as advanced positioning capabilities: ECAM, Dual Loop and increased program size.

Both versions operate with RS-232 and CAN communication.

2.2. Product Features

2.2.1. Current Control

- Fully digital
- Sinusoidal commutation with vector control or trapezoidal commutation with encoder and/or digital Hall sensors
- 12-bit current loop resolution
- Automatic gain scheduling, to compensate for variations in the DC bus power supply

2.2.2. Velocity Control

- Fully digital
- Programmable PI and FFW (feed forward) control filters
- Sample rate two times current loop sample time
- “On-the-fly” gain scheduling
- Automatic, manual and advanced manual tuning and determination of optimal gain and phase margins

2.2.3. Position Control

- Programmable PIP control filter
- Programmable notch and low-pass filters
- Position follower mode for monitoring the motion of the slave axis relative to a master axis, via an auxiliary encoder input
- Pulse-and-direction inputs
- Sample time: four times that of the current loop
- Fast event capturing inputs
- PT and PVT motion modes
- Fast output compare (OC)
- Position-based and time-based ECAM mode that supports a non-linear follower mode, in which the motor tracks the master motion using an ECAM table stored in flash memory
- Dual (position/velocity) loop

2.2.4. Communication Options

Depending on the application, Hawk users can select from two communication options:

- RS-232 serial communication
- CAN for fast communication in a multi-axis distributed environment

2.2.5. Feedback Options

- Incremental Encoder – up to 20 Mega-Counts (5 Mega-Pulse) per second
- Digital Halls – up to 2 kHz
- Incremental Encoder with Digital Halls for commutation – up to 20 Mega-Counts per second for encoder
- Interpolated Analog (Sine/Cosine) Encoder – up to 250 kHz (analog signal)
  - Internal interpolation - up to x4096
  - Automatic correction of amplitude mismatch, phase mismatch, signals offset
  - Auxiliary emulated, unbuffered, single-ended, encoder output
- Resolver
  - Programmable 10 to 15 bit resolution
  - Up to 512 revolutions per second (RPS)
  - Auxiliary emulated, unbuffered, single-ended, encoder output
- Tachometer, Potentiometer
- Elmo drives provide supply voltage for all the feedback options

2.2.6. Fault Protection

The Hawk includes built-in protection against possible fault conditions, including:

- Software error handling
- Status reporting for a large number of possible fault conditions
- Protection against conditions such as excessive temperature, under/over voltage, loss of commutation signal, short circuits between the motor power outputs and between each output and power input/return
- Recovery from loss of commutation signals and from communication errors

2.3. System Architecture

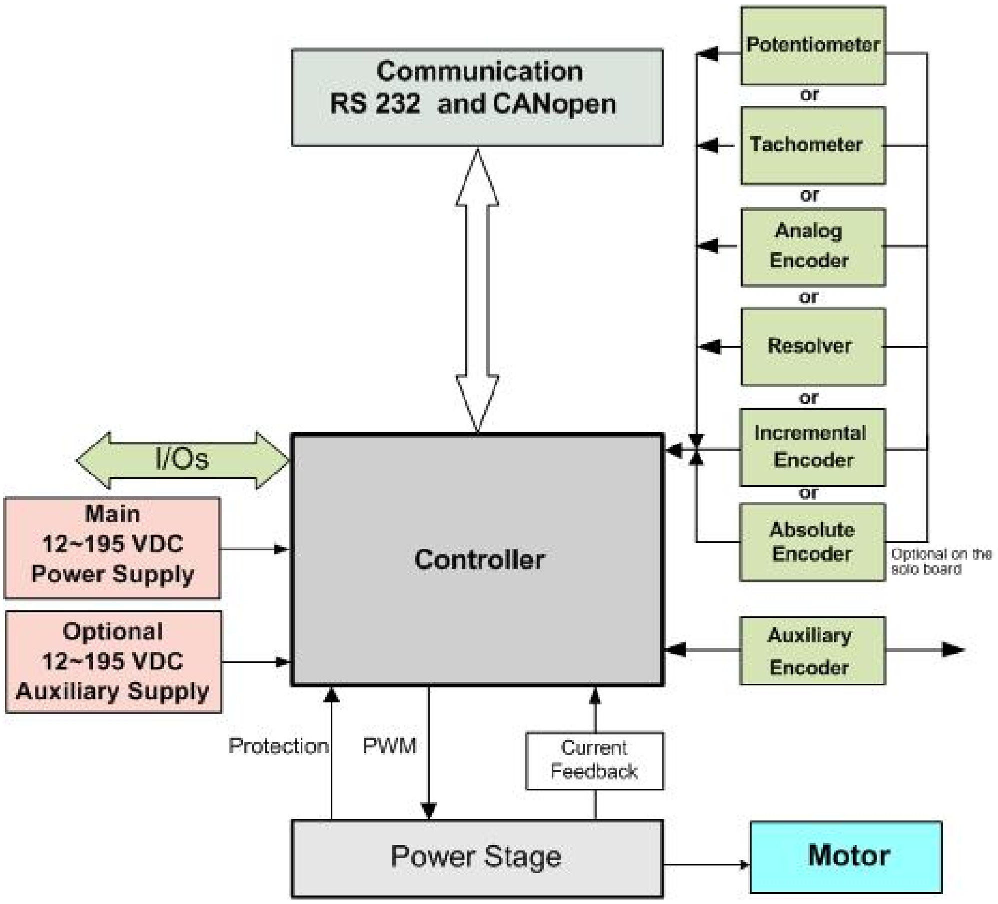


Figure 1: Hawk System Block Diagram

2.4. How to Use this Guide

In order to install and operate your Elmo Hawk servo drive, you will use this manual in conjunction with a set of Elmo documentation. Installation is your first step; after carefully reading the safety instructions in the first chapter, the following chapters provide you with installation instructions as follows:

- Chapter 3, *Installation*, provides step-by-step instructions for unpacking, mounting, connecting and powering up the Hawk.
- Chapter 4, *Technical Specifications,* lists all the drive ratings and specifications.

Upon completing the instructions in this guide, your Hawk servo drive should be successfully mounted and installed. From this stage, you need to consult higher-level Elmo documentation in order to set up and fine-tune the system for optimal operation. The following figure describes the accompanying documentation that you will require.

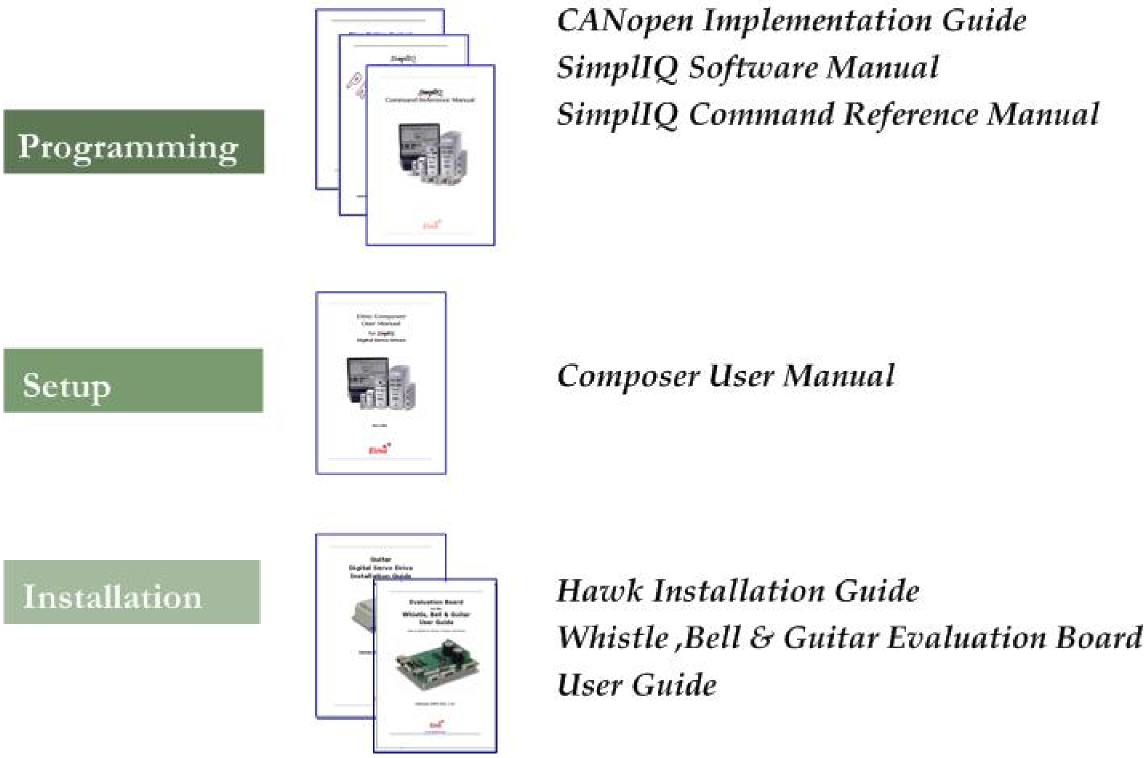


Figure 2: Elmo Digital Servo Drive Documentation Hierarchy

As depicted in the previous figure, this installation guide is an integral part of the Hawk documentation set, comprising:

- The *SimplIQ Software Manual,* which describes the comprehensive software used with the Hawk
- The *SimplIQ Command Reference Manual,* which describes, in detail, each software command used to manipulate the Hawk motion controller
- The Composer *Software Manual,* which includes explanations of all the software tools that are part of Elmo's Composer software environment
- The *Whistle, Bell & Guitar Evaluation Board User Guide* contains information about how to use the Evaluation Board and Cable Kit

Chapter 3: Installation

The Hawk must be installed in a suitable environment and properly connected to its voltage supplies and the motor.

3.1. Site Requirements

You can guarantee the safe operation of the Hawk by ensuring that it is installed in an appropriate environment.

Feature	Value
Ambient operating temperature	-40 °C to +70 °C (-40 °F to 160 °F)
Maximum operating altitude	12,000 m (39370 feet)
Maximum non-condensing humidity	95%
Operating area atmosphere	No flammable gases or vapors permitted in area
Models for extended environmental conditions are available.	

Caution:
The Hawk dissipates its heat by convection. The maximum operating ambient temperature of 0 °C to 40 °C (32 °F to 104 °F) must not be exceeded.

3.2. Unpacking the Drive Components

Before you begin working with the Hawk, verify that you have all of its components, as follows:

- The Hawk servo drive
- The Composer software and software manual

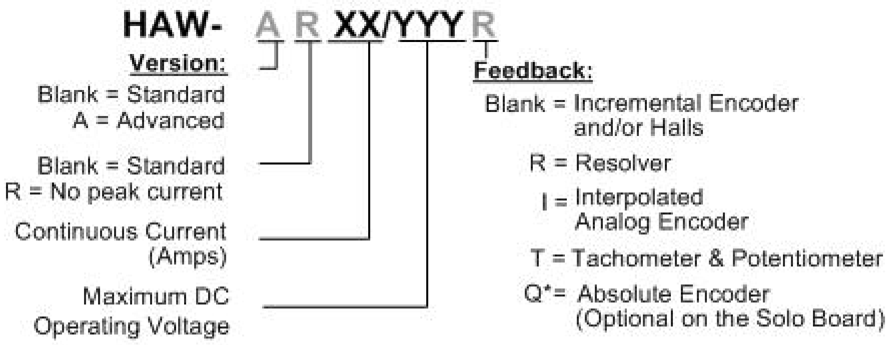
The Hawk is shipped in a cardboard box with Styrofoam protection.

To unpack the Hawk:

1. Carefully remove the servo drive from the box and the Styrofoam.
2. Check the drive to ensure that there is no visible damage to the instrument. If any damage has occurred, report it immediately to the carrier that delivered your drive.

3. To ensure that the Hawk you have unpacked is the appropriate type for your requirements, locate the part number sticker on the side of the Hawk. It looks like this:

The part number at the top gives the type designation as follows:

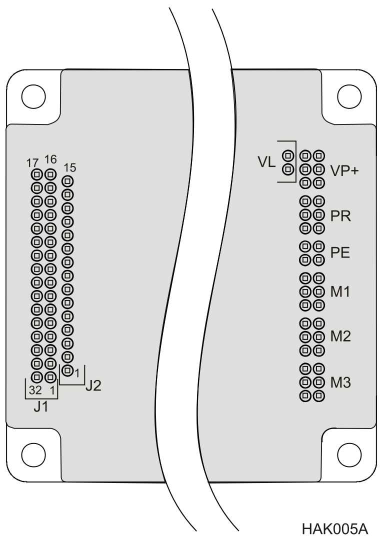


4. Verify that the Hawk type is the one that you ordered, and ensure that the voltage meets your specific requirements.

3.3. Pinouts

The Hawk has nine connectors.

3.3.1. Connector Types

Pins	Type	Port	Function	Connector Location
2x16	2 mm pitch 0.51 mm sq	J1	I/O, COMM, Auxiliary Feedback	
15		J2	Main Feedback, Analog Input, LED	
6		VL	Auxiliary power input	
6		VP+	Positive power input	
6		PR	Power input return	
4		PE	Protective earth	
6		M1	Motor power output 1	
6		M2	Motor power output 2	
2		M3	Motor power output 3	

3.3.2. Connector J1

Connector J1: Main Feedback and Analog Input functions

Pin (J1)	Signal	Function
1	RS232_RX	RS232 receive
2	RS232_TX	RS232 Transmit
3	RS232_COMRET	Communication return
4	AUX PORT CHA	Auxiliary port CHA (bidirectional)
5	AUX PORT CHB	Auxiliary port CHB (bidirectional)
6	SUPRET	Supply return
7	OUT1	Programmable digital output 1
8	OUT2	Programmable digital output 2
9	OUT3	Programmable digital output 3
10	OUT4	Programmable digital output 4
11	IN1	Programmable digital input 1
12	IN2	Programmable digital input 2
13	IN3	Programmable digital input 3
14	IN4	Programmable digital input 4
15	IN5	Programmable digital input 5
16	IN6	Programmable digital input 6
17	INRET6	Programmable digital input 6 return
18	INRET5	Programmable digital input 5 return
19	INRET4	Programmable digital input 4 return
20	INRET3	Programmable digital input 3 return
21	INRET2	Programmable digital input 2 return
22	INRET1	Programmable digital input 1 return
23	OUTRET4	Programmable digital output 4 return
24	OUTRET3	Programmable digital output 3 return
25	OUTRET2	Programmable digital output 2 return
26	OUTRET1	Programmable digital output 1 return

Pin (J1)	Signal	Function
27	+5 V	Encoder +5 V supply voltage. Maximum output current: 200 mA.
28	COMRET	Common return
29	AUX PORT INDEX	Auxiliary port index (bidirectional)
30	CAN_COMRET	CAN communication return
31	CAN_L	CAN_L busline (dominant low)
32	CAN_H	CAN_H busline (dominant high)

3.3.3. Connector J2

Connector J2: Communications, Auxiliary Feedback and I/O functions

Pin (J2)	Signal	Function
1	+5V	Encoder/Hall +5V supply voltage Maximum output current: 200 mA
2	SUPRET	Supply return
3	ANALIN1+	Analog input 1+
4	ANALIN1-	Analog input 1-
5	CHA	Channel A input
6	CHA-	Channel A input complement
7	CHB	Channel B input
8	CHB-	Channel B input complement
9	INDEX+	Index input
10	INDEX-	Index input complement
11	HA	Hall sensor A input
12	HB	Hall sensor B input
13	HC	Hall sensor C input
14	LED_2_OUT	Bi-color indication output 2 (Cathode)
15	LED_1_OUT	Bi-color indication output 1 (Anode)

3.4. Mounting the Hawk

The Hawk was designed for mounting on a printed circuit board (PCB) via 2 mm pitch 0.51 mm square pins. When integrating the Hawk into a device, be sure to leave about 1 cm (0.4") outward from the heatsink to enable free air convection around the drive. We recommend that the Hawk be soldered directly to the board. Alternatively, though this is not recommended, the Hawk can be attached to socket connectors mounted on the PCB. If the PCB is enclosed in a metal chassis, we recommend that the Hawk be screw-mounted to it as well to help with heat dissipation. The Hawk has screw-mount holes on each corner of the heatsink for this purpose – see below.

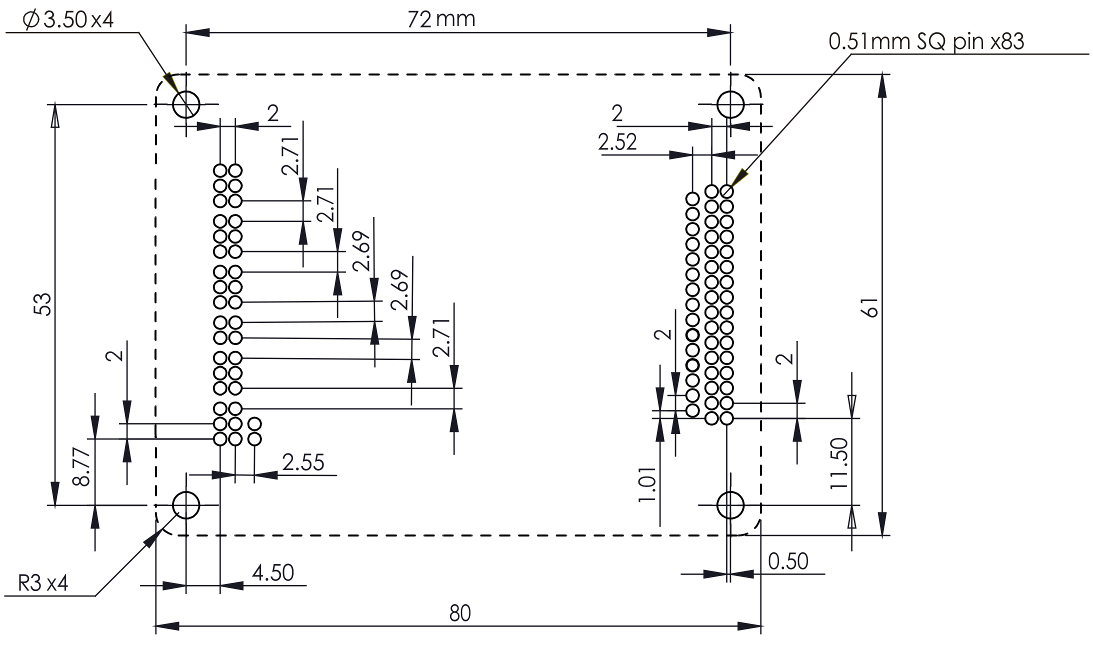


Figure 3: The Hawk Footprint

When the Hawk is not connected to a metal chassis, the application's thermal profile may require a solution for heat dissipation due to insufficient air convection. In this case, we recommend that you connect an external heatsink.

3.5. Integrating the Hawk on a PCB

The Hawk is designed to be mounted on a PCB, either by soldering its pins directly to the PCB or by using suitable socket connectors. In both cases the rules in the following sub-sections apply.

3.5.1. Traces

1. The **size of the traces** on the PCB (thickness and width) is determined by the current carrying capacity required by the application.
   - The rated continuous current limit (Ic) of the Hawk is the current used for sizing the motor traces (M1, M2, M3 and PE) and power traces (VP+, PR and PE).
   - For control, feedbacks and Inputs/outputs conductors the actual current is very small but "generous" thickness and width of the conductors will contribute to a better performance and lower interferences.
2. The **traces should be as short as possible** to minimize EMI and to minimize the heat generated by the conductors.
3. The **spacing** between the high voltage conductors (VP+, PR, M1, M2, M3, VL) must be at least:
   - Surface layer: 1.5 mm
   - Internal layer: 0.5 mm

Complying with the rules above will help satisfy UL safety standards, and the IPC-D-275 standard for non-coated conductors, operating at voltages lower than 200 VDC.

3.5.2. Grounds and Returns

The "Returns" of the Hawk are structured internally in a star configuration. The returns in each functional block are listed below:

Functional Block	Return Pin
Power	PR (Power Return)
Internal Switch Mode P.S.	PR (Power Return)
RS232 Communications	RS232_COMRET (J1/3)
CAN Communications	CAN_COMRET (J1/30)
Control section	COMRET (J1/28)
Main Feedback	SUPRET (J2/2)
Aux. Feedback	SUPRET (J1/6)
Analog input	ANLRET (J2/2)

The returns above are all shorted within the Hawk in a topology that results in optimum performance.

1. When wiring the traces of the above functions, on the Integration Board, the **Returns** of each function must be **wired separately** to its designated terminal on the Hawk. **DO NOT**

USE A COMMON GROUND PLANE. Shorting the commons on the Integration Board may cause performance degradation (ground loops, etc.).

2. **Inputs**: The 6 inputs are optically isolated from the other parts of the Hawk. Each input has a separate floating return (INRET1 for input 1 and INRET2 for input 2, etc.). To retain isolation, the Input Return pins, as well as other conductors on the input circuit, must be laid out separately.
3. **Outputs**: The 4 outputs are optically isolated from the other parts of the Hawk. Each output has a separate floating return (OUTRET1 for output 1 and OUTRET2 for output 2, etc.) To retain isolation, the Output Return pins, as well as other conductors on the output circuit, must be laid out separately.
4. **Return Traces:** The return traces should be as large as possible, but without shorting each other, and with minimal cross-overs.
5. **Main Power Supply and Motor Traces:** The power traces must be kept as far away as possible from the feedback, control and communication traces.
6. **PE Terminal**: The PE terminal is connected directly to the Hawk's heat-sink. The heat-sink serves as an EMI common plane. The PE terminal should be connected to the system's Protective Earth. Any other metallic parts (such as the chassis) of the assembly should be connected to the Protective Earth as well.
7. Under normal operating conditions, the PE trace carries no current. The only time these traces carry current is under abnormal conditions (such as when the device has become a potential shock or fire hazard while conducting external EMI interferences directly to ground). When connected properly the PE trace prevents these hazards from affecting the drive.

Caution:
Follow these instructions to ensure safe and proper implementation. Failure to meet any of the above-mentioned requirements can result in drive/controller/host failure.

3.6. The Hawk Connection Diagram

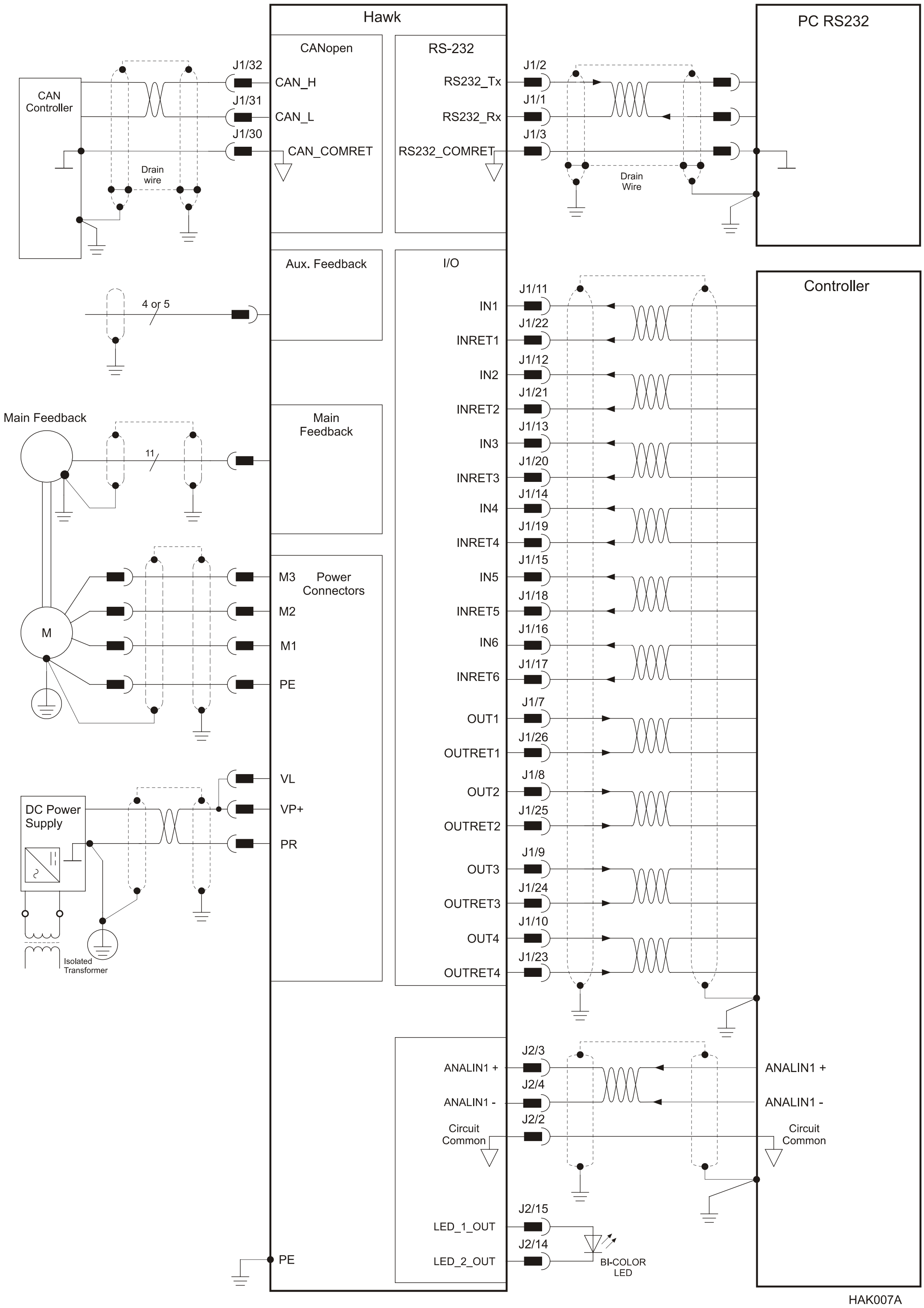
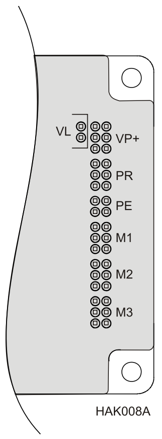


Figure 4: The Hawk Connection Diagram

3.7. Main Power and Motor Power

The Hawk receives power from main supply and delivers power to the motor. The table below describes the pinout connections to the main power and motor power cables.

Pin	Function	Cable		Pin Positions
VP+	Pos. Power input	Power		
PR	Power return	Power		
PE	Protective earth	Power		
		AC Motor	**DC Motor**	
PE	Protective earth	Motor	Motor	
M1	Motor phase	Motor	N/C	
M2	Motor phase	Motor	Motor	
M3	Motor phase	Motor	Motor	

Note: When connecting several drives to several motors, all should be wired in an identical manner. This will enable the same *ExtrIQ* program to run on all drives.

Table 1: Connector for Main Power and Motor

3.7.1. Connecting Motor Power

Connect the M1, M2, M3 and PE pins on the Hawk in the manner described in Section 3.5 (Integrating the Hawk on a PCB). The phase connection is arbitrary as the Composer will establish the proper commutation automatically during setup. However, if you plan to copy the setup to other drives, then the phase order on all copy drives must be the same.

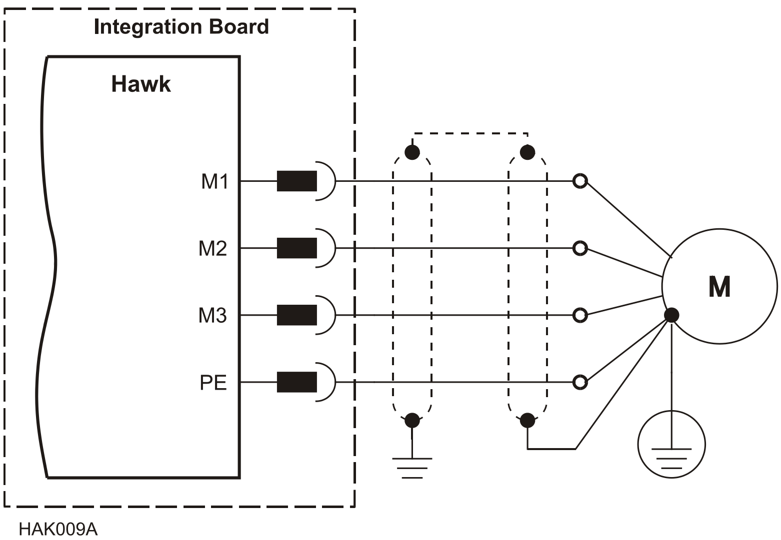


Figure 5: AC Motor Power Connection Diagram

3.7.2. Connecting Main Power

Connect the VP+, PR and PE pins on the Hawk in the manner described in Section 3.5 (Integrating the Hawk on a PCB).

Note: The source of the 12 to 195 VDC Main Power Supply must be isolated.

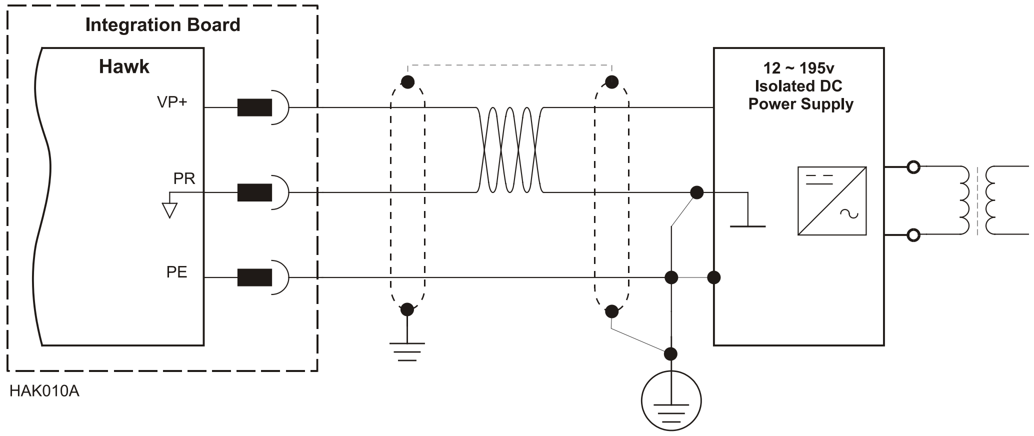


Figure 6: Main Power Supply Connection Diagram (no Auxiliary Supply)

3.8. Auxiliary Supply (for drive logic)

Notes for 12 to 195 VDC auxiliary supply connections:

- The source of the 12 to 195 VDC Auxiliary Supply must be isolated.

Connect the VL and PR pins on the Hawk in the manner described in Section 3.5 (Integrating the Hawk on a PCB).

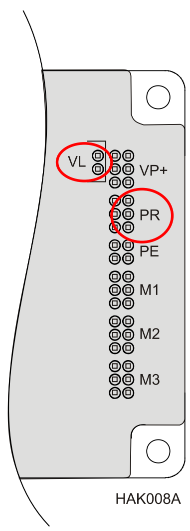
Pin	Function	Pin Positions
VL	Auxiliary Supply Input	
PR	Supply Input Return	
	**Caution:** Power from the Hawk to the motor must come from the Main Supply and **NOT** from the Auxiliary Supply.	

Table 2: Auxiliary Supply Pins

3.8.1. Single Supply

A single isolated DC power supply can provide power for both the main power and the Auxiliary (Drive Logic) Supply. The drawing below shows how a single supply is connected.

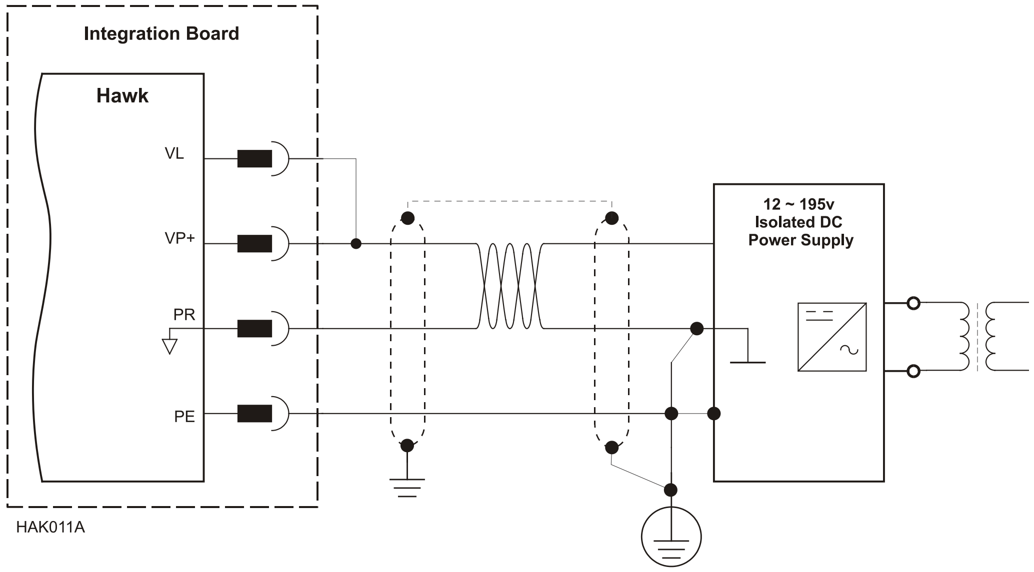


Figure 7: Single Supply for both the Main Power Supply and the Auxiliary Supply

3.8.2. Separate Auxiliary Supply

Power to the Auxiliary Supply can be provided by a separate Auxiliary Supply.

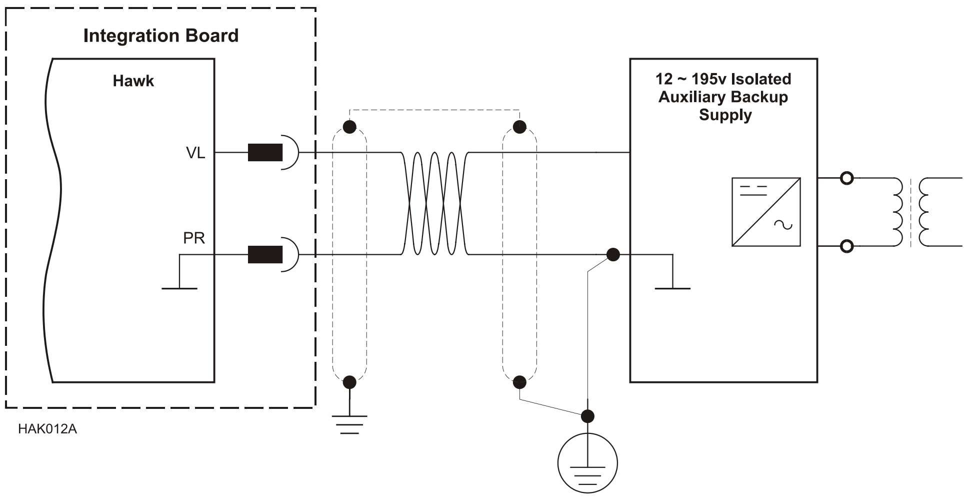


Figure 8: Separate Auxiliary Supply Connection Diagram

3.8.3. Shared Supply

A "Main" DC Power Supply can be designed to supply power to the drive's logic as well as to the Main Power (see Figure 7 and the upper portion of Figure 9). If backup functionality is required for continuous operation of the drive's logic in the event of a main power-out, a backup supply can be connected by implementing "diode coupling" (see the Aux. Backup Supply in Figure 9).

Note: Elmo's Evaluation Board (Catalog number: EVA-WHI/GUI/BEL) implements diode coupling on the board. When you create your own PCB, you need to implement diode coupling.

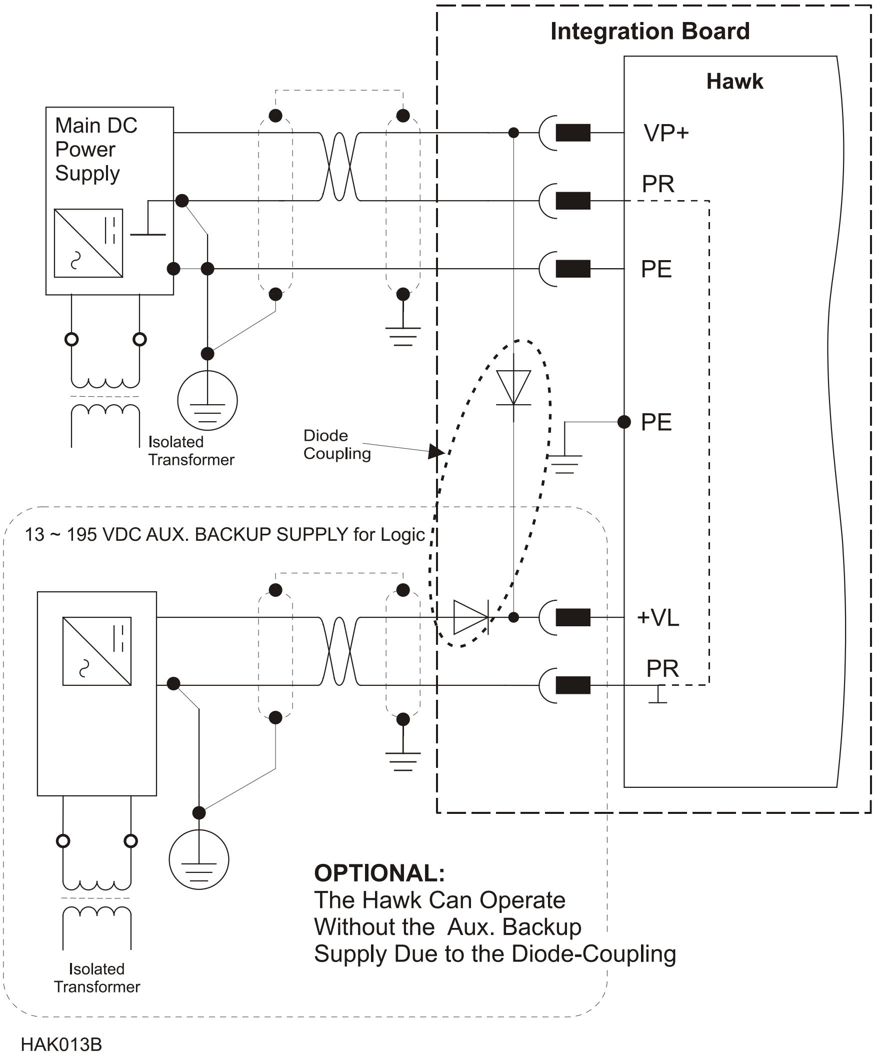


Figure 9: Shared Supply Connection Diagram

3.9. Main Feedback

The Main Feedback port is used to transfer feedback data from the motor to the drive.

The Hawk can accept any one the following devices as a main feedback mechanism:

- Incremental encoder only
- Incremental encoder with digital Hall sensors
- Digital Hall sensors only
- Interpolated Analog (Sine/Cosine) encoder (option)
- Resolver (option)
- Tachometer (option)
- Potentiometer (option)
- Absolute Encoder (optional on the solo board)

	Incremental Encoder		Interpolated Analog Encoder		Resolver		Tachometer and Potentiometer	
	HAW-XX/YYY_		HAW-XX/YYYI		HAW-XX/YYYR		HAW-XX/YYYT	
Pin (J2)	Signal	Function	Signal	Function	Signal	Function	Signal	Function
1	+5V	Encoder/Hall +5V supply	+5V	Encoder/Hall +5V supply	+5V	Encoder/Hall +5V supply	+5V	Encoder/Hall +5V supply
2	SUPRET	Supply return	SUPRET	Supply return	SUPRET	Supply return	SUPRET	Supply return
3	ANALIN+ is used for Analog Input							
4	ANALIN- is used for Analog Input							
5	CHA	Channel A	A+	Sine A	S1	Sine A	Tac 1+	Tacho Input 1 Pos. (20 V max)
6	CHA-	Channel A complement	A-	Sine A complement	S3	Sine A complement	Tac 1-	Tacho Input 1 Neg. (20 V max)
7	CHB	Channel B	B+	Cosine B	S2	Cosine B	Tac 2+	Tacho Input 2 Pos. (50 V max)
8	CHB-	Channel B complement	B-	Cosine B complement	S4	Cosine B complement	Tac 2-	Tacho Input 2 Neg. (50 V max)
9	INDEX	Index	R+	Reference	R1	Vref f=1/TS, 50 mA Max	POT	Potentiometer Input (5 V Max)
10	INDEX-	Index complement	R-	Reference complement	R2	Vref complement f = 1/TS, 50 mA Max	NC	-
11	HA	Hall sensor A input	HA	-	NC	-	HA	Hall sensor A input
12	HB	Hall sensor B input	HB	-	NC	-	HB	Hall sensor B input
13	HC	Hall sensor C input	HC	-	NC	-	HC	Hall sensor C input
14	LED_2_OUT (AOKLED cathode) is used for LED indication							
15	LED_1_OUT (AOKLED anode) is used for LED indication							

Table 3: Main Feedback Pin Assignments

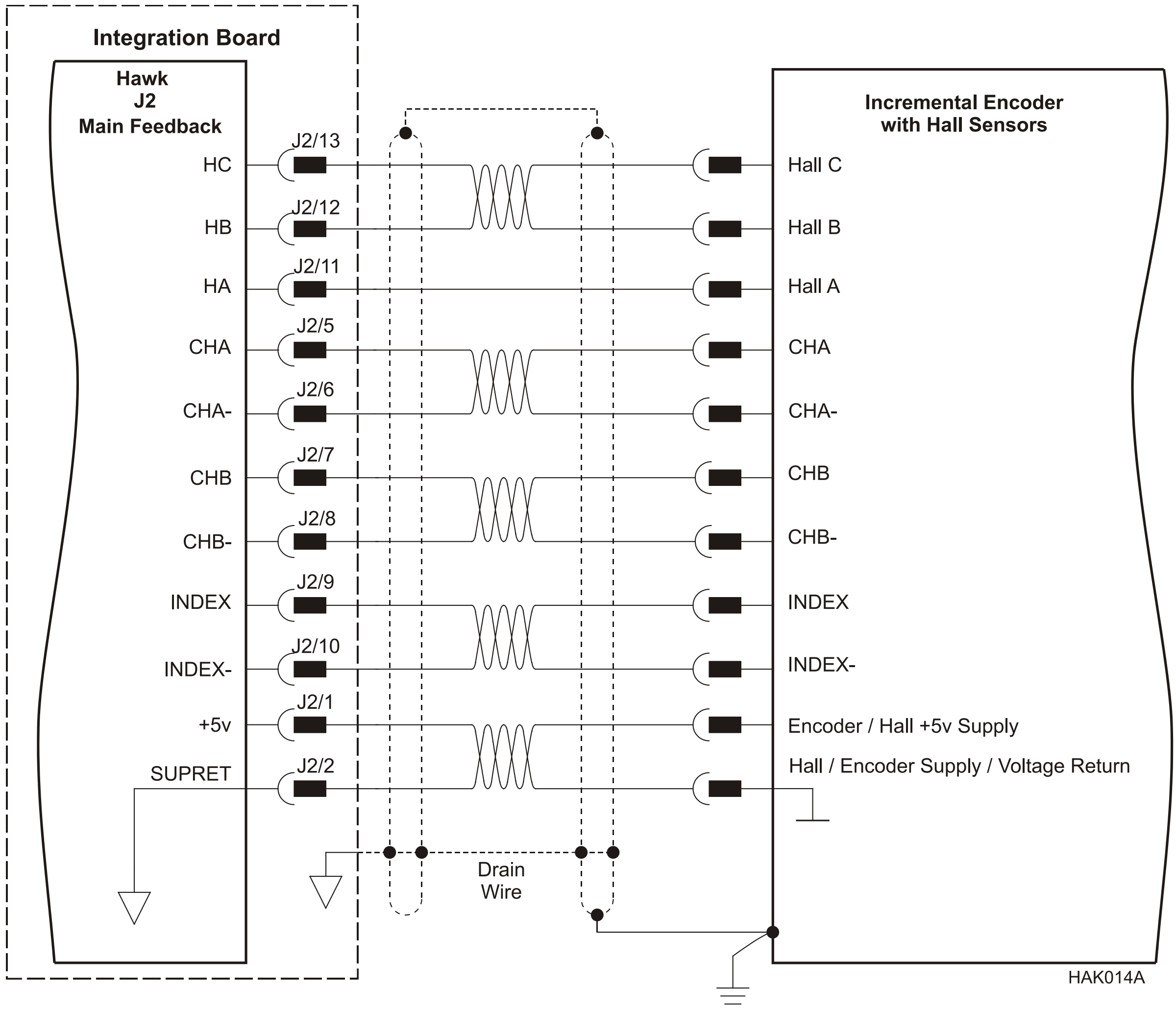


Figure 10: Main Feedback- Incremental Encoder with Digital Hall Sensors Connection Diagram

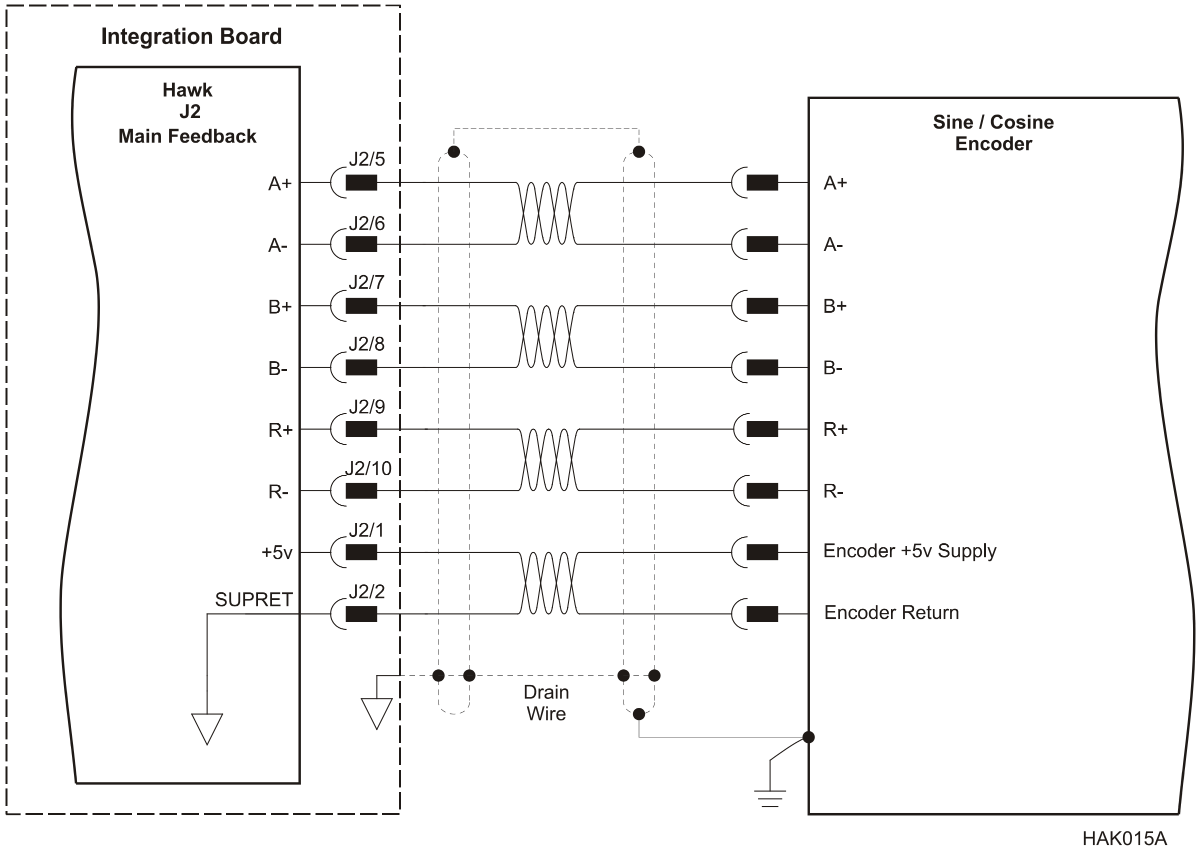


Figure 11: Main Feedback – Interpolated Analog (Sine/Cosine) Encoder Connection Diagram

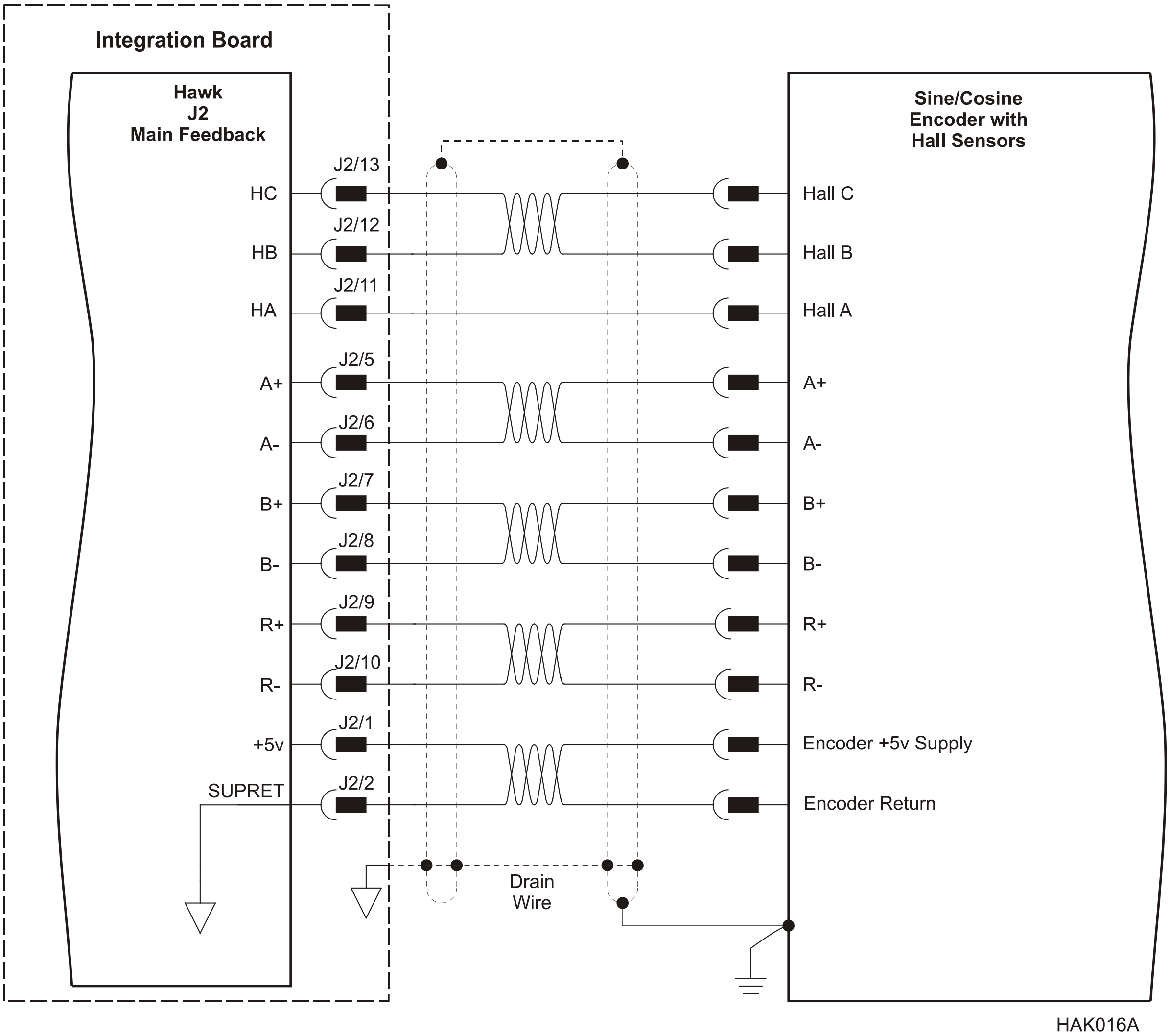


Figure 12: Main Feedback – Interpolated Analog (Sine/Cosine) Encoder with Digital Hall Sensors Connection Diagram

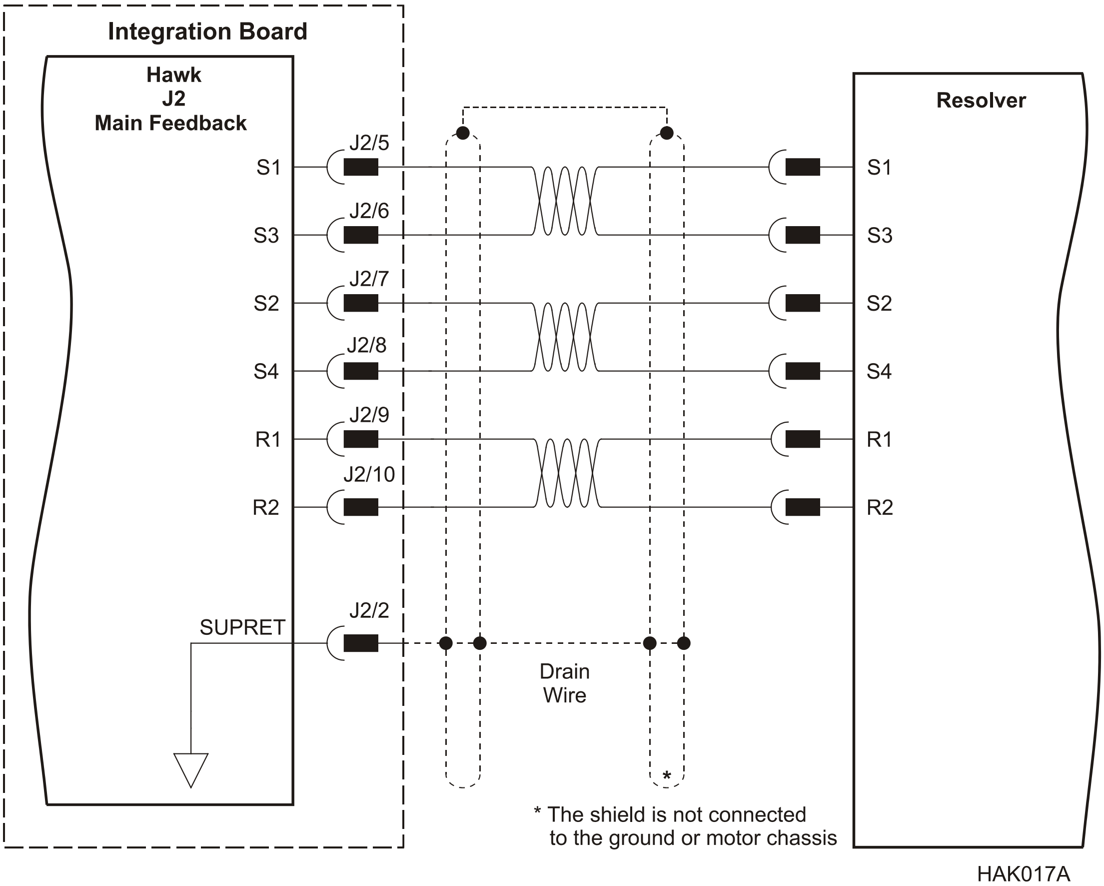


Figure 13: Main Feedback – Resolver Connection Diagram

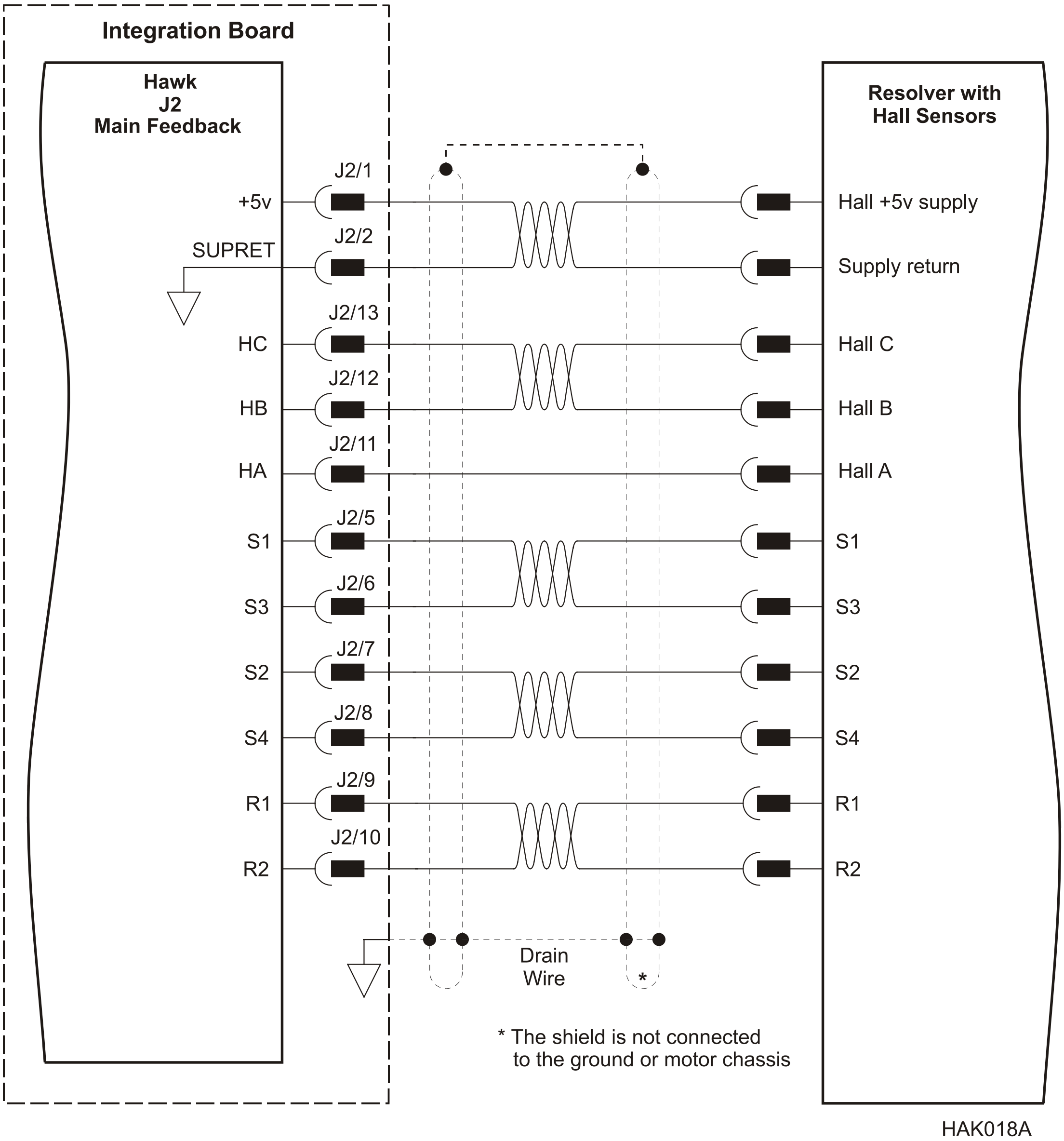


Figure 14: Main Feedback – Resolver and Digital Hall Sensors Connection Diagram

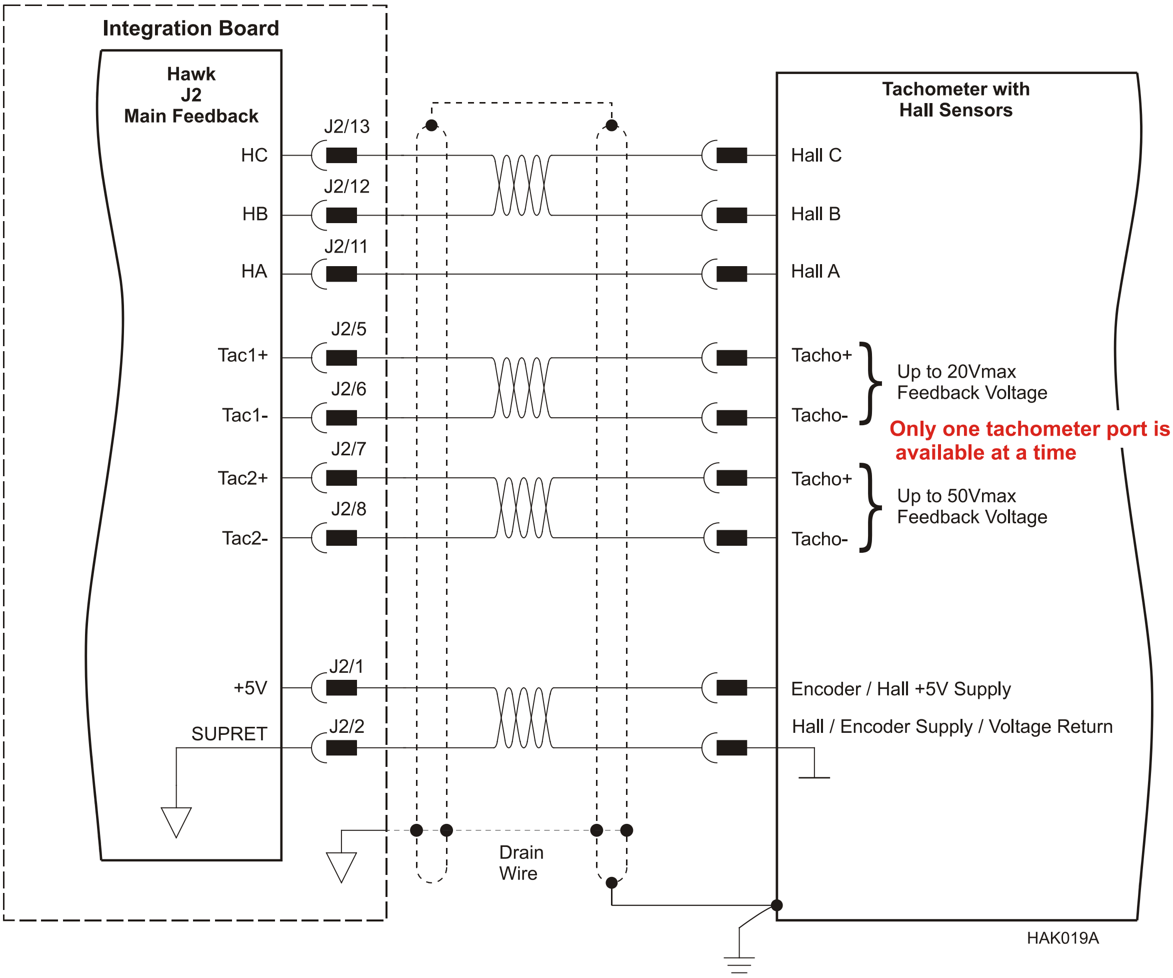


Figure 15: Main Feedback – Tachometer Feedback with Digital Hall Sensors Connection Diagram for Brushless Motors

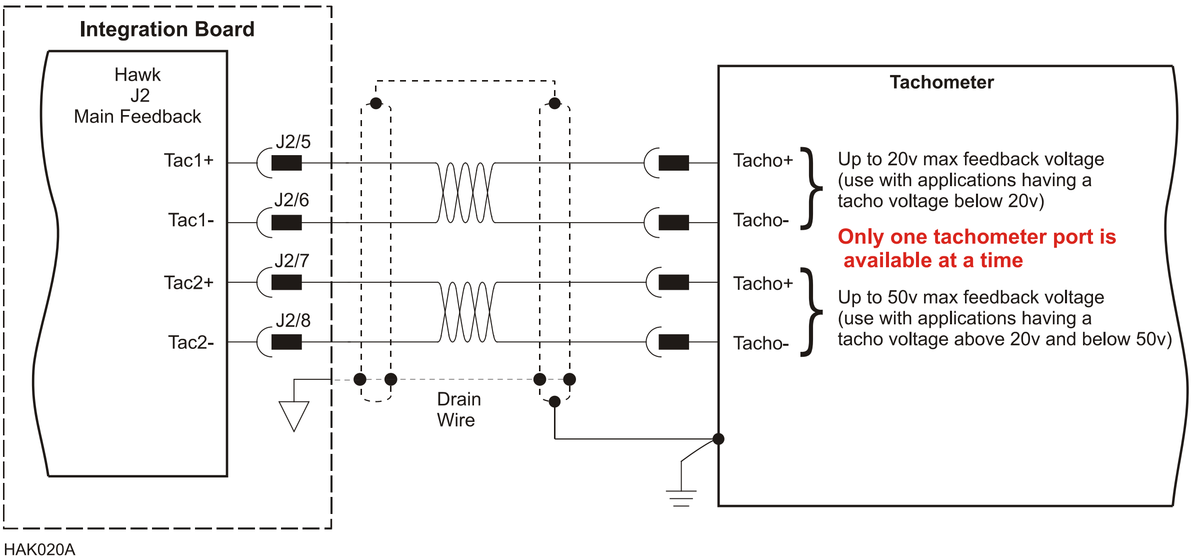


Figure 16: Main Feedback – Tachometer Feedback Connection Diagram for Brush Motors

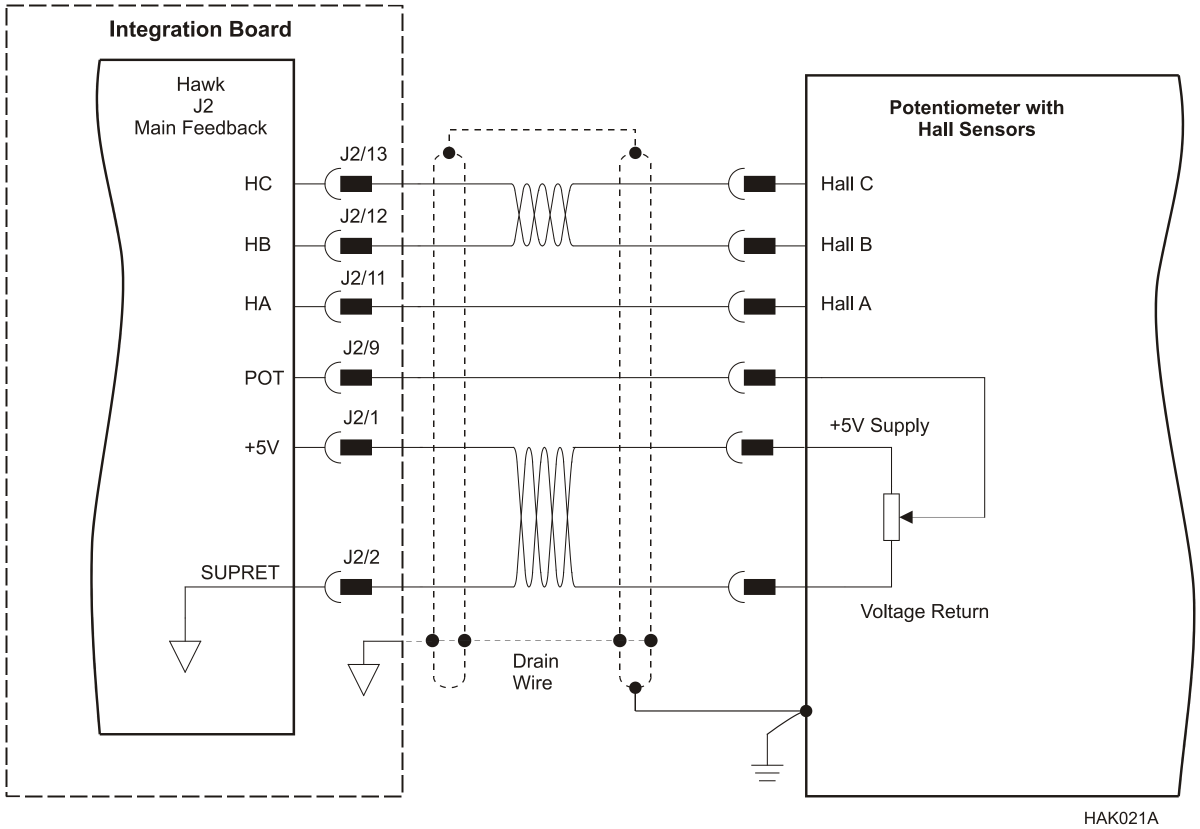


Figure 17: Main Feedback – Potentiometer Feedback with Digital Hall Sensors Connection Diagram for Brushless Motors

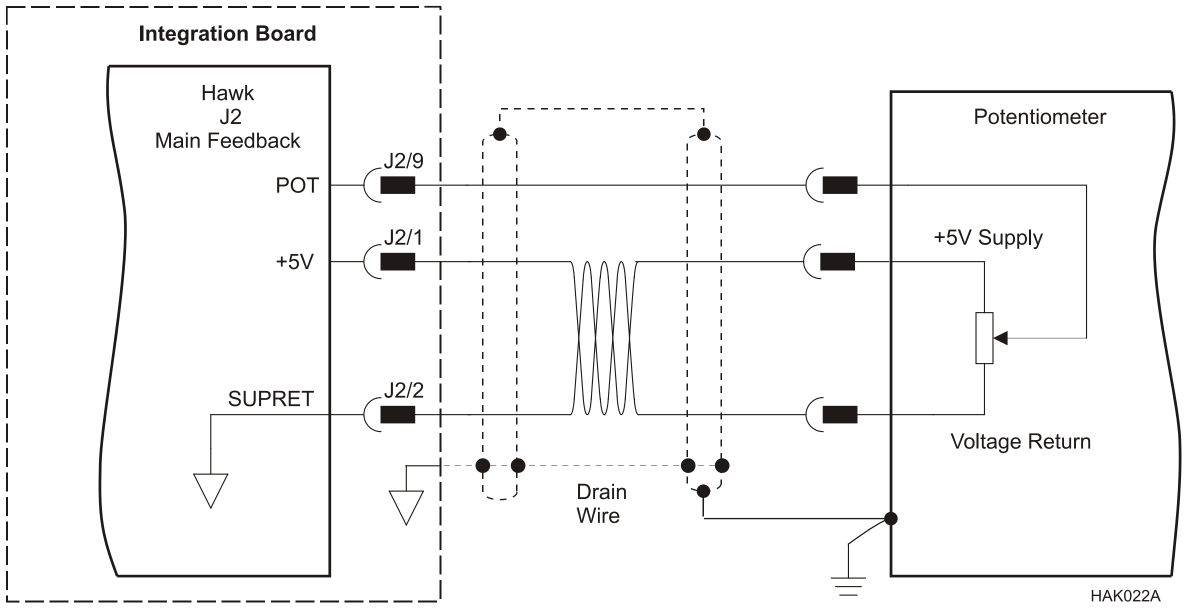


Figure 18: Main Feedback –
Potentiometer Feedback Connection Diagram for Brush Motors and Voice Coils

3.10. Auxiliary Feedback

For auxiliary feedback, select one of the following options:

a. **Single-ended emulated encoder outputs**, used to provide emulated encoder signals to another controller or drive. The Emulated Encoder Output Option is only available when using a Resolver, Analog Encoder, Tachometer, Potentiometer or Absolute Encoder as the main feedback device. The absolute model provides differential emulated encoder output.

   This option can be used when:

   - The Hawk is used as a current amplifier to provide position data to the position controller.
   - The Hawk is used in velocity mode, to provide position data to the position controller.
   - The Hawk is used as a master in follower or ECAM mode.

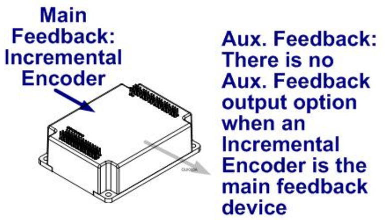
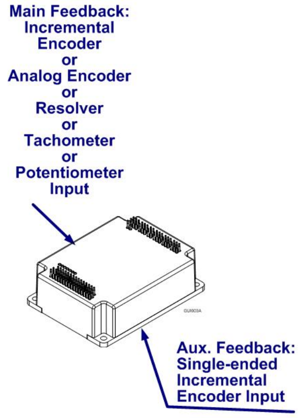
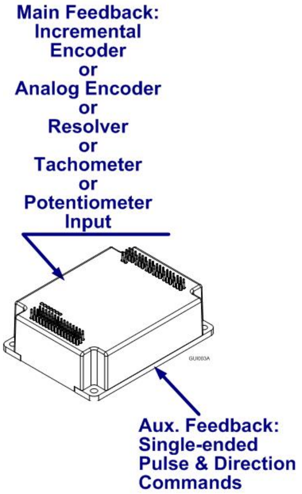
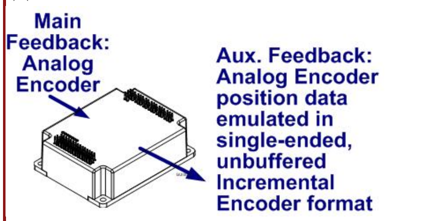
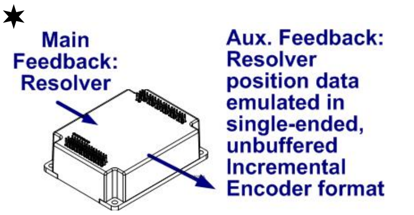
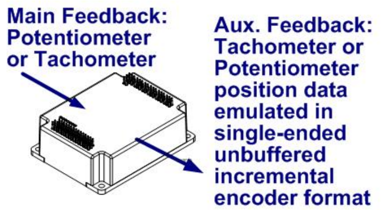
b. **Single-ended auxiliary encoder input**, for the input of position data of the master encoder in follower or ECAM mode.

c. **Pulse-and-direction input**, for single-ended input of pulse-and-direction position commands.

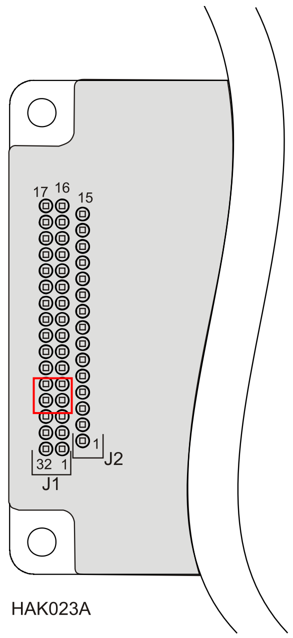
When using one of the auxiliary feedback options, the relevant functionality is software selected for that option. Refer to the *SimplIQ Command Reference Manual* for detailed setup information.

3.10.1. Main and Auxiliary Feedback Combinations

The Main Feedback is always used in motion control devices whereas Auxiliary Feedback is often, but not always used. The Auxiliary Feedback connector on the Hawk has three bi-directional pins (CHA, CHB and INDEX). When used in combination with Main Feedback, the Auxiliary Feedback can be set, by software, as follows:

Main Feedback	Auxiliary Feedback		
Software Setting	YA[4] = 4 (Aux. Feedback: output)	YA[4] = 2 (Aux. Feedback: input)	YA[4] = 0 (Aux. Feedback: input)
Incremental Encoder Input			
Interpolated Analog (Sin/Cos) Encoder Input	★ 		
Resolver Input	✶ 		
Potentiometer or Tachometer Input	✸ 		
Typical Applications	★ Analog Encoder applications where position data is required in the Encoder's quadrature format. ✶ Resolver applications where position data is required in the Encoder's quadrature format. ✸ Tachometer or potentiometer applications where position data is required in the Encoder's quadrature format.	Any application where two feedbacks are used by the drive. The Auxiliary Feedback port serves as an input for the auxiliary incremental encoder. For applications such as Follower, ECAM, or Dual Loop.	Any application where two feedbacks are used by the drive. The Auxiliary Feedback port serves as an input for Pulse & Direction Commands.

3.10.2. Auxiliary Feedback: Emulated Encoder Output Option (YA[4]=4)

Pin (J1)	Signal	Function	Pin Positions
28	COMRET	Common return	
29	INDEX	Auxiliary index output	
5	CHBO	Auxiliary Channel B output	
4	CHAO	Auxiliary Channel A output	

Notes:

- The Emulated Encoder Output Option is only available when using a Resolver, Analog Encoder, Tachometer or Potentiometer as the main feedback device.
- The Hawk's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential (Figure 21 (highly recommended)).

Table 4: Emulated Single-Ended Encoder Output Pin Assignments

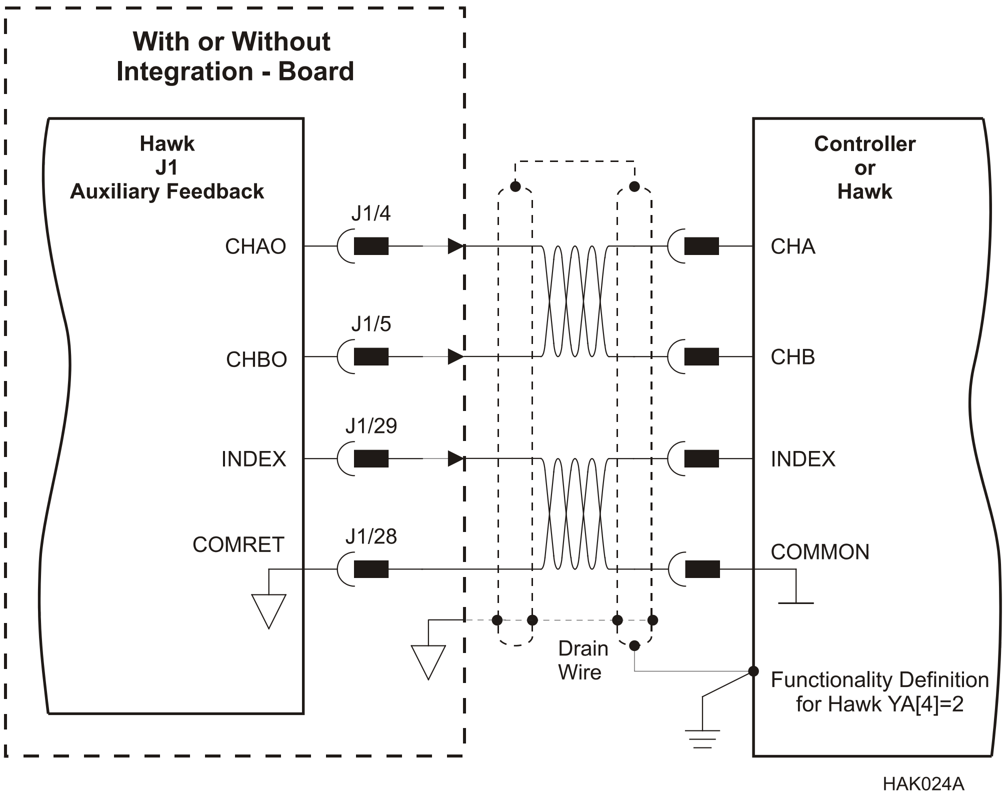


Figure 19: Emulated Encoder Direct Output – Acceptable Connection Diagram

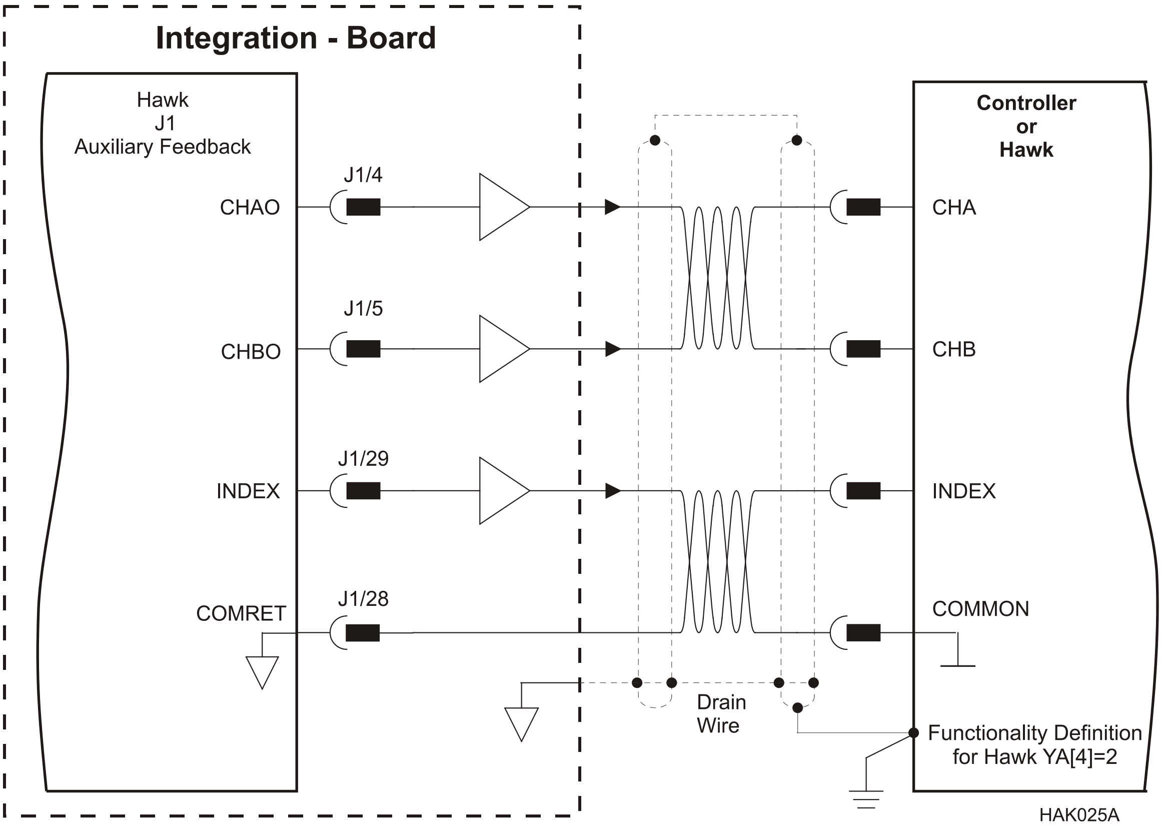


Figure 20: Emulated Encoder Buffered Output – Recommended Connection Diagram

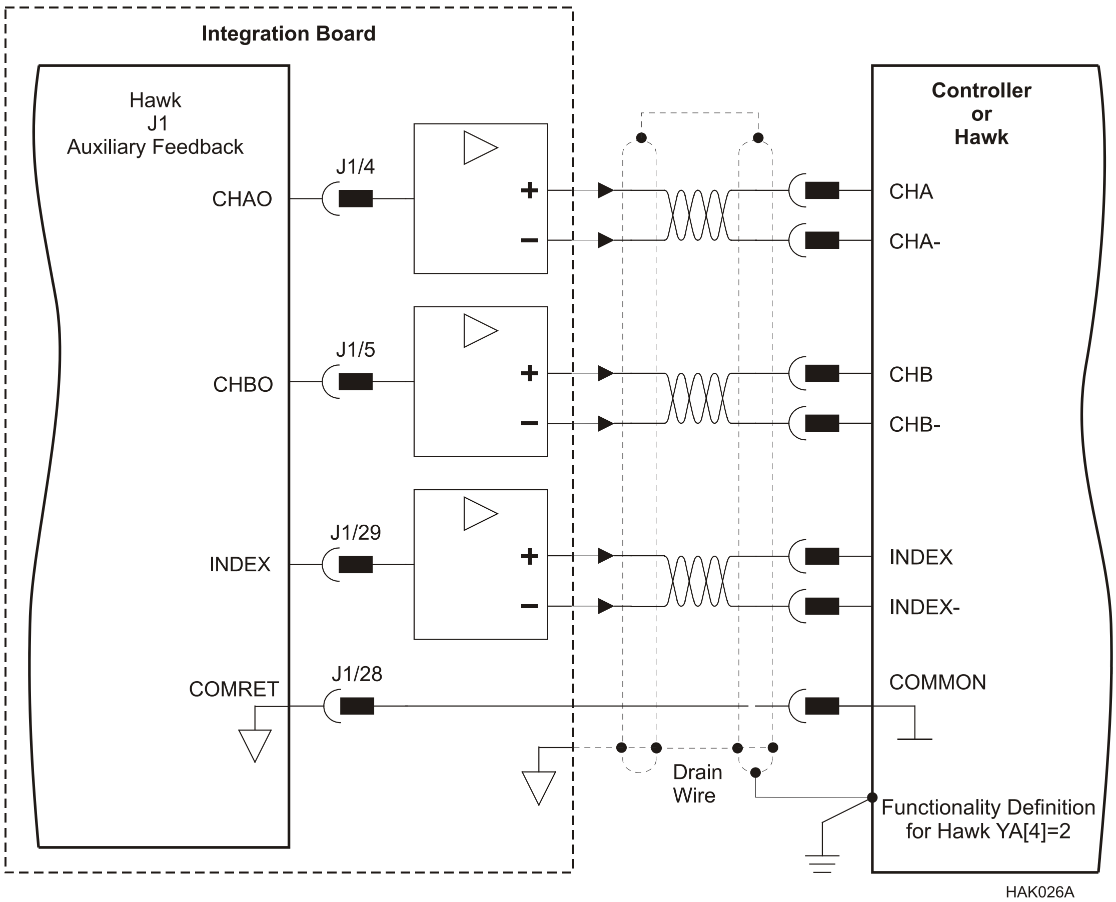
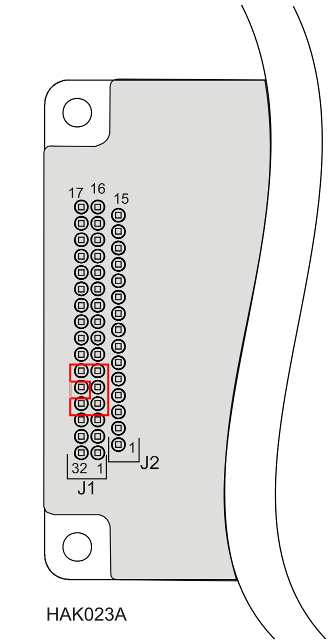


Figure 21: Emulated Encoder Differential Output – Highly Recommended Connection Diagram

3.10.3. Auxiliary Feedback: Single-Ended Encoder Input Option (YA[4]=2)

Pin (J1)	Signal	Function	Pin Positions
27	+5 V	Encoder supply voltage	
6	SUPRET	Supply return	
29	INDEX	Auxiliary index input	
5	CHB	Auxiliary channel B input	
4	CHA	Auxiliary channel A input	

Note: The Hawk's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential (Figure 24 (highly recommended)).

Table 5: Single-Ended Auxiliary Encoder Pin Assignment

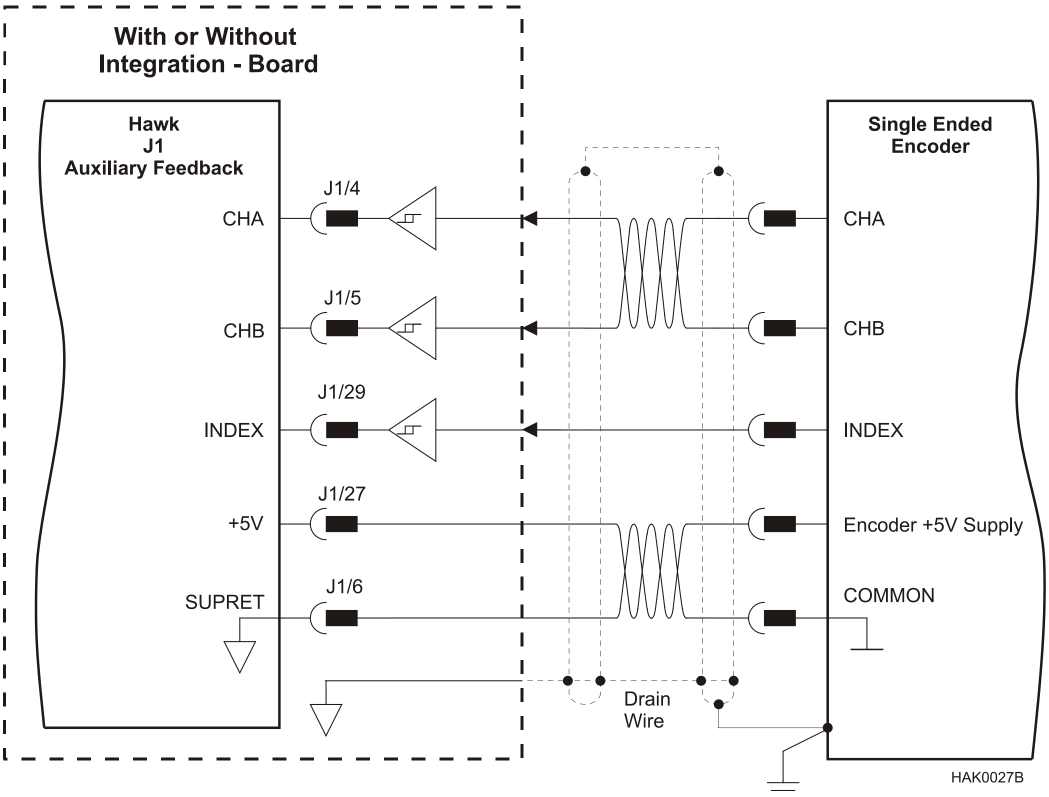


Figure 22: Single-Ended Auxiliary Encoder Input - Acceptable Connection Diagram

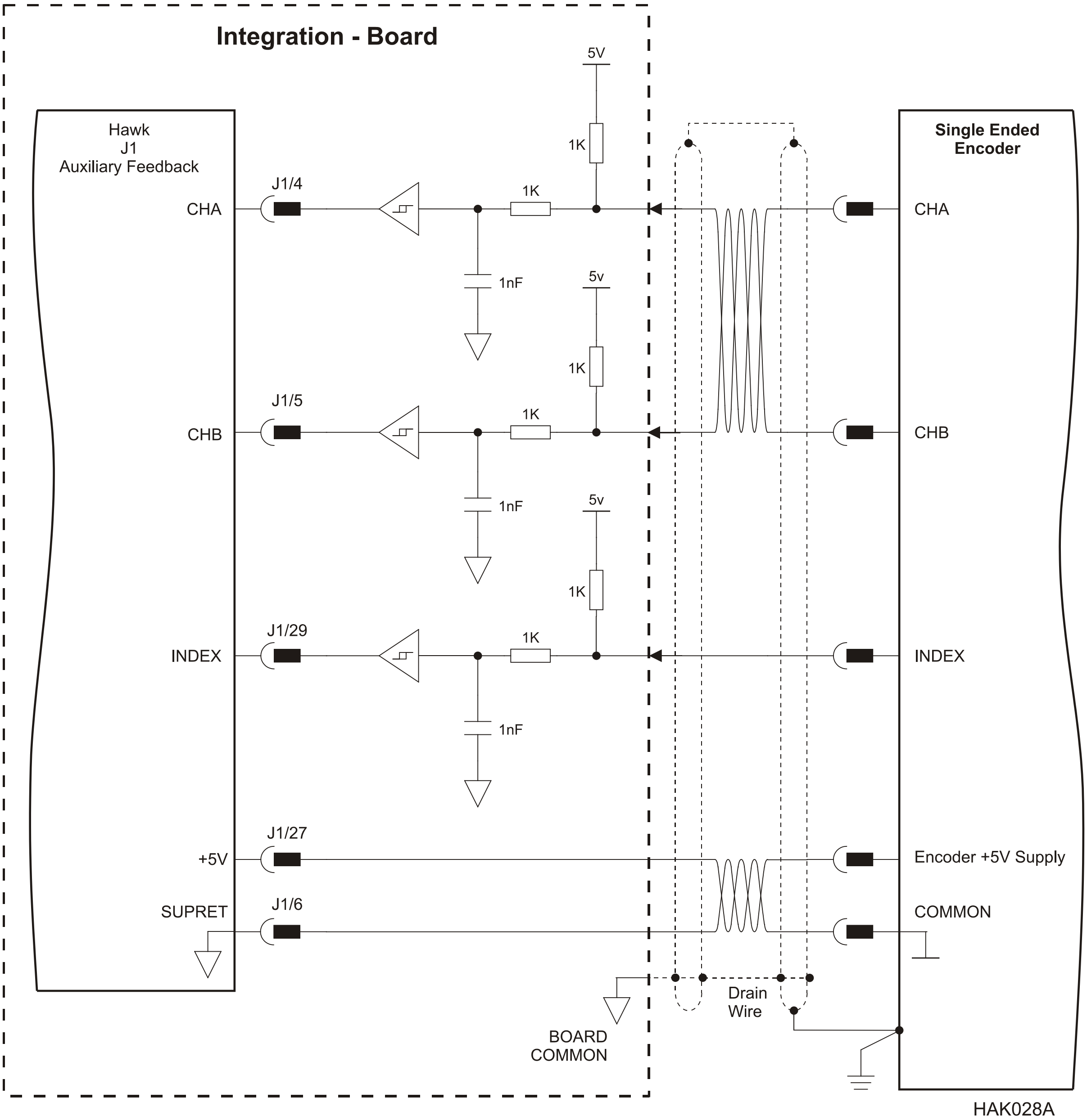


Figure 23: Single-ended Auxiliary Encoder Input - Recommended Connection Diagram

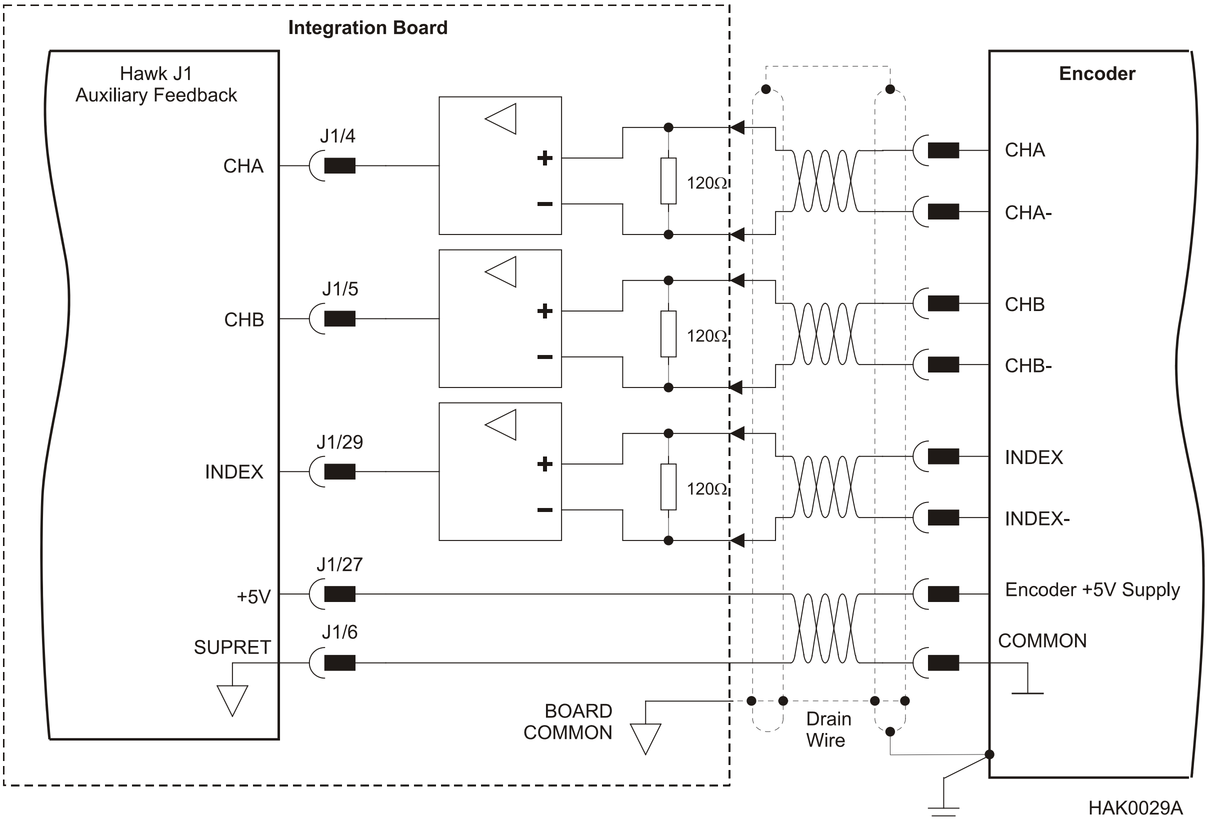


Figure 24: Differential Auxiliary Encoder Input – Highly Recommended Connection Diagram

3.10.4. Auxiliary Feedback: Pulse-and-Direction Input Option (YA[4]=0)

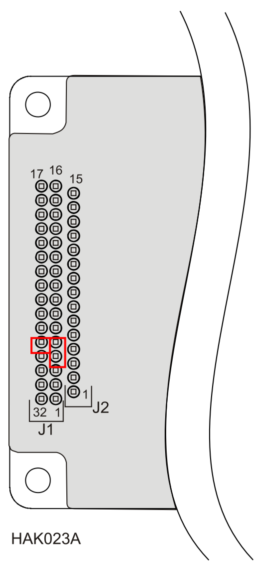
Pin (J1)	Signal	Function	Pin Positions
28	COMRET	Common return	
5	DIR/CHB	Direction input (push/pull 5 V or open collector)	
4	PULS/CHA	Pulse input (push/pull 5 V or open collector)	
Note: The Hawk's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential (Figure 27 (highly recommended)).			

Table 6: Pulse-and-Direction Pin Assignments

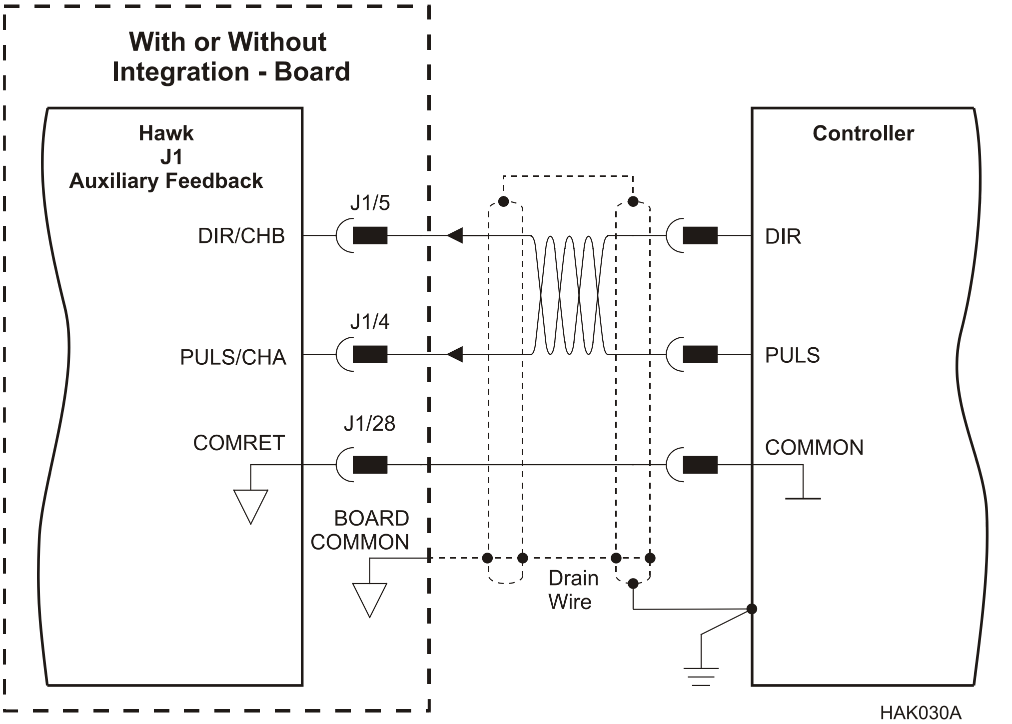


Figure 25: Pulse-and-Direction Auxiliary Encoder Input – Direct Connection Diagram

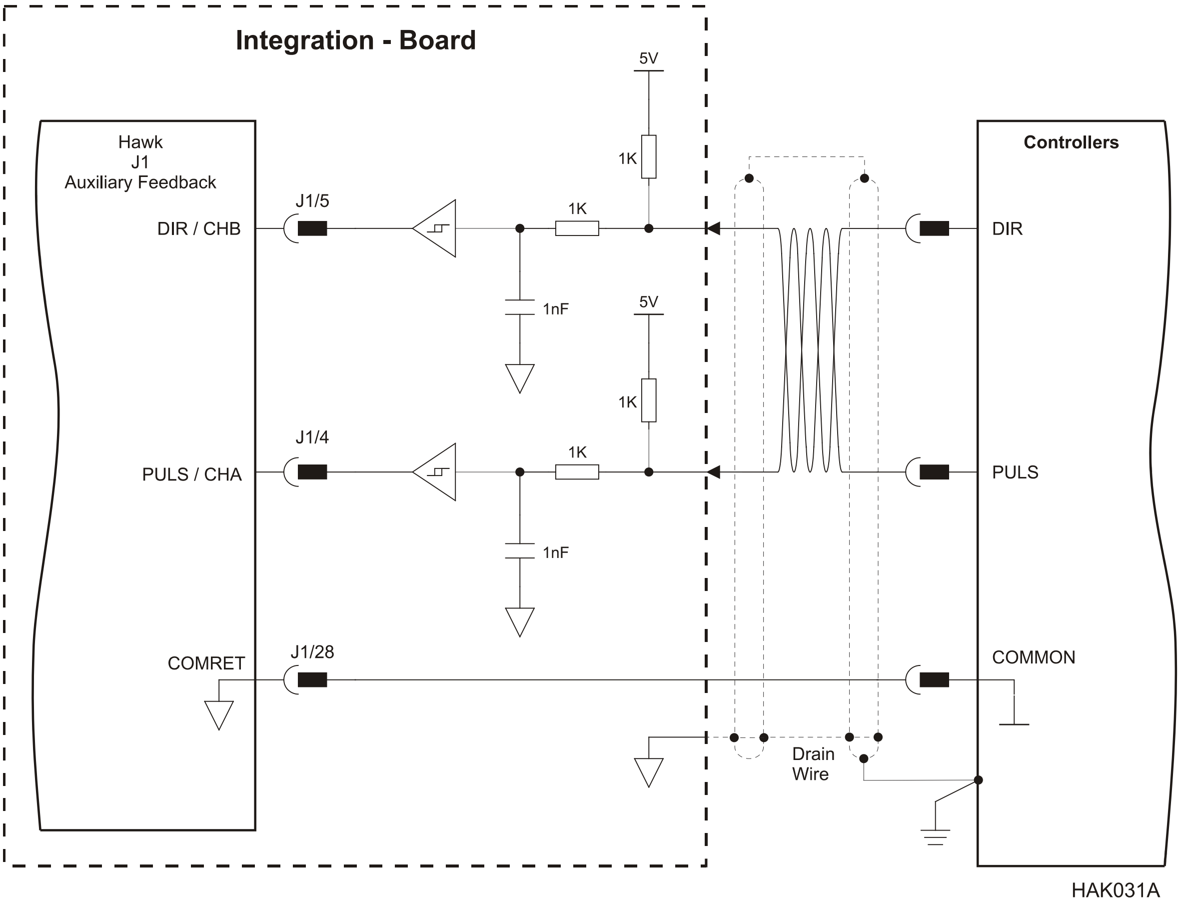


Figure 26: Pulse-and-Direction Auxiliary Encoder Input – Buffered Connection Diagram

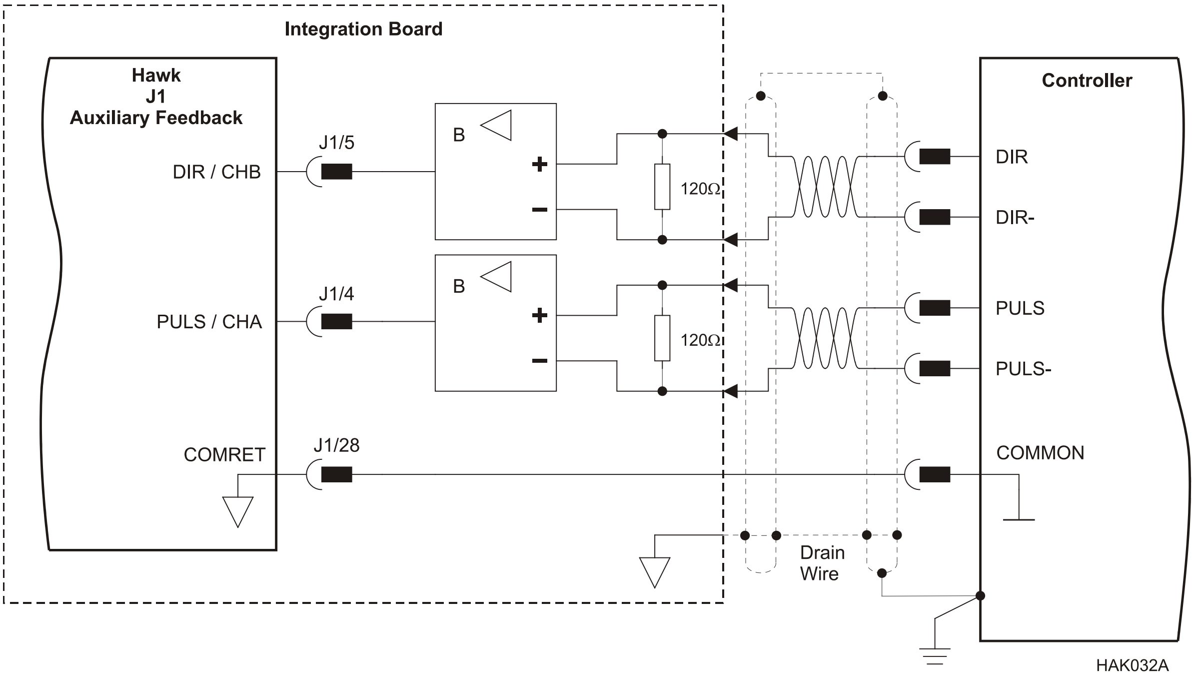


Figure 27: Pulse-and-Direction Auxiliary Encoder Input – Differential Connection Diagram, Highly Recommended

3.11. I/Os

The Hawk has:

- 6 Digital Inputs
- 4 Digital Outputs
- 1 Analog Input

I/O	J1	J2	Total
Digital Input	6	-	6
Digital Output	4	-	2
Analog Input	-	1	1

3.11.1. Digital Input

Each of the pins below can function as an independent input.

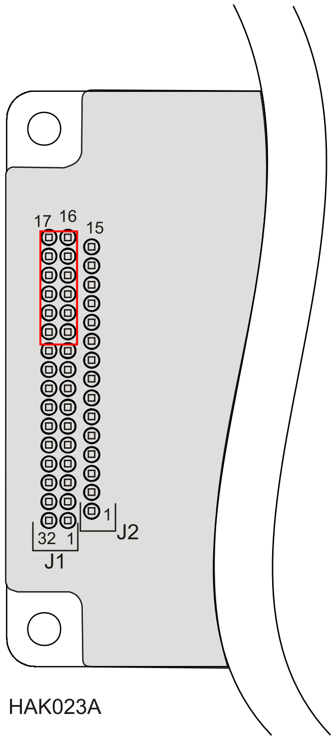
Pin (J1)	Signal	Function	Pin Positions
11	IN1	Programmable input 1 (general purpose, RLS, FLS, INH)	
12	IN2	Programmable input 2 (general purpose, RLS, FLS, INH)	
13	IN3	Programmable input 3 (general purpose, RLS, FLS, INH)	
14	IN4	Programmable input 4 (general purpose, RLS, FLS, INH)	
15	IN5	Hi-Speed Programmable input 5 (event capture, Main Home, general purpose, RLS, FLS, INH)	
16	IN6	Hi-Speed Programmable input 6 (event capture, Auxiliary Home, general purpose, RLS, FLS, INH)	
17	INRET6	Programmable input 6 return	
18	INRET5	Programmable input 5 return	
19	INRET4	Programmable input 4 return	
20	INRET3	Programmable input 3 return	
21	INRET2	Programmable input 2 return	
22	INRET1	Programmable input 1 return	

Table 7: Digital Input Pin Assignments

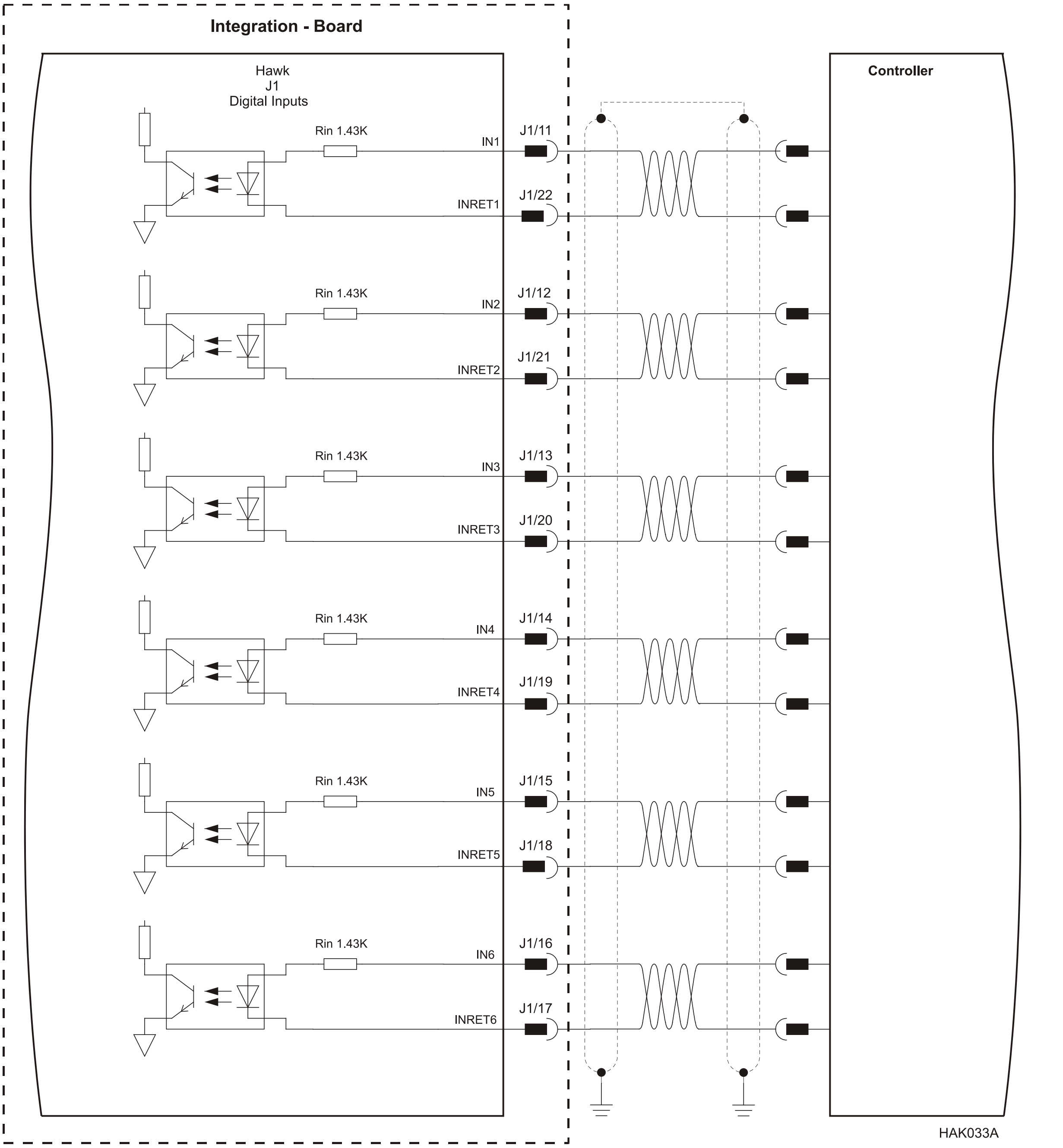


Figure 28: Digital Input Connection Diagram

3.11.2. Digital Output

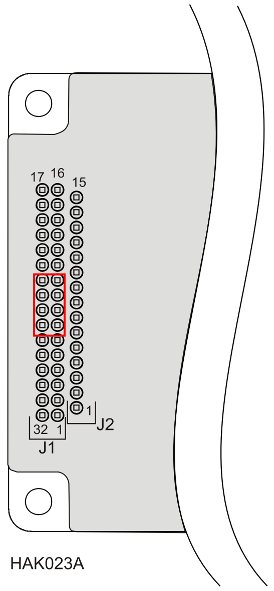
Pin (J1)	Signal	Function	Pin Positions
7	OUT1	High-Speed Programmable digital output 1	
8	OUT2	Programmable digital output 2	
9	OUT3	Programmable digital output 3	
10	OUT4	Programmable digital output 4	
26	OUTRET1	Programmable digital output 1 return	
25	OUTRET2	Programmable digital output 2 return	
24	OUTRET3	Programmable digital output 3 return	
23	OUTRET4	Programmable digital output 4 return	

Table 8: Digital Output Pin Assignment

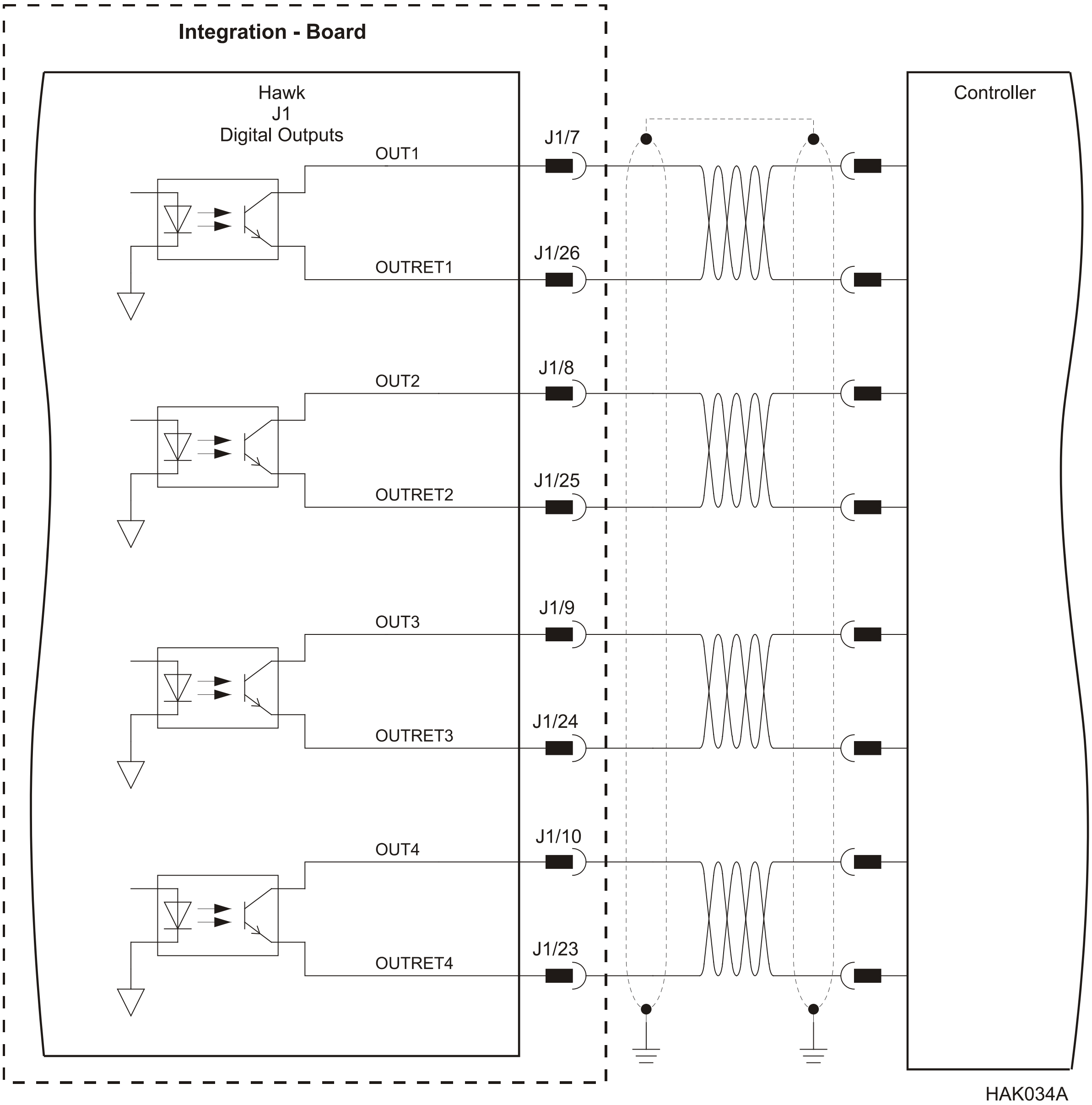


Figure 29: Digital Output Connection Diagram

3.11.3. Analog Input

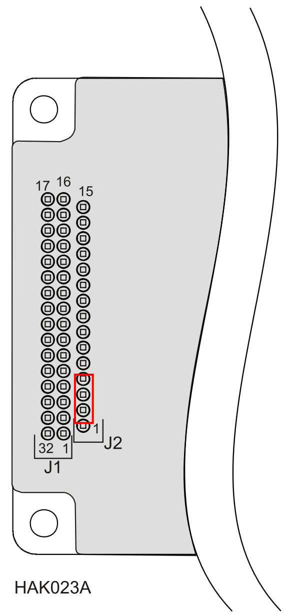
Pin (J2)	Signal	Function	Pin Positions
3	ANLIN1+	Analog input 1+	
4	ANLIN1-	Analog input 1-	
2	ANLRET	Analog ground	

Table 9: Analog Input Pin Assignments

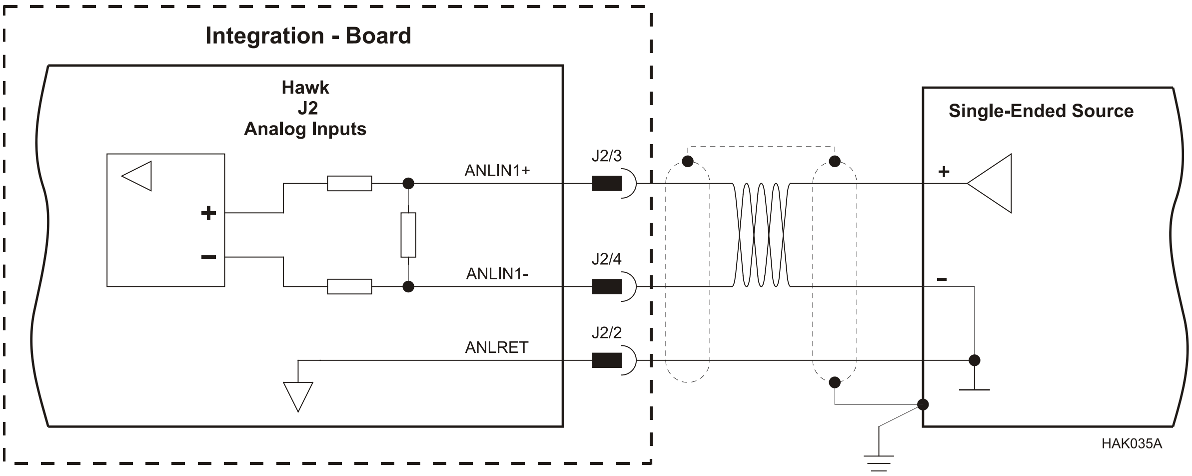


Figure 30: Analog Input with Single-Ended Source

3.12. Communications

The communication interface may differ according to the user's hardware. The Hawk can communicate using the following options:

a. RS-232, full duplex

b. CAN

RS-232 communication requires a standard, commercial 3-core null-modem cable connected from the Hawk to a serial interface on the PC. The interface is selected and set up in the Composer software.

In order to benefit from **CAN** communication, the user must have an understanding of the basic programming and timing issues of a CAN network.

For ease of setup and diagnostics of CAN communication, RS-232 and CAN can be used simultaneously.

3.12.1. RS-232 Communication

Notes for connecting the RS-232 communication cable:

- Connect the shield to the ground of the host (PC). Usually, this connection is soldered internally inside the connector at the PC end. You can use the drain wire to facilitate connection.
- The RS-232 communication port is **non-isolated**.
- Ensure that the shield of the cable is connected to the shield of the connector used for RS-232 communications. The drain wire can be used to facilitate the connection.

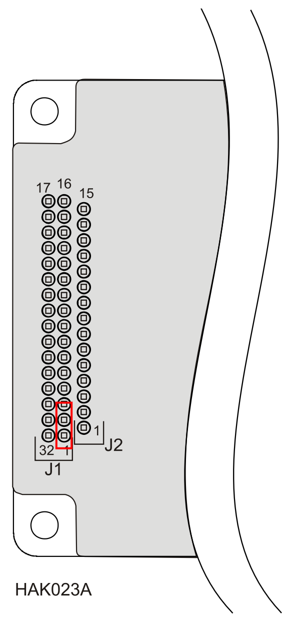
Pin (J1)	Signal	Function	Pin Location
1	RS232_Rx	RS-232 receive	
2	RS232_Tx	RS-232 transmit	
3	RS232_COMRET	Communication return	

Table 10: RS-232 Pin Assignments

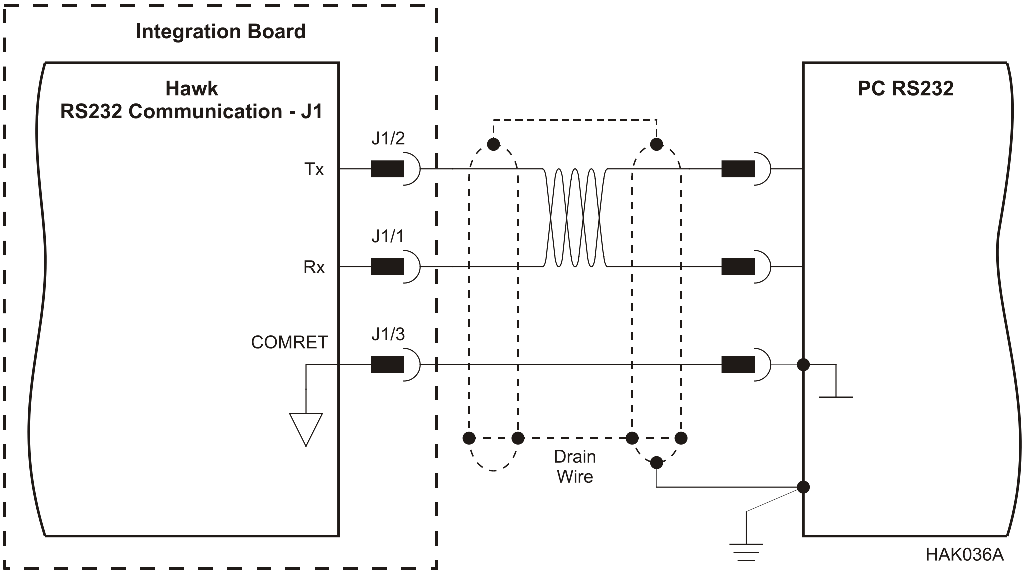


Figure 31: RS-232 Connection Diagram

3.12.2. CAN Communication

Notes for connecting the CAN communication cable:

- Connect the shield to the ground of the host (PC). Usually, this connection is soldered internally inside the connector at the PC end. You can use the drain wire to facilitate connection.
- Ensure that the shield of the cable is connected to the shield of the connector used for communications. The drain wire can be used to facilitate the connection.
- Make sure to have a 120-Ω resistor termination at each of the two ends of the network cable.
- The Hawk's CAN port is **non-isolated**.

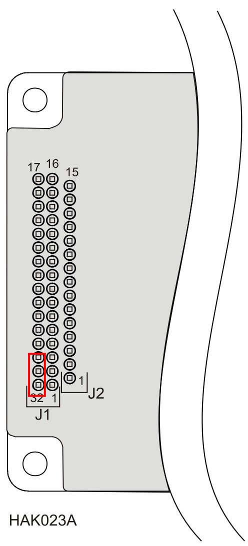
Pin (J1)	Signal	Function	Pin Positions
30	CAN_GND	CAN ground	
31	CAN_L	CAN_L busline (dominant low)	
32	CAN_H	CAN_H busline (dominant high)	

Table 11: CAN - Pin Assignments

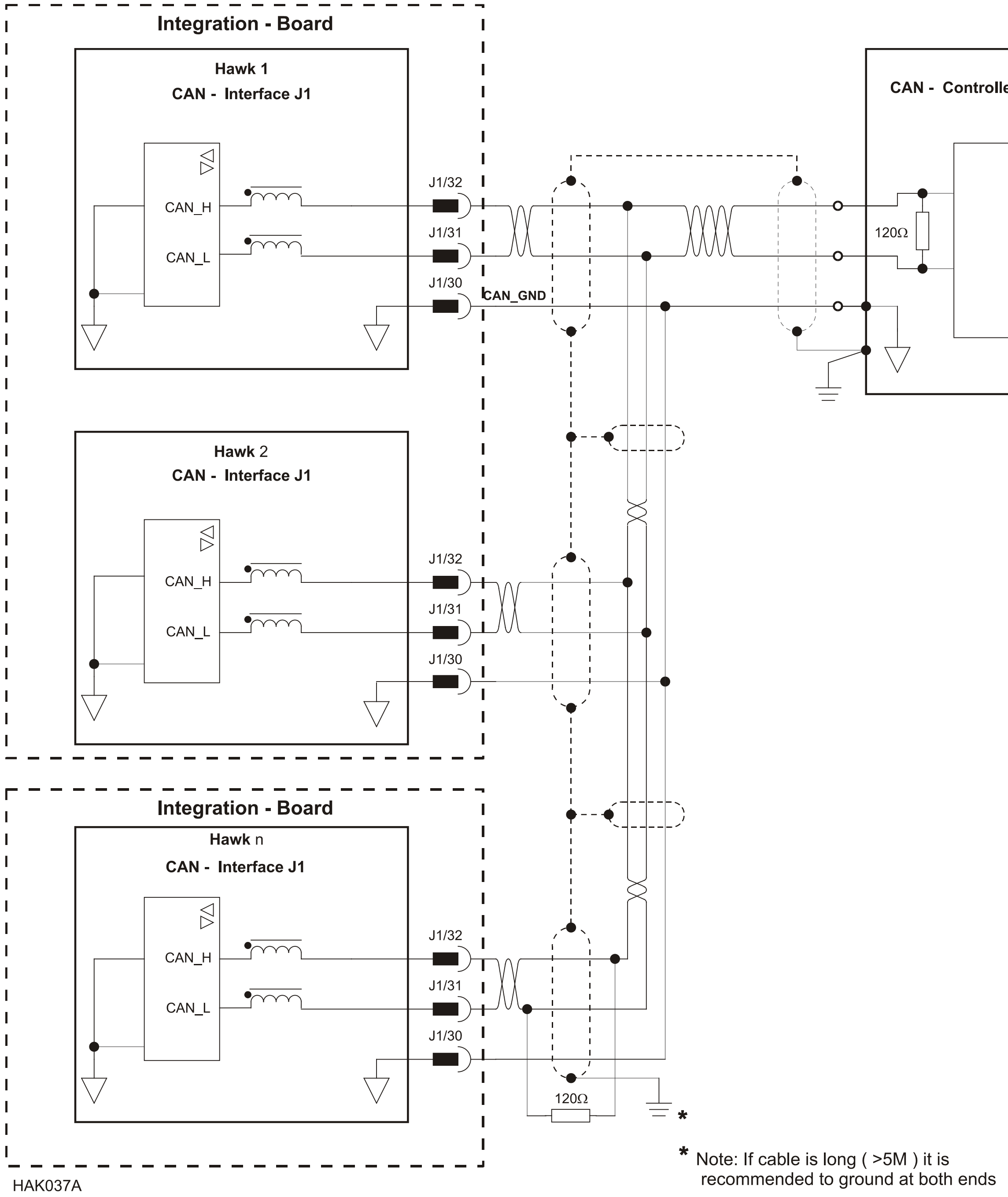


Figure 32: CAN Network Diagram

Caution:
When installing CAN communication, ensure that each servo drive is allocated a unique ID. Otherwise, the CAN network may hang.

3.13. Powering Up

After the Hawk is connected to its device, it is ready to be powered up.

Caution:
Before applying power, ensure that the DC supply is within the specified range and that the proper plus-minus connections are in order.

3.14. Initializing the System

After the Hawk has been connected and mounted, the system must be set up and initialized. This is accomplished using the *Composer*, Elmo's Windows-based software application. Install the application and then perform setup and initialization according to the directions in the *Composer Software Manual*.

3.15. Heat Dissipation

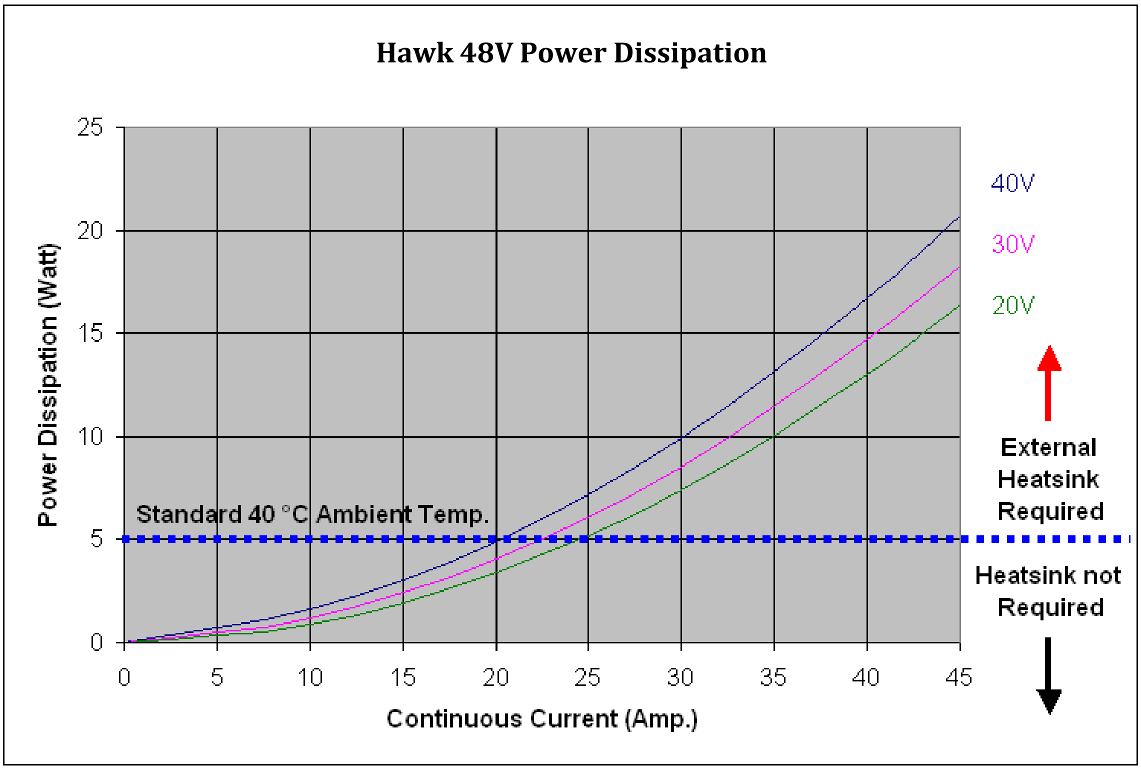
The best way to dissipate heat from the Hawk is to mount it so that its heatsink faces up. For best results leave approximately 10 mm of space between the Hawk's heatsink and any other assembly.

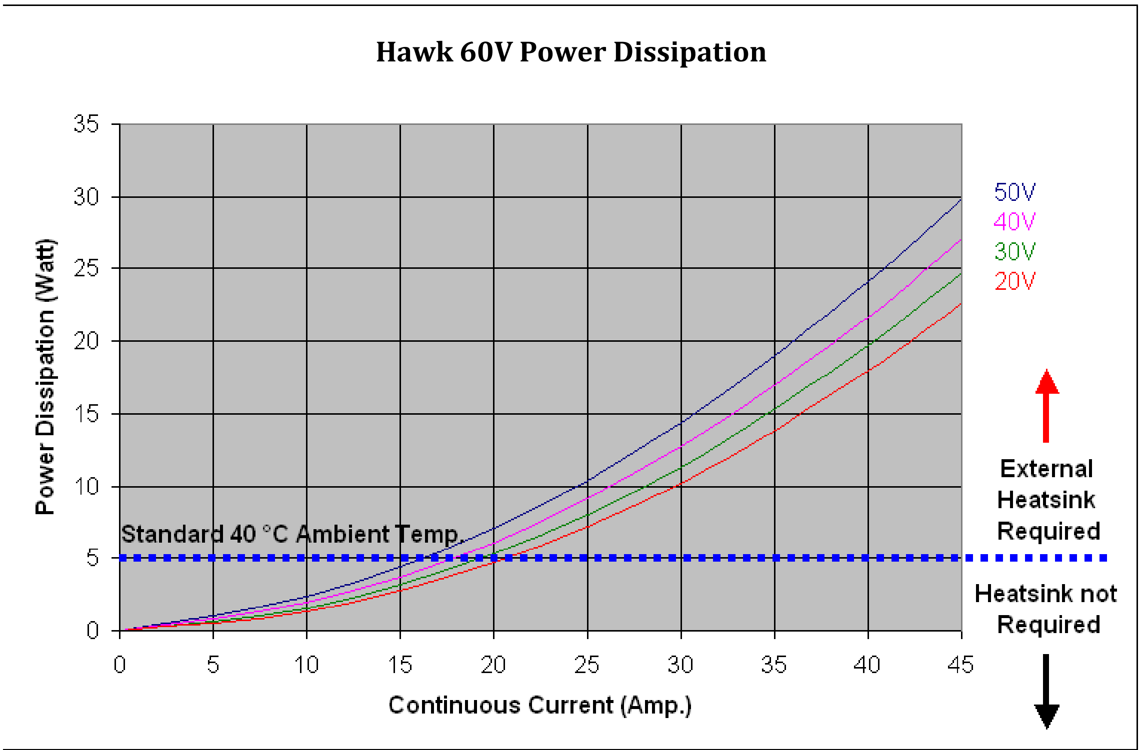
3.15.1. Hawk Thermal Data

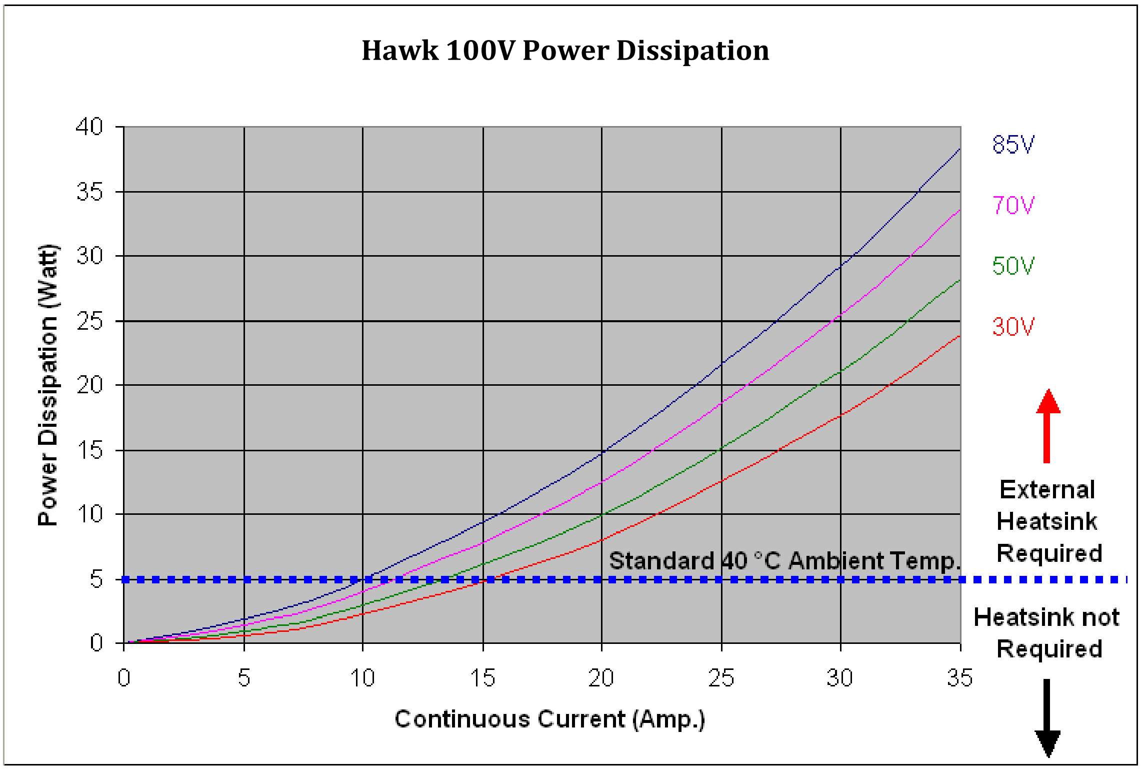
- Heat dissipation capability (θ): Approximately 8 °C/W.
- Thermal time constant: Approximately 360 seconds (thermal time constant means that the Hawk will reach 2/3 of its final temperature after 6 minutes).
- Shut-off temperature: 86 °C to 88 °C (measured on the heatsink)

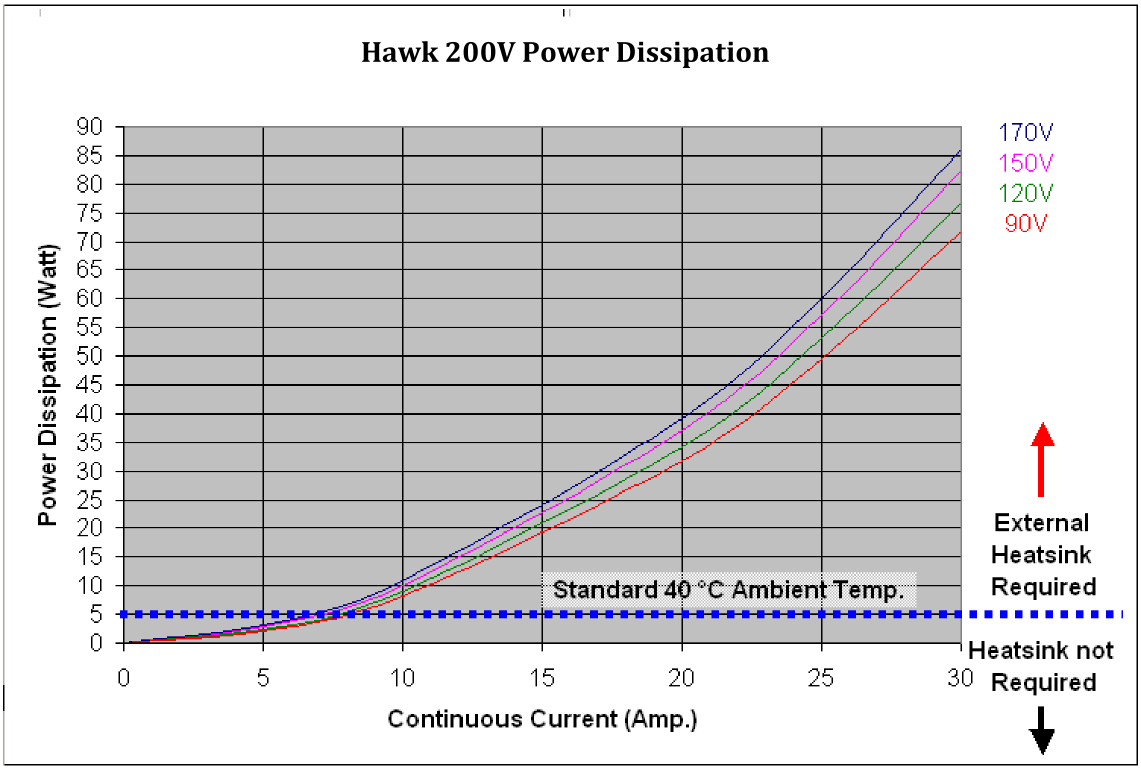
3.15.2. Heat Dissipation Data

Heat Dissipation is shown in graphically below:






Hawk 100V Power Dissipation
Power Dissipation (Watt)
0
5
10
15
20
25
30
35
40
Continuous Current (Amp.)
85V
70V
50V
30V
Standard 40 °C Ambient Temp.
External Heatsink Required
Heatsink not Required


Hawk 200V Power Dissipation
Power Dissipation (Watt)
Continuous Current (Amp.)
170V
150V
120V
90V
Standard 40 °C Ambient Temp.
External Heatsink Required
Heatsink not Required

3.15.3. How to Use the Charts

The charts above are based upon theoretical worst-case conditions. Actual test results show 30% to 50% better power dissipation.

To determine if your application needs a heatsink:

1. Allow maximum heatsink temperature to be 80 °C or less.
2. Determine the ambient operating temperature of the Hawk.
3. Calculate the allowable temperature increase as follows:
   - for an ambient temperature of 40 °C , ΔT= 80 °C – 40 °C = 40 °C
4. Use the chart to find the actual dissipation power of the drive. Follow the voltage curve to the desired output current and then find the dissipated power.
5. If the dissipated power is below 5 W the Hawk will need no additional cooling.

Note: The chart above shows that no heatsink is needed when the heatsink temperature is 80 °C, ambient temperature is 40 °C and heat dissipated is 5 Watts.

3.16. Evaluation Board and Cable Kit

A circuit board is available for evaluating the Hawk. It comes with standard terminal blocks for power connections and D-sub plugs/sockets for signal connections. The Evaluation Board is provided with a cable kit.

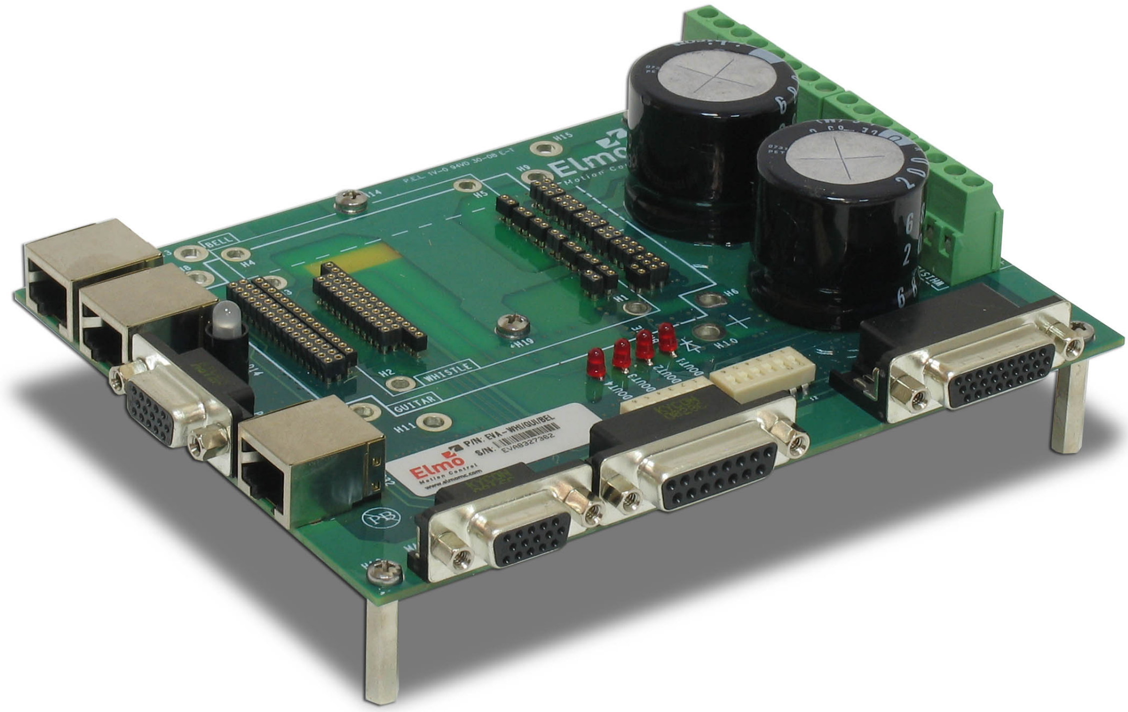


Figure 33: The Evaluation Board (available upon request)

Evaluation Board	**Catalog Number**: EVA-WHI/GUI/BEL
Evaluation Board User Manual	MAN-EVLBRD-WHI-BEL-GUI.pdf (available on our web site)

Chapter 4: Technical Specifications

This chapter provides detailed technical information regarding the Hawk. This includes its dimensions, power ratings, the environmental conditions under which it can be used, the standards to which it complies and other specifications.

4.1. Features

The Hawk's features determine how it controls motion, as well as how it processes host commands, feedback and other input.

4.1.1. Motion Control Modes

- Current/Torque - up to 14 kHz sampling rate
- Velocity - up to 7 kHz sampling rate
- Position - up to 3.5 kHz sampling rate

4.1.2. Advanced Positioning Control Modes

- PTP, PT, PVT, ECAM, Follower, Dual Loop, Current Follower
- Fast event capturing inputs
- Fast output compare (OC)
- Motion Commands: Analog current and velocity, PWM current and velocity, digital (SW) and Pulse and Direction

4.1.3. Advanced Filters and Gain Scheduling

- "On-the-Fly" gain scheduling of current and velocity
- Velocity and position with "1-2-4" PIP controllers
- Automatic commutation alignment
- Automatic motor phase sequencing

4.1.4. Fully Programmable

- Third generation programming structure with motion commands – "Composer"
- Event capturing interrupts
- Event triggered programming

4.1.5. Feedback Options

- Incremental Encoder – up to 20 Mega-Counts (5 Mega-Pulse) per second
- Digital Halls – up to 2 kHz
- Incremental Encoder with Digital Halls for commutation – up to 20 Mega-Counts per second for encoder
- Interpolated Analog (Sine/Cosine) Encoder – up to 250 kHz (analog signal)
  - Internal Interpolation - up to x4096
  - Automatic Correction of amplitude mismatch, phase mismatch, signal offset
  - Emulated encoder outputs, single-ended, unbuffered of the Analog encoder
- Analog Hall Sensor
- Resolver
  - Programmable 10 to 15 bit resolution
  - Up to 512 revolutions per second (RPS)
  - Emulated encoder outputs, single-ended, unbuffered of the Resolver.
- Auxiliary Encoder inputs (ECAM, follower, etc.) single-ended, unbuffered.
- Tachometer & Potentiometer
- The Hawk can provide power (5 V, 2x200 mA max) for Encoders, Resolver or Halls.

4.1.6. Input/Output

- One **Analog Input** – up to 14-bit resolution
- Six separate programmable **Digital Inputs**, optically isolated (two of which are fast event capture inputs).
  - Inhibit/Enable motion
  - Software and analog reference stop
  - Motion limit switches
  - Begin on input
  - Abort motion
  - Homing
  - General-purpose
- Four separate programmable **Digital Outputs**, optically isolated (open collector) one with fast output compare (OC):
  - Brake Control
  - Amplifier fault indication
  - General-purpose
  - Servo enable indication
- Pulse and Direction inputs (single-ended)
- PWM current command output for torque and velocity

4.1.7. Built-In Protection

- Software error handling
- Abort (hard stops and soft stops)
- Status reporting
- Protection against:
  - Shorts between motor power outputs
  - Shorts between motor power outputs and power input/return
  - Failure of internal power supplies
  - Over-heating
    - Continuous temperature measurement. Temperature can be read on the fly; a warning can be initiated x degrees before temperature disable is activated.
  - Over/Under voltage
  - Loss of feedback
  - Following error
  - Current limits

4.1.8. Accessories

- External heatsink (TBD)
- Evaluation Board, see Section 3.16 for a picture and more details.
  Catalog number: EVA-WHI/GUI/BEL
- Cable Kit, see Section 3.16 for more details.
  Catalog number: CBL-EVAUNIKIT01

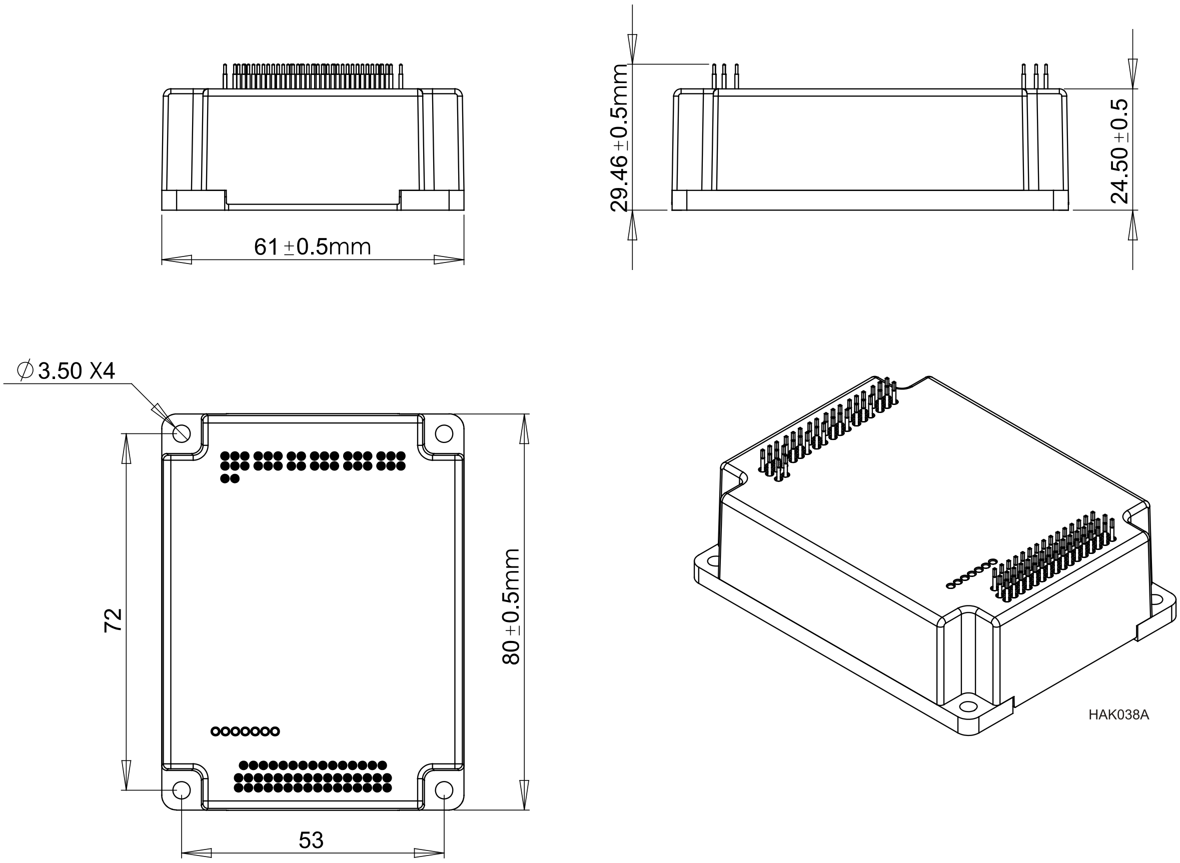
4.1.9. Status Indication

- Output for a bi-color LED

4.1.10. Automatic Procedures

- Commutation alignment
- Phase sequencing
- Current loop offset adjustment
- Current loop gain tuning
- Current gain scheduling
- Velocity loop offset adjustment
- Velocity gain tuning
- Velocity gain scheduling
- Position gain tuning

4.2. Hawk Dimensions



4.3. Power Ratings for up to 100 V models

<table>
<tr><th>Feature</th><th>Units</th><th>35/48</th><th>20/60</th><th>25/60</th><th>35/60</th><th>20/100</th><th>25/100</th><th>50/100</th><th>R45/48</th><th>R75/48</th><th>R45/60</th><th>R75/60</th><th>R35/100</th></tr>
<tr><td>Minimum supply voltage</td><td>VDC</td><td>11</td><td colspan="3">14</td><td colspan="3">23</td><td colspan="2">11</td><td colspan="2">14</td><td>23</td></tr>
<tr><td>Nominal supply voltage</td><td>VDC</td><td>42</td><td colspan="3">50</td><td colspan="3">85</td><td colspan="2">42</td><td colspan="2">50</td><td>85</td></tr>
<tr><td>Maximum supply voltage</td><td>VDC</td><td>48</td><td colspan="3">59</td><td colspan="3">95</td><td colspan="2">48</td><td colspan="2">59</td><td>95</td></tr>
<tr><td>Maximum auxiliary supply voltage</td><td>VDC</td><td>48</td><td colspan="3">59</td><td colspan="3">95</td><td colspan="2">48</td><td colspan="2">59</td><td>95</td></tr>
<tr><td>Maximum continuous power output</td><td>W</td><td>1300</td><td>960</td><td>1200</td><td>1700</td><td>1600</td><td>2000</td><td>4000</td><td>1700</td><td>3000</td><td>2200</td><td>3700</td><td>2800</td></tr>
<tr><td>Efficiency at rated power (at nominal conditions)</td><td>%</td><td colspan="12">> 97</td></tr>
<tr><td>Maximum output voltage</td><td></td><td colspan="12">97% of DC bus voltage at f=22 kHz</td></tr>
<tr><td>Amplitude sinusoidal/DC continuous current (Ic)</td><td>A</td><td>35</td><td>20</td><td>25</td><td>35</td><td>20</td><td>25</td><td>50</td><td>45</td><td>75</td><td>45</td><td>75</td><td>35</td></tr>
<tr><td>Sinusoidal continuous RMS current limit (Ic)</td><td>A</td><td>25</td><td>14.1</td><td>17.7</td><td>24.8</td><td>14.1</td><td>17.7</td><td>35.3</td><td>31.8</td><td>53</td><td>31.8</td><td>53</td><td>24.8</td></tr>
<tr><td>Peak current limit</td><td>A</td><td colspan="7">2 x Ic</td><td colspan="5">No peak</td></tr>
<tr><td>Weight</td><td>g (oz)</td><td colspan="12">165 g (5.8 oz)</td></tr>
<tr><td>Dimensions</td><td>mm (in)</td><td colspan="12">80 x 61 x 24.5 (3.15" x 2.4" x 0.965")</td></tr>
<tr><td colspan="2">Digital in/Digital out/ Analog in</td><td colspan="12">6/4/1</td></tr>
<tr><td colspan="2">Mounting method</td><td colspan="12">PCB mount</td></tr>
</table>

4.4. Power Ratings for 200 V models

Feature	Units	10/200	17/200	20/200	R30/200
Minimum supply voltage	VDC	46			
Nominal supply voltage	VDC	170			
Maximum supply voltage	VDC	195			
Maximum auxiliary supply voltage	VDC	195			
Maximum continuous power output	W	1600	2700	3200	4800
Efficiency at rated power (at nominal conditions)	%	> 97			
Maximum output voltage		97% of DC bus voltage at f=22 kHz			
Amplitude sinusoidal/DC continuous current (Ic)	A	10	17	20	30
Sinusoidal continuous RMS current limit (Ic)	A	7	12	14.1	21.2
Peak current limit	A	2 x Ic			No peak
Weight	g (oz)	165 g (5.8 oz)			
Dimensions	mm (in)	80 x 61 x 24.5 (3.15" x 2.4" x 0.965")			
Digital in/Digital out/ Analog in		6/4/1			
Mounting method		PCB mount			

The following notes apply to all the above Power Rating models up to 100 V and 200 V.

Note on current ratings: The current ratings of the Hawk are given in units of DC amperes (ratings that are used for trapezoidal commutation or DC motors). The RMS (sinusoidal commutation) value is the DC value divided by 1.41.

4.5. Auxiliary Supply

Feature	Details
Auxiliary power supply	Isolated DC source only
Auxiliary supply input voltage	12 VDC to 195 VDC
Auxiliary supply input power	7 VA

4.6. Environmental Conditions

The ExtrIQ products are designed, manufactured and tested to meet extreme environmental conditions. The **ExtrIQ durability** is qualified, verified and tested according to the most severe environmental, EMC and safety standards exceeding the traditional and senior military Standards.

The ExtrIQ series of drives support the following extended environmental conditions.

Feature	Operation Conditions	Range
Ambient Temperature Range	Non-operating conditions	-50 °C to +100 °C (-58 °F to 212 °F)
	Operating conditions	-40 °C to +70 °C (-40 °F to 160 °F)
Temperature Shock	Non-operating conditions	-40 °C to +70 °C (-40 °F to 160 °F) within 3 min
Altitude	Non-operating conditions	Unlimited
	Operating conditions	-400 m to 12,000 m (-1312 to 39370 feet)
Maximum Humidity	Non-operating conditions	Up to 95% non-condensing humidity at 35 °C (95 °F)
	Operating conditions	Up to 95% non-condensing humidity at 25 °C (77 °F), up to 90% non-condensing humidity at 42 °C (108 °F)
Vibration	Operating conditions	20 Hz to 2000 Hz, 14.6g
Mechanical Shock	Non-operating conditions	±40g; Half sine, 11 msec
	Operating conditions	±20g; Half sine, 11 msec

4.7. Control Specifications

4.7.1. Current Loop

Feature	Details
Controller type	Vector, digital
Compensation for bus voltage variations	"On-the-fly" automatic gain scheduling
Motor types	• AC brushless (sinusoidal) • DC brushless (trapezoidal) • DC brush • Linear motors • "Voice" coils
Current control	• Fully digital • Sinusoidal with vector control • Programmable PI control filter based on a pair of PI controls of AC current signals and constant power at high speed
Current loop bandwidth	< 2.5 kHz
Current sampling time	Programmable 70 to 100 µsec
Current sampling rate	Up to 16 kHz; default 11 kHz

4.7.2. Velocity Loop

Feature	Details
Controller type	PI
Velocity control	• Fully digital • Programmable PI and FFW control filters • "On-the-fly" gain scheduling • Automatic, manual and advanced manual tuning
Velocity and position feedback options	• Incremental Encoder • Digital Halls • Interpolated Analog (Sine/Cosine) Encoder (optional) • Resolver (optional) • Tachometer and Potentiometer (optional) **Note:** With all feedback options, 1/T with automatic mode switching is activated (gap, frequency and derivative).
Velocity loop bandwidth	<350 Hz
Velocity sampling time	140 to 200 µsec (2x current loop sample time)
Velocity sampling rate	Up to 8 kHz; default 5.5 kHz
Velocity command options	• Analog • Internally calculated by either jogging or step **Note:** All software-calculated profiles support on-the-fly changes.

4.7.3. Position Loop

Feature	Details
Controller type	"1-2-4" PIP
Position command options	• Software • Pulse and Direction • Analog Potentiometer
Position loop bandwidth	<80 Hz
Position sampling time	280 to 400 µsec (4x current loop sample time)
Position sampling rate	Up to 4 kHz; default 2.75 kHz

4.8. Feedbacks

The Hawk can receive and process feedback input from diverse types of devices.

4.8.1. Feedback Supply Voltage

The Hawk has two feedback ports (Main and Auxiliary). The Hawk supplies voltage only to the main feedback device and to the auxiliary feedback device if needed.

Feature	Details
Main encoder supply voltage	5 V ±5% @ 200 mA maximum
Auxiliary encoder supply voltage	5 V ±5% @ 200 mA maximum

4.8.2. Main Feedback Options

4.8.2.1. Incremental Encoder Input

Feature	Details
Encoder format	• A, B and Index • Differential • Quadrature
Interface	RS-422
Input resistance	Differential: 120 Ω
Maximum incremental encoder frequency	Maximum absolute: 5 MHz pulses
Minimum quadrature input period (P_{IN})	112 nsec
Minimum quadrature input high/low period (P_{HL})	56 nsec
Minimum quadrature phase period (P_{PH})	28 nsec
Maximum encoder input voltage range	Common mode: ±7 V Differential mode: ±7 V

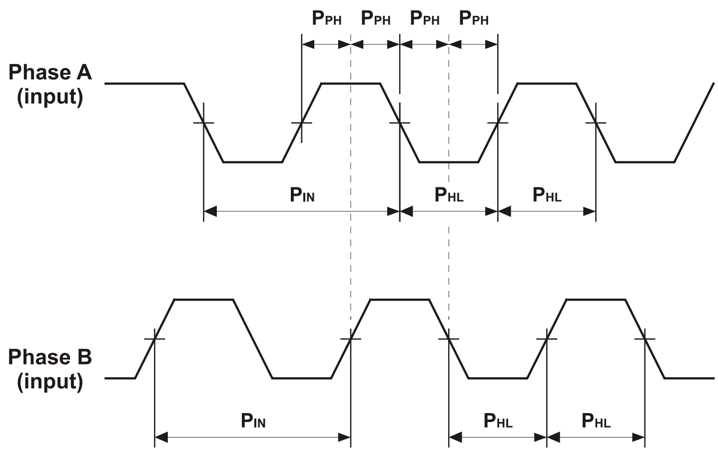


Figure 34: Main Feedback - Encoder Phase Diagram

4.8.2.2. Digital Halls

Feature	Details
Halls inputs	• H_A, H_B, H_C. • Single ended inputs • Built in hysteresis of 1 V for noise immunity
Input voltage	Nominal operating range: $0\ V < V_{In\_Hall} < 5\ V$ Maximum absolute: $-1\ V < V_{In\_Hall} < 15\ V$ High level input voltage: $V_{InHigh} > 2.5\ V$ Low level input voltage: $V_{InLow} < 1\ V$
Input current	Sink current (when input pulled to the common): 5 mA
Maximum frequency	f_{MAX} : 2 kHz

4.8.2.3. Interpolated Analog (Sine/Cosine) Encoder

Feature	Details
Analog encoder format	• Sine and Cosine signals
Analog input signal level	• Offset voltage: 2.2 V to 2.8 V • Differential, 1 V peak to peak
Input resistance	Differential 120 Ω
Maximum analog signal frequency	f_{MAX} : 250 kHz
Interpolation multipliers	Programmable: x4 to x4096
Maximum “counts” frequency	80 mega-counts/sec “internally”
Automatic errors correction	Signal amplitudes mismatch Signal phase shift Signal offsets
Encoder outputs	See Auxiliary Encoder Outputs specifications (4.8.3)

4.8.2.4. Resolver

Feature	Details
Resolver format	• Sine/Cosine • Differential
Input resistance	Differential 2.49 kΩ
Resolution	Programmable: 10 to 15 bits
Maximum electrical frequency (RPS)	512 revolutions/sec
Resolver transfer ratio	0.5
Reference frequency	1/Ts (Ts = sample time in seconds)
Reference voltage	Supplied by the Hawk
Reference current	up to ±50 mA
Encoder outputs	See Auxiliary Encoder Output specifications (4.8.3)

4.8.2.5. Tachometer*

Feature	Details
Tachometer format	Differential
Maximum operating differential voltage for TAC1+, TAC1-	±20 V
Maximum absolute differential input voltage for TAC1+, TAC1-	±25 V
Maximum operating differential voltage for TAC2+, TAC2-	±50 V
Maximum absolute differential input voltage for TAC2+, TAC2-	±60 V
Input resistance for TAC1+, TAC1-	46 kΩ
Input resistance for TAC2+, TAC2-	100 kΩ
Resolution	14 bit

* Only one Tachometer port can be used at a time (either TAC1+/TAC1- or TAC2+/TAC2-).
TAC1+/TAC1- is used in applications with having a Tachometer of less than 20 V.
TAC2+/TAC2- is used in applications with having a Tachometer of between 20 V and 50 V.

4.8.2.6. Potentiometer

Feature	Details
Potentiometer Format	Single-ended
Operating Voltage Range	0 to 5 V supplied by the Hawk
Potentiometer Resistance	100 Ω to 1 kΩ ... above this range, linearity is affected detrimentally
Input Resistance	100 kΩ
Resolution	14 bit

4.8.3. Auxiliary Feedback Port (output mode YA[4]= 4)

Feature	Details
Emulated output	• A, B, Index • Single ended
Output current capability	Maximum output current: I_{OH} (max) = 2 mA High level output voltage: V_{OH} > 3.0 V Minimum output current: I_{OL} = 2 mA Low level output voltage: V_{OL} < 0.4 V
Available as options	• Emulated encoder outputs of analog encoder • Emulated encoder outputs of the resolver • Emulated encoder outputs of the tachometer • Emulated encoder outputs of the potentiometer
Maximum frequency	f_{MAX}: 5 MHz pulses/output
Edge separation between A & B	Programmable number of clocks to allow adequate noise filtering at remote receiver of emulated encoder signals
Index (marker):	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

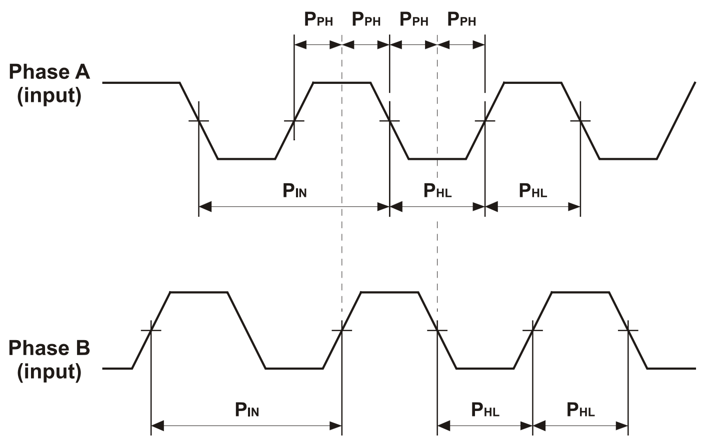


Figure 35: Auxiliary Feedback - Encoder Phase Diagram

4.8.4. Auxiliary Feedback Port (input mode YA[4]= 2, 0)

Feature	Details
Encoder input, pulse and direction input	• A, B, Index • Single ended
Input voltage	V_{In} Low: 0 V < V_{IL} < 0.8 V V_{In} High: 2 V < V_{IH} < 5 V Maximum absolute voltage: 0 < V_{In} < 5.5 V Input current: ±1 µA
Available as options	• Single-ended Encoder inputs • Pulse and Direction inputs
Edge separation between A & B	Programmable number of clocks to allow adequate noise filtering at remote receiver of emulated encoder signals
Index (marker)	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

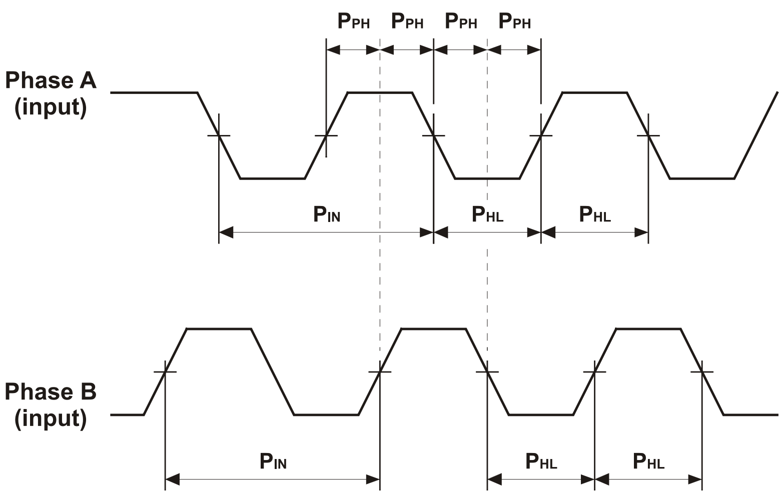


Figure 36: Auxiliary Feedback - Encoder Phase Diagram

4.9. I/Os

The Hawk has:

- 6 Digital Inputs
- 4 Digital Outputs
- 1 Analog Input

4.9.1. Digital Input Interfaces

Feature	Details
Type of input	• Optically isolated • Each input has its own return
Input current for all inputs	Iin = 2.4 mA @ Vin = 5 V
High-level input voltage	2.5 V < Vin < 10 V, 5 V typical
Low-level input voltage	0 V < Vin < 1 V
Minimum pulse width	> 4 x TS, where TS is sampling time
Execution time (all inputs): the time from application of voltage on input until execution is complete	If input is set to one of the built-in functions — Home, Inhibit, Hard Stop, Soft Stop, Hard and Soft Stop, Forward Limit, Reverse Limit or Begin — execution is immediate upon detection: 0<T<4xTS If input is set to General input, execution depends on program. Typical execution time: ≅ 0.5 msec.
High-speed inputs – 5 & 6 minimum pulse width, in high-speed mode	T < 5 µsec **Notes:** • Home mode is high-speed mode and can be used for fast capture and precise homing. • High speed input has a digital filter set to same value as digital filter (EF) of main encoder. • Highest speed is achieved when turning on optocouplers.

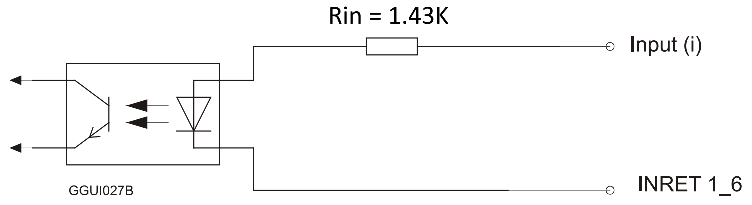


Figure 37: Digital Input Schematic

4.9.2. Digital Output Interface

Feature	Details
Type of output	• Optically isolated • Open collector and open emitter
Maximum supply output (VCC)	30 V
Max. output current I_{out} (max) (V_{out} = Low)	I_{out} (max) ≤ 15 mA
VOL at maximum output voltage (low level)	V_{out} (on) ≤ 0.3 V
R_L	The external resistor R_L must be selected to limit the output current to no more than 15 mA. $R_L = \frac{VCC - VOL}{I_{out}(max)}$
Executable time	If output is set to one of the built-in functions — Home flag, Brake or AOK — execution is immediate upon detection: 0 < T < 4 x TS If output is set to General output and is executed from a program, the typical time is approximately 0.5 msec.

Figure 38: Digital Output Schematic

4.9.3. Analog Input

Feature	Details
Maximum operating differential voltage	± 10 V
Maximum absolute differential input voltage	± 16 V
Differential input resistance	3.74 kΩ
Analog input command resolution	14-bit

4.10. Communications

Specification	Details
RS-232	**Signals:** • RxD , TxD , Gnd • Full duplex, serial communication for setup and control. • Baud Rate of 9,600 to 57,600 bit/sec.
CAN	**CAN bus Signals:** • CAN_H, CAN_L, CAN_GND • Maximum Baud Rate of 1 Mbit/sec. **Version:** • DS 301 V4.01 **Layer Setting Service and Protocol Support:** • DSP 305 **Device Profile** (drive and motion control)**:** • DSP 402

4.11. Pulse-Width Modulation (PWM)

Feature	Details
PWM resolution	12-bit
PWM switching frequency on the load	2/Ts (factory default 22 kHz on the motor)

4.12. Compliance with Standards

Specification	Details
Quality Assurance	
ISO 9001:2008	Quality Management
Design	
Approved **IEC/EN 61800-5-1, Safety**	Printed wiring for electronic equipment (clearance, creepage, spacing, conductors sizing, etc.)
MIL-HDBK- 217F	Reliability prediction of electronic equipment (rating, de-rating, stress, etc.)
• **UL 60950** • **IPC-D-275** • **IPC-SM-782** • **IPC-CM-770** • **UL 508C** • **UL 840**	Printed wiring for electronic equipment (clearance, creepage, spacing, conductors sizing, etc.)
In compliance with **VDE0160-7 (IEC 68)**	Type testing
Safety	
Recognized **UL 508C**	Power Conversion Equipment
In compliance with **UL 840**	Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment
In compliance with **UL 60950**	Safety of Information Technology Equipment Including Electrical Business Equipment
Approved **IEC/EN 61800-5-1, Safety**	Adjustable speed electrical power drive systems
In compliance with **EN 60204-1**	Low Voltage Directive 73/23/EEC

EMC	
Approved **IEC/EN 61800-3, EMC**	Adjustable speed electrical power drive systems
In compliance with **EN 55011** Class A with **EN 61000-6-2**: Immunity for industrial environment, according to: **IEC 61000-4-2** / criteria B **IEC 61000-4-3** / criteria A **IEC 61000-4-4** / criteria B **IEC 61000-4-5** / criteria B **IEC 61000-4-6** / criteria A **IEC 61000-4-8** / criteria A **IEC 61000-4-11** / criteria B/C	Electromagnetic compatibility (EMC)
Workmanship	
In compliance with **IPC-A-610**, level 3	Acceptability of electronic assemblies
PCB	
In compliance with **IPC-A-600**, level 2	Acceptability of printed circuit boards
Packing	
In compliance with **EN 100015**	Protection of electrostatic sensitive devices
Environmental	
In compliance with **2002/96/EC**	Waste Electrical and Electronic Equipment regulations (WEEE) **Note:** Out-of-service Elmo drives should be sent to the nearest Elmo sales office.
In compliance with **2002/95/EC** (effective July 2006)	Restrictions on Application of Hazardous Substances in Electric and Electronic Equipment (RoHS)