SimplIQ Line

Trombone
Digital Servo Drive
Installation Guide

October 2017 (Ver. 1.405)

Elmo
Motion Control

www.elmomc.com

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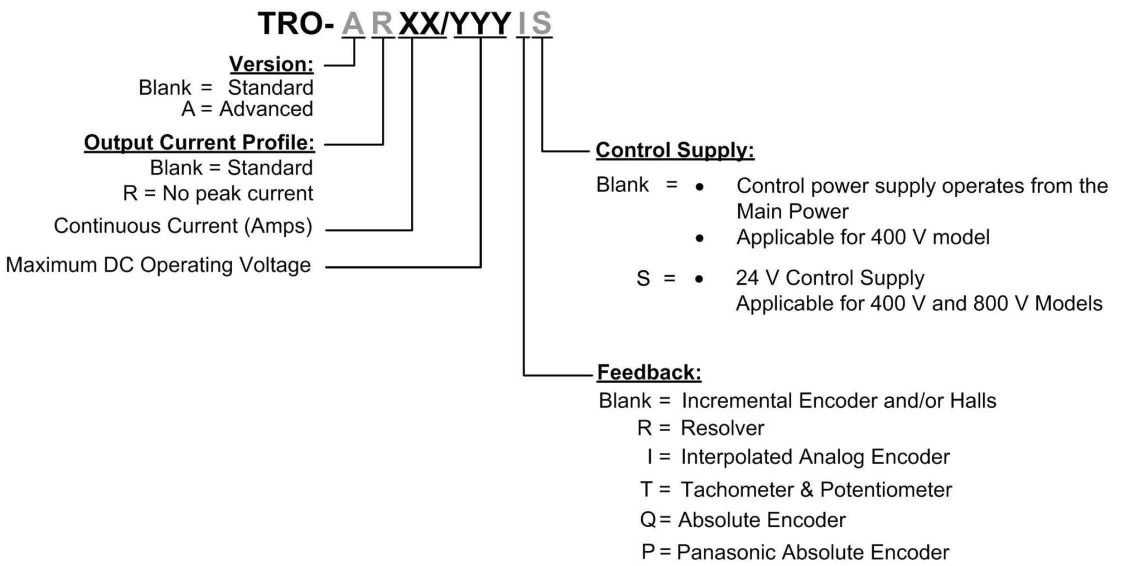

Revision History

Version		Details
1.0		Initial release
1.1		Significant changes to the Appendix (Chapter 4)
1.2		Upgraded Trombone version to include new absolute encoder settings and STO.
1.3		Sections 4.3 and 4.3.1: Auxiliary Supply Voltage range: 18 V to 30 V
1.4	September 2012	Change the overvoltage in 800 V mode, Pin layout, UL recognition, and further optional versions added “Metronome” was replaced by the “Composer” software.
1.401	February 2013	Added a caution and recommendation on the type of cleaning solution to use for the Elmo unit.
1.402	June 2014	Document update
1.403	July 2014	Basic format changes
1.404	March 2016	Basic format changes
1.405	October 2017	Updated the Warranty Information section 1.5 and the part number label in section 3.2

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 Trombone 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 Trombone and accompanying equipment.

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

Before you start, make sure 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 Trombone 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.
- Disconnect the Trombone from all voltage sources before it is opened for servicing.
- The Trombone 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). It is recommended to measure the electrical contact points with a meter before touching the equipment.

1.2. Cautions

- The Trombone 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 to Trombone to an approved isolated 24 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 Trombone, 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 Trombone 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 Trombone 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 Trombone 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 Trombone servo drive is intended for incorporation in a machine or end product. The actual 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 Trombone 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: Product Description

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

2.1. Drive Description

The Trombone series of digital servo drives are highly resilient and designed to deliver the highest density of power and intelligence. The Trombone delivers up to **10 kW of continuous power** or **16 kW of peak power** in a compact package.

The digital drives are based on Elmo's advanced SimplIQ motion control technology. They operate 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. They are designed for use with any type of sinusoidal and trapezoidal commutation, with vector control. The Trombone 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 drives are easily set up and tuned using Elmo's Composer software tools. This Windows-based application enables users to configure the servo drive quickly and simply for optimal use with their motor. The Trombone, as part of the SimplIQ product line, is fully programmable with Elmo's Composer motion control language.

Power to the drives is provided by a DC power source (not included with the Trombone).

Since the power stage is fully isolated from the control stage, the DC rectifier can be fed directly from the mains, without the need for a bulky and expensive transformer.

If backup functionality is required to store control parameters in the event of a mains power outage, then an S-model Trombone should be used, with an external 24 VDC isolated supply connected to it.

Note: The backup functionality can operate from an isolated voltage source within the range of 18 to 30 VDC.

Whenever backup functionality is not required, Trombone models that do *not* have the Control Supply S suffix in the catalog number (only for 400 V models -see page 17) can be used, i.e., they do not have a 24 V control supply. In these models, a smart control-supply algorithm enables the Trombone to operate with only the main power supply VP+ and VN-, with no need for a 24 VDC auxiliary power supply for the logic.

The Trombone is a PCB-mounted device, which enables efficient and cost-effective implementation. However, stand-alone integrated products (the DC Trombone and Solo Trombone) are also available, using pluggable connections.

The Trombone is available in two versions:

- The Standard Trombone 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 catalog number begins TRO but is not followed by an A.)
- The Advanced Trombone 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. (The catalog number begins TRO-A.).

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)

2.2.4. Advanced Position Control

This relates to the advanced model only.

- 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

2.2.5. Communication Options

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

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

2.2.6. Feedback Options

- Incremental Encoder – up to 20 Megacounts (5 Megapulses) per second
- Digital Halls – up to 2 kHz
- Incremental Encoder with Digital Halls for commutation – up to 20 Megacounts 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
- Absolute Encoder
  - Heidenhain 2.1
  - Heidenhain 2.2
  - Panasonic
- Elmo drives provide supply voltage for all the feedback options

2.2.7. Fault Protection

The Trombone 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

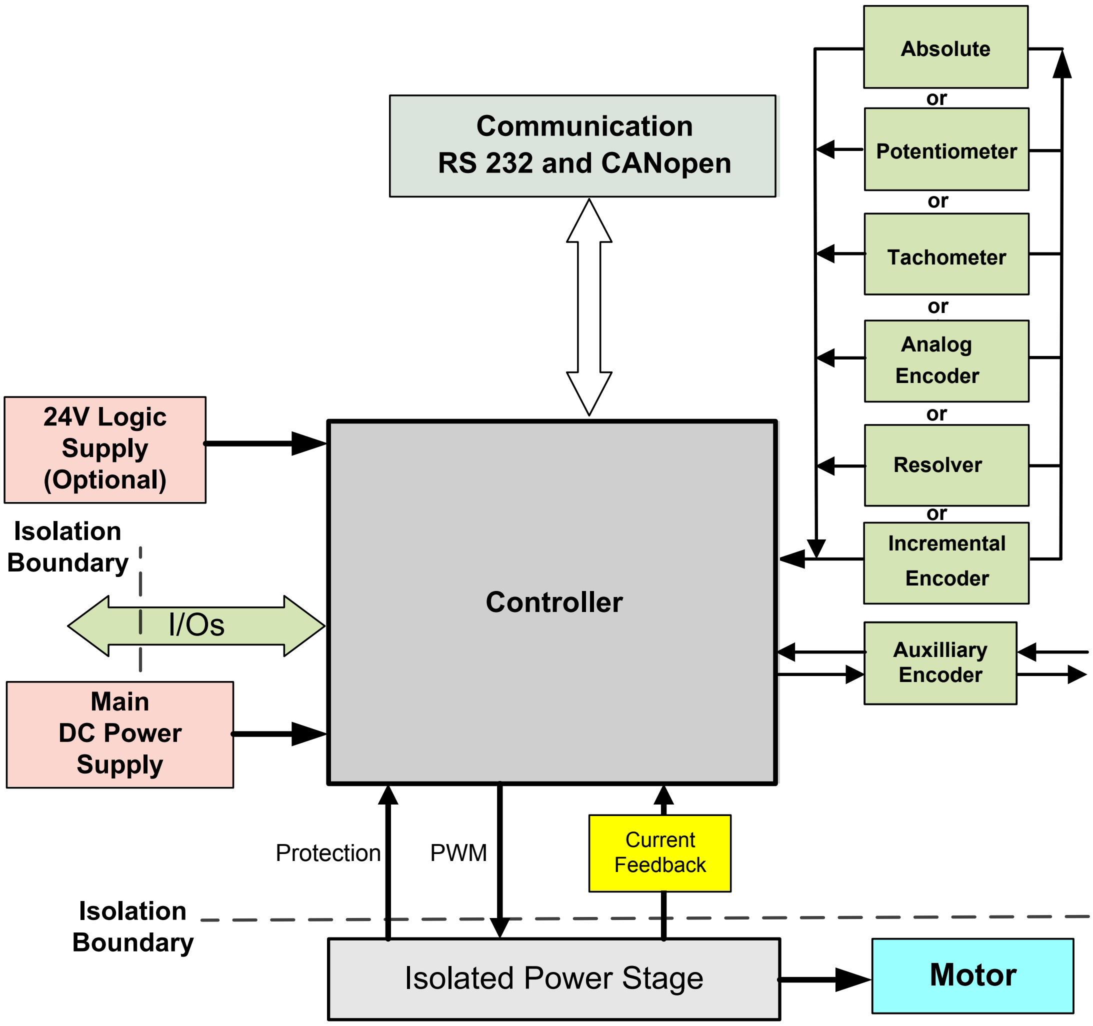


Figure 1: Trombone System Block Diagram

2.4. How to Use this Guide

In order to install and operate the Trombone 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 Trombone.
- Chapter 4 - *Technical Specifications*, lists all the drive ratings and specifications.

When you have completed the instructions in this guide, the Trombone 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 SimplIQ Software Manual, which describes the comprehensive software used with the Trombone
- The SimplIQ Command Reference Manual, which describes, in detail, each software command used to manipulate the Trombone motion controller
- The Composer Software Manual, which includes explanations of all the software tools that are part of Elmo's Composer software environment

Chapter 3: Installation

The Trombone 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 Trombone by ensuring that it is installed in an appropriate environment.

Feature	Value
Ambient operating temperature	0 °C to 40 °C (32 °F to 104 °F)
Maximum non-condensing humidity	90%
Operating area atmosphere	No flammable gases or vapors permitted in area
Models for extended environmental conditions are available.	

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

3.2. Unpacking the Drive Components

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

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

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

To unpack the Trombone

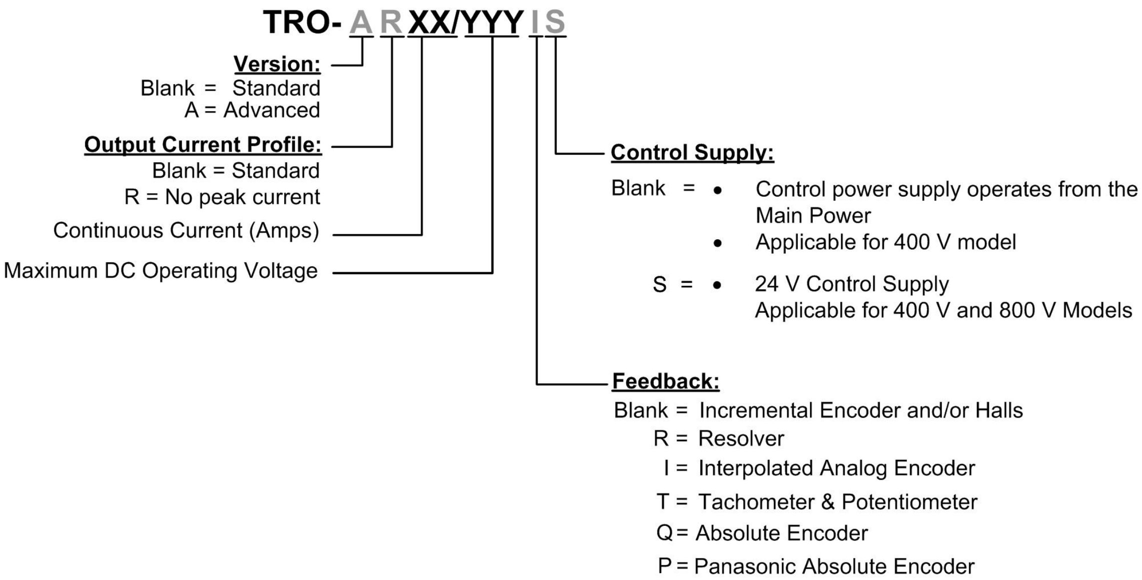
1. Carefully remove the servo drive from the box and the Styrofoam.
2. Check the drive to ensure that there is no visible damage to the instrument. If any damage has occurred, report it immediately to the carrier that delivered your drive.

3. To ensure that the Trombone you have unpacked is the appropriate type for your requirements, locate the part number sticker on the side of the Trombone.

   It looks like this:

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

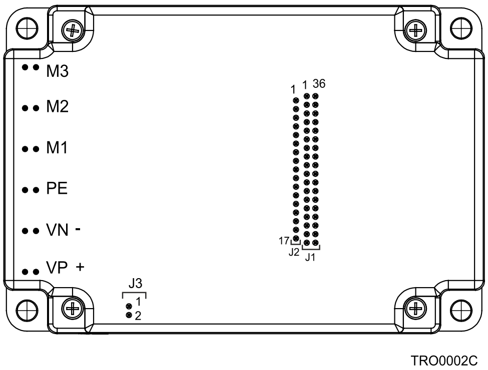
   The part number at the top gives the type designation as follows:



3.3. Pinouts

The Trombone has 9 connectors.

3.3.1. Connector Types

Pins	Type	Port	Function	Connector Location
2x18	2 mm pitch 0.51 mm²	J1	I/O, COMM, Auxiliary Feedback	
17		J2	Main Feedback, Analog Input, LED	
1x2		J3.1	24 VDC Auxiliary power input positive (Only in Trombone models with the S suffix)	
		J3.2	24 VDC Auxiliary power input return (Only in Trombone models with the S suffix)	
2	2.54 mm pitch 0.64 mm²	VP+	Positive DC power input	
2		VN-	Negative DC power input	
2		PE	Protective earth	
2		M1	Motor power output 1	
2		M2	Motor power output 2	
2		M3	Motor power output 3	

3.3.2. Connector J1

Connector J1: Communications, Auxiliary Feedback, I/O functions)

Pin (J1)	Signal	Function
1	RS232_RX	RS-232 receive
2	RS232_TX	RS-232 transmit
3	RS232_COMRET	RS-232 communication return
4	AUX PORT CHA	Auxiliary port CHA (bidirectional)
5	AUX PORT CHB	Auxiliary port CHB (bidirectional)
6	COMRET	Common 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	SAFETY1	Safety input 1
18	SAFETY2	Safety input 2
19	SAFETY2RET	Safety input 1 return (optionally connected to J1/20)
20	SAFETY1RET	Safety input 2 return (optionally connected to J1/19)
21	INRET6	Programmable digital input 6 return
22	INRET5	Programmable digital input 5 return
23	INRET4	Programmable digital input 4 return
24	INRET3	Programmable digital input 3 return
25	INRET2	Programmable digital input 2 return
26	INRET1	Programmable digital input 1 return
27	OUTRET4	Programmable digital output 4 return
28	OUTRET3	Programmable digital output 3 return
29	OUTRET2	Programmable digital output 2 return
30	OUTRET1	Programmable digital output 1 return

Pin (J1)	Signal	Function
31	+5 V	Encoder +5 V supply voltage Maximum output current: 200 mA
32	SUPRET	Supply return
33	AUX PORT INDEX	Auxiliary port index (bidirectional)
34	CAN_COMRET	CAN communication return
35	CAN_L	CAN_L bus line (dominant low)
36	CAN_H	CAN_H bus line (dominant high)

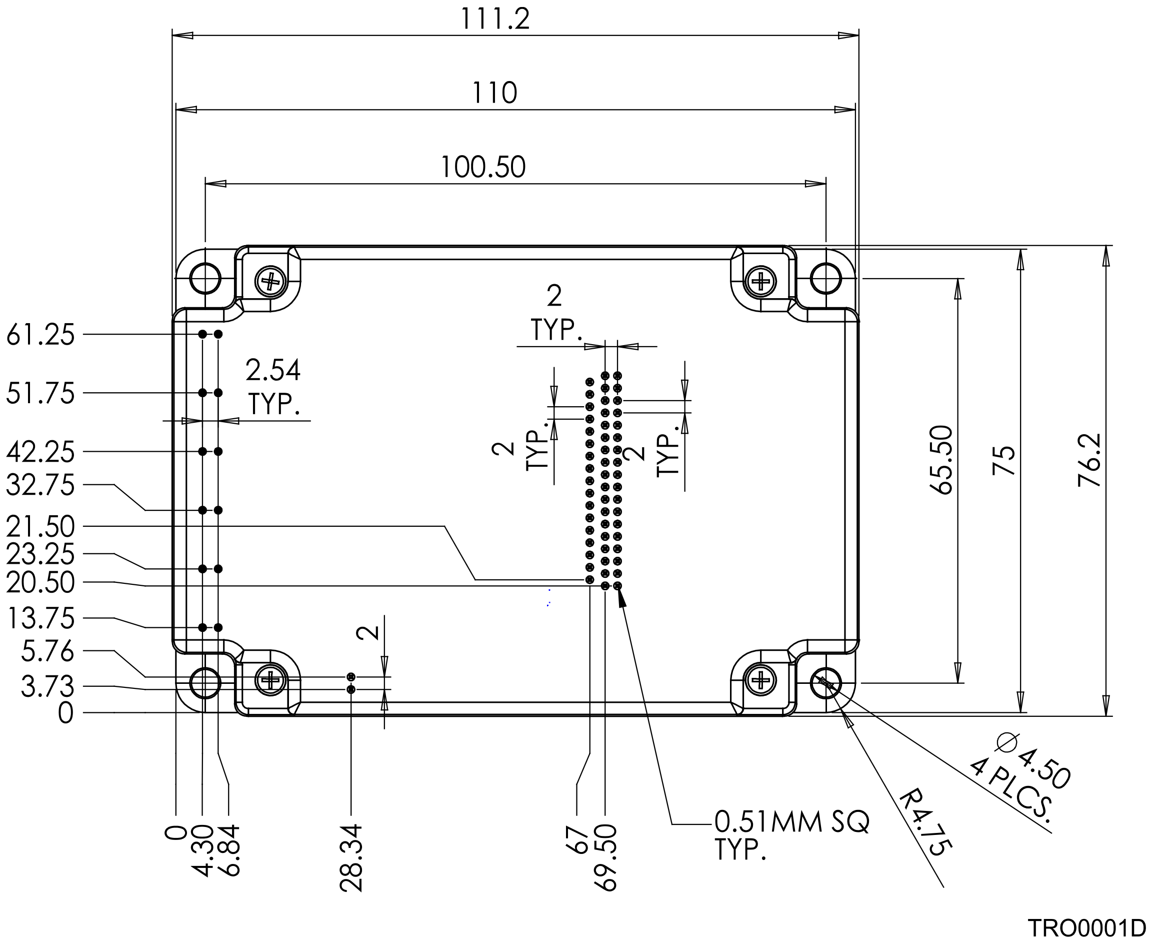
3.3.3. Connector J2

Connector J2: Main Feedback and Analog Input functions

Pin (J2)	Signal	Function
1	+5V	Encoder/Hall +5V supply voltage Maximum output current: 200 mA
2	COMRET	Supply and common return
3	ANALIN1+	Analog input 1+
4	ANALIN1-	Analog input 1-
5	CHA	Channel A+
6	CHA-	Channel A-
7	CHB	Channel B+
8	CHB-	Channel B-
9	INDEX+/DATA+	Index + or Data+
10	INDEX-/DATA-	Index – or Data-
11	CLOCK+	Clocking+
12	CLOCK-	Clocking-
13	HA	Hall sensor A input
14	HB	Hall sensor B input
15	HC	Hall sensor C input
16	LED_2_OUT	Bi-color indication output 2 (Cathode). Implement this pin-out usage by connecting it to a led (as necessary).
17	LED_1_OUT	Bi-color indication output 1 (Anode). Implement this pin-out usage by connecting it to a led (as necessary).

3.4. Mounting the Trombone

The Trombone (Figure 2) is designed for mounting on a printed circuit board (PCB). It is connected by 2 mm pitch 0.51 mm square pins and 2.54 mm pitch 0.64 mm square pins. When integrating the Trombone into a PCB, be sure to leave about 1 cm (0.4") outward from the heat sink to enable free convection of the air around the Trombone. We recommend that the Trombone be soldered directly to the board. If the PCB is enclosed in a metal chassis, we recommend that the Trombone be screw-mounted to it as well to help with heat dissipation. The Trombone has screw-mount holes on each corner of the heat sink for this purpose.



All dimensions are in mm.

Figure 2: Trombone Dimensions

3.5. Integrating the Trombone on a PCB

The Trombone is designed to be mounted on a PCB, by soldering its pins directly to the PCB. The following procedures apply.

3.5.1. Traces

To implement 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 Trombone is the current used for sizing the motor traces (M1, M2, M3 and PE) and power traces (VP+, VN- and PE).
   - For control, feedbacks and I/O conductors the actual current is very small, but "generous" thickness and width of the conductors will contribute to better performance and lower interference.
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+, VN-, M1, M2, M3) must be at least:

		400 V Drives	800 V Drives
Surface layer	Non-coated	2.4 mm	4.2 mm
	Coated	1.0 mm	2.4 mm
Internal layer		0.5 mm	1.0 mm

4. The spacing between the high voltage conductors (VP+, VN-, M1, M2, M3) and the logic part of the drive must be at least:

		400 V Drives	800 V Drives
Surface layer	Non-coated	4.8 mm	8.4 mm
	Coated	2.0 mm	3.8 mm
Internal layer		0.5 mm	1.0 mm

5. The spacing between any voltage conductors and the PE part of the drive, must be at least:

		400 V Drives	800 V Drives
Surface layer	Non-coated	2.4 mm	4.2 mm
	Coated	1.0 mm	2.4 mm
Internal layer		0.5 mm	1.0 mm

Complying with the rules above will help satisfy UL safety standards, MIL-STD-275 and the IPC-D-275 standard for non-coated conductors, operating at voltages lower than 800 VDC.

3.5.2. Grounds and Returns

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

Functional Block	Return Pin
RS232 Communications	RS232_COMRET (J1/3)
CAN Communications	CAN_COMRET (J1/34)
Control section	COMRET (J1/6)
Aux. Feedback	SUPRET (J1/32)
Main Feedback/ Analog input	SUPRET (J2/2)

The returns above are all shorted within the control section of the Trombone, 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 Trombone. **DO NOT USE A COMMON GROUND PLANE**. Shorting the common returns on the Integration Board may cause performance degradation (ground loops, etc.).
2. **Inputs**: The 6 digital inputs are optically isolated from the other parts of the Trombone. Each input has its own return line, INRET#. To retain isolation, the Input Return pins and all other conductors on the input circuit, must be laid out separately.
3. **Outputs**: The 4 digital outputs are optically isolated from the other parts of the Trombone. Each output has its own return line, OUTRET# that is also optically isolated. To retain isolation, all the output circuit conductors 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 crossover.
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 (Protective Earth) terminal is connected directly to the Trombone'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. Connection Diagrams

The following three connection diagrams (Figure 3, Figure 4) show the three different ways of connecting the power supply:

- 400 V and 800 V S models (the catalog number has an S suffix) that feature backup functionality and require an auxiliary 24 V backup supply. The drive will not be operative without the external 24 VDC supply.
- 400 V model without backup functionality. The drive's internal DC/DC converter is fed from the VP+ and VN- of the internal drive's bus line.

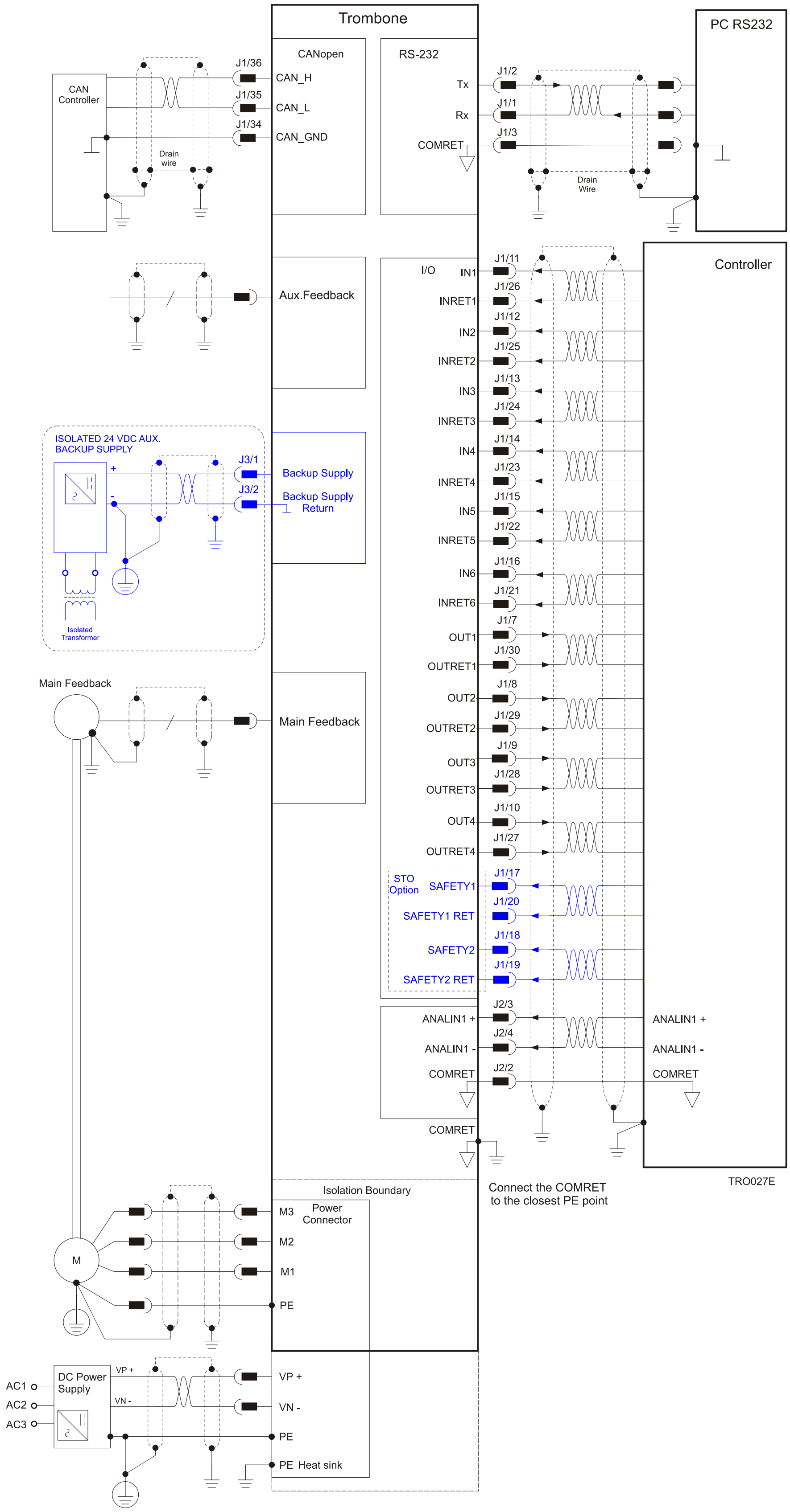


Figure 3: Trombone Connection Diagram – with Backup Functionality (S Model Drive)

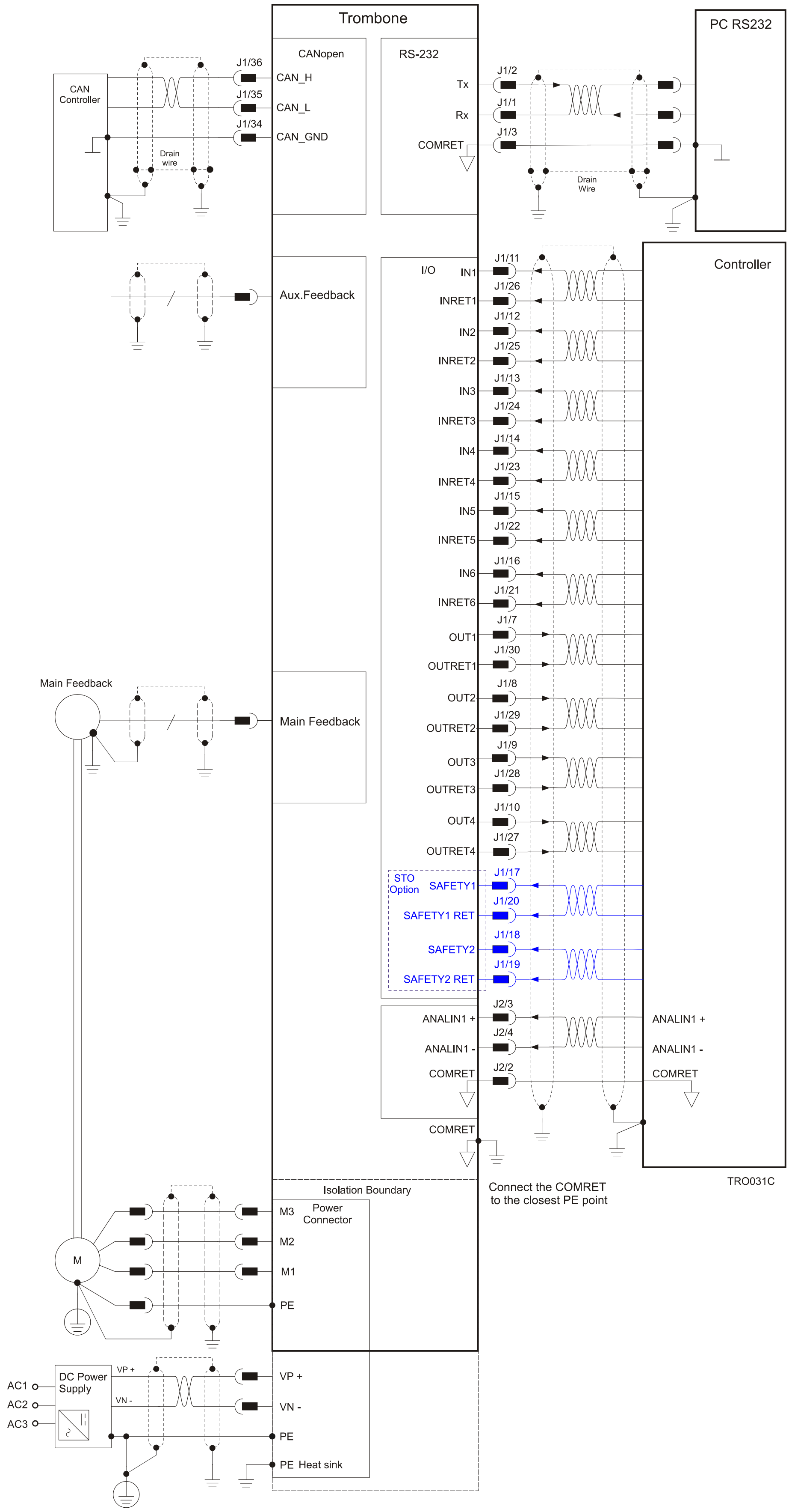
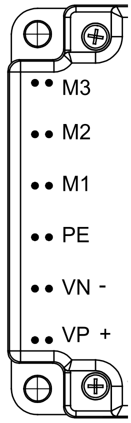


Figure 4: Trombone Connection Diagram – 400 V without Backup Functionality

3.7. Main Power and Motor Power

The Trombone 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
		AC Motor	DC Motor	
M3	Motor phase	Motor	Motor	
M2	Motor phase	Motor	Motor	
M1	Motor phase	Motor	N/C	
PE	Protective Earth	Power and Motor		
VN-	DC Negative Power input	Power		
VP+	DC Positive Power input	Power		

3.7.1. Connecting Motor Power

Connect the M1, M2, M3 and PE pins (Figure 5) on the Trombone in the manner described in section 3.5 (Integrating the Trombone on a PCB). The phase connection is arbitrary, as the Composer will establish the proper commutation automatically during setup. When tuning a number of drives, you can copy the setup file to the other drives and thus avoid tuning each drive separately. In this case, the motor-phase order must be the same as on the first drive.

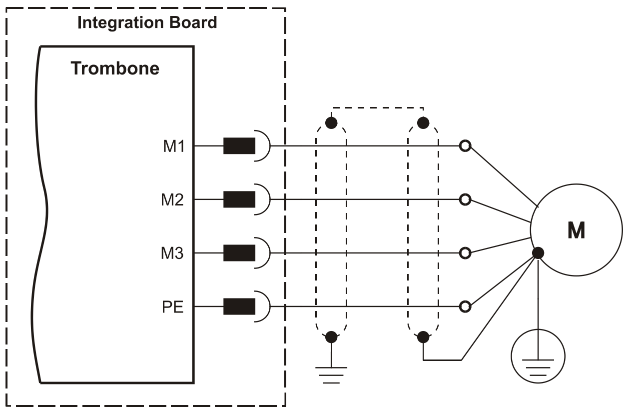


Figure 5: Motor Power Connection Diagram

Notes:

- For best immunity, it is highly recommended to use a 4-wire shielded (not twisted) cable for the motor connection. The gauge is determined by the actual current consumption of the motor.
- Connect the cable shield to the closest ground connection at the motor end.
- Connect the cable shield to the closest PE terminal of the Trombone.
- Ensure that the motor chassis is properly grounded.

3.7.2. Connecting the DC Power

The DC power for the Trombone is delivered from a separated rectifying unit (supplied by the user). The following sections contain topology recommendations for implementing three-phase and a single-phase supply chains. Elmo offers the end-user, the option to purchase its Tambourine rectifier, which offers a range of versatile options.

The power stage of the Trombone is fully isolated from the other sections of the Trombone, such as the control-stage and the heat sink. This isolation allows the user to connect the common of the control section to the PE, a connection that significantly contributes to proper functionality, safety and EMI immunity, leading to better performance of the Trombone.

In addition, this isolation simplifies the requirements of the DC power supply that is used to power the DC bus of the Trombone, by allowing it to operate with a non-isolated DC power source (a direct-to-mains connection) which eliminates the need for a bulky and expensive isolation transformer.

However, as well as operating from a non-isolated/direct-to-mains DC power supply, the Trombone can also operate from an isolated power supply or batteries.

When rectifying an AC voltage source, the AC voltage level must be limited to 270 VAC so as not to exceed the maximum 390 VDC in the case of a 400 VDC drive, or 528 VAC so as not to exceed the maximum 747 VDC in the case of an 800 VDC drive.

If the Trombone is connected to Elmo's Tambourine power supply, then the end-user can exploit the Tambourine's options, such as EMI-filtering and shunt-regulator.

3.7.2.1. Direct-to-Mains Power Source (Non-Isolated Rectifier)

This section relates to the configuration of the power supply and drive, which are connected directly to the mains (Figure 6, Figure 7, Figure 8 and Figure 9).

Recommended connection of a non-isolated DC power supply

1. For best immunity, it is highly recommended to use twisted cables for the DC power supply cable. A 3-wire shielded cable should be used. The gauge is determined by the actual current consumption of the motor.
2. Connect both ends of the cable shield to the closest PE connections.
3. Tie one end to the power supply's PE terminal, and tie the other end to the PE pins of the module/PE terminal of the integration board, or attach it to one of the four mounting screws of the drive's heat sink.

3.7.2.1.a Three-Phase Direct-to-Mains Connection Topology

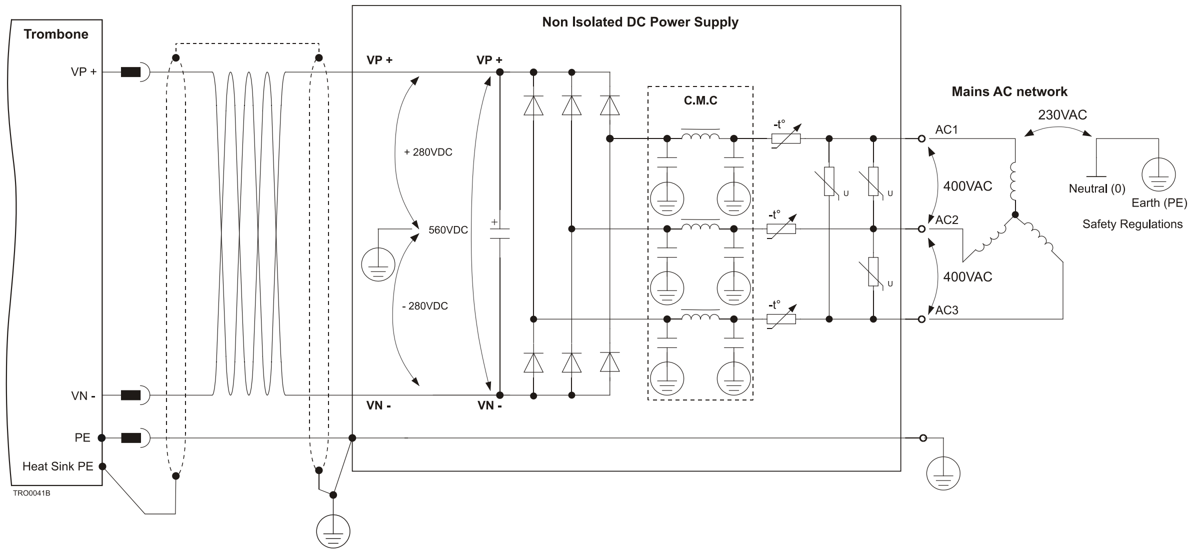


Figure 6: Non-Isolated Three-Phase Connection Topology

Caution:

Do not connect VN- to PE. In a direct-to-mains connection, the VN- must *not* be connected to the PE, as this will cause irreparable damage to the system.

Take care to note that in a direct-to-mains connection the Neutral point is *not* the most negative voltage level. It is the mid-point level of the rectified DC bus.

3.7.2.1.b Single-Phase Direct-to-Mains Connection Topology

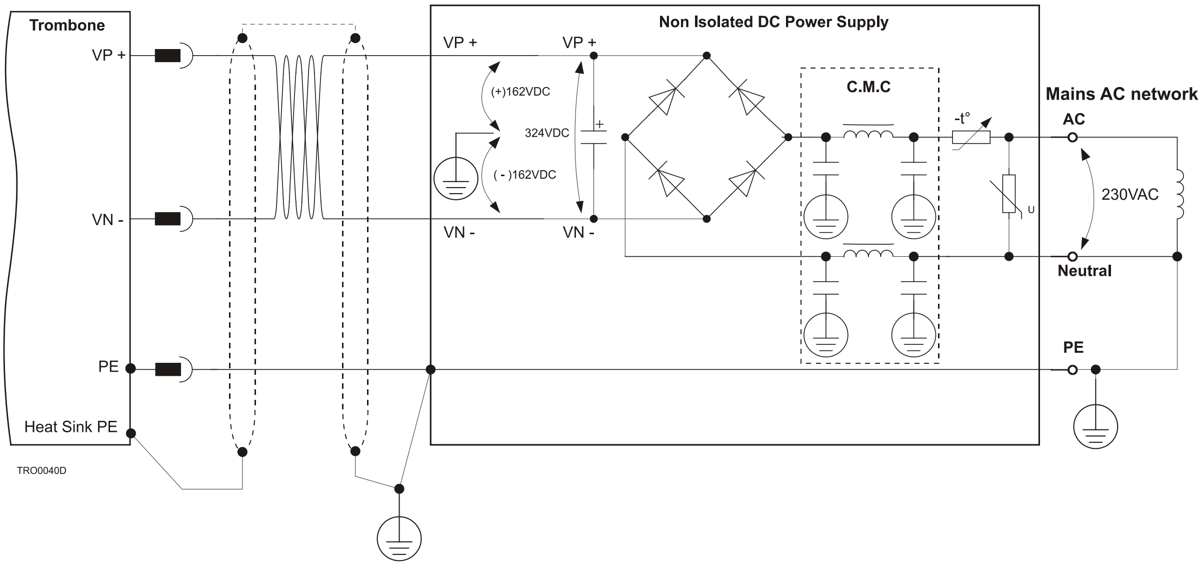


Figure 7: Non-Isolated Single-Phase Connection Topology

The Power Supply is connected directly to the Mains AC line.

Caution:
Do not connect VN- to PE. In a direct-to-mains connection the VN- must *not* be connected to the PE, as this will cause irreparable damage to the system.

Take care and note that in a direct-to-mains connection the Neutral point is *not* the most negative voltage level. It is the mid-point level of the rectified DC bus.

3.7.2.1.c Multiple Connections Topology

When applied in a multi-axis arrangement, it is likely that a single power supply can feed several drives in parallel.

This topology is efficient and cost saving, reducing the number of power supplies and the amount of wiring. More importantly, it utilizes an energy-sharing environment among all the drives that share the same DC bus network.

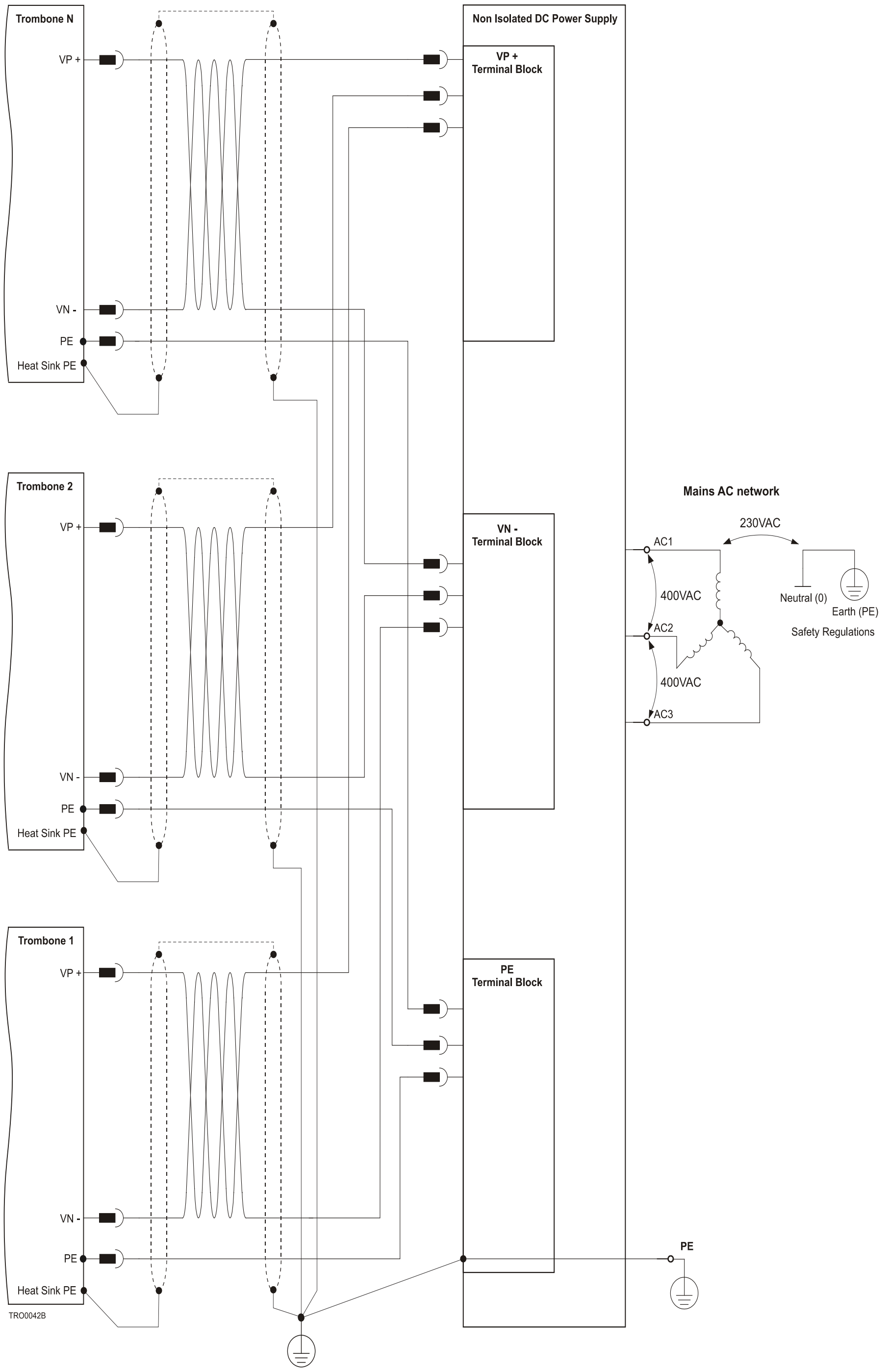


Figure 8: Non-Isolated Three-Phase Multiple-Connection Topology

The power supply is connected directly to the Mains AC line and it feeds more than one drive.

3.7.2.2. Battery Power Supply

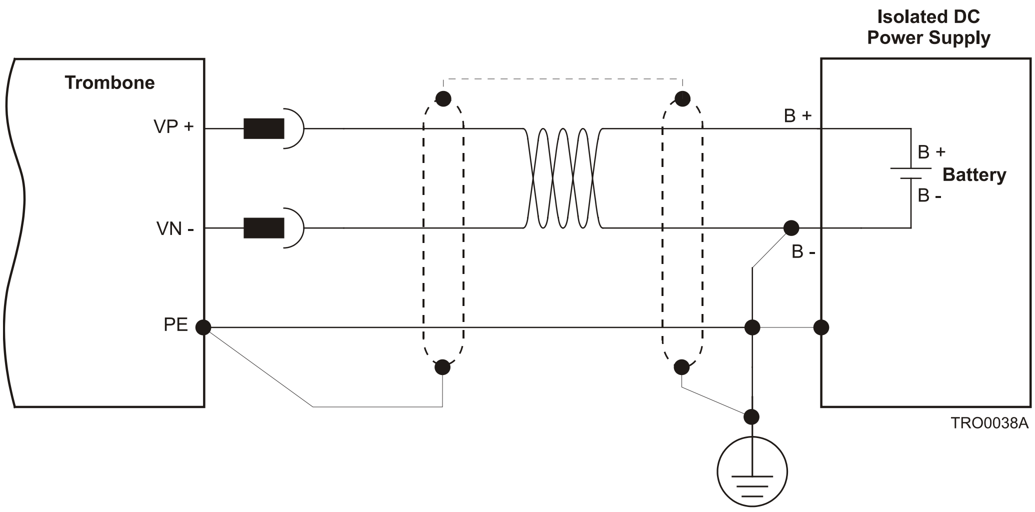


Figure 9: Battery Connection Topology

Caution:
When using batteries, it is recommended to connect the negative pole to the PE.
When doing so, the charger of the battery **must** be isolated from the mains by an isolation transformer.

3.8. Connecting the Control and Backup Supply

In Trombone models without the S suffix in the catalog number, a smart control-supply algorithm enables the Trombone to operate with the main power supply only, *with no need for an auxiliary supply voltage to supply the drive's logic section*.

Note: In Trombone models without the S suffix, there is no backup ability at all.

If a backup functionality is required to store control parameters in the event of a mains power outages, then an S-model Trombone should be used, with an external 24 VDC isolated power supply connected to it.

Note that S-model Trombone always requires an external 24 VDC power supply, regardless of whether or not backup functionality is required.

Connect the auxiliary 24 VDC power supply as described below (Figure 10).

Notes for 24 VDC backup supply connections:

- Use a 24 AWG twisted pair shielded cable. The shield should have copper braid.
- The source of the 24 VDC backup supply must be isolated with an isolation transformer.
- For safety and EMI reasons, connect the return of the 24 VDC backup supply to the closest ground (PE).
  Connect the cable shield to the closest ground (PE) near the power source.
  Before applying power, first verify that the polarity of the connection is correct.

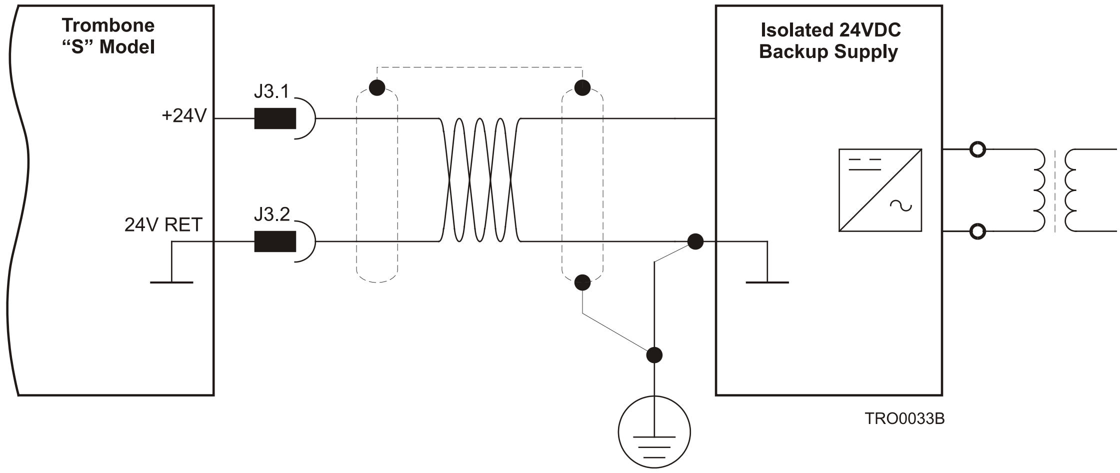


Figure 10: Auxiliary 24 VDC Backup Supply Connection Diagram

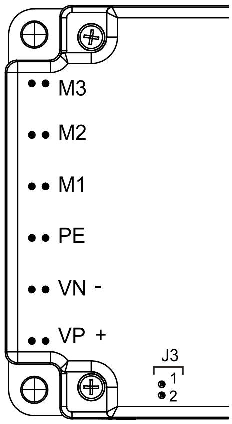
Pin (J3)	Function	Pin Positions
1	+24V Auxiliary Supply Input Positive	
2	24VRET Auxiliary Supply Input Return	

Table 1: Auxiliary 24 VDC Backup Supply Pins and Polarity

3.9. Main Feedback

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

The Trombone 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 (optional)
- Resolver (optional)
- Tachometer (optional)
- Potentiometer (optional)
- Absolute Encoder (optional)

Table 2 and Table 3 describe the various options available for the main feedback pin assignments for Encoders, Resolver, and the Tachometer & Potentiometer.

	Incremental Encoder		**Interpolated Analog Encoder**		**Absolute Encoder**	
	TRO-XX/YYY_		**TRO-XX/YYYI**		**TRO-XX/YYYQ**	
Pin (J2)	**Signal**	**Function**	**Signal**	**Function**	**Signal**	**Function**
1	+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
3	ANALIN+ is used for Analog Input					
4	ANALIN- is used for Analog Input					
5	CHA	Channel A+	A+	Sine A+	A+	Sine A+
6	CHA-	Channel A-	A-	Sine A-	A-	Sine A-
7	CHB	Channel B+	B+	Cosine B+	B+	Cosine B+
8	CHB-	Channel B -	B-	Cosine B -	B-	Cosine B -
9	INDEX	Index+	R+	Reference+	DATA+	Data+
10	INDEX-	Index -	R-	Reference -	DATA-	Data-
11	NC		NC		Clock+	Clock+
12	NC		NC		Clock-	Clock-
13	HA	Hall sensor A input	HA	Hall sensor A input	HA	Hall sensor A input
14	HB	Hall sensor B input	HB	Hall sensor B input	HB	Hall sensor B input
15	HC	Hall sensor C input	HC	Hall sensor C input	HC	Hall sensor C input
16	LED_2_OUT (AOKLED cathode) is used for implementing LED indication					
17	LED_1_OUT (AOKLED anode) is used for implementing LED indication					

Table 2: Main Feedback Pin Assignments in Encoders

	Resolver		Tachometer & Potentiometer	
	TRO-XX/YYYR		TRO-XX/YYYT	
Pin	**Signal**	**Function**	**Signal**	**Function**
1	+5V		+5V	Encoder/ Hall +5V supply
2	SUPRET		SUPRET	Supply return
3	ANALIN+ is used for Analog Input			
4	ANALIN- is used for Analog Input			
5	S1	Sine A+	Tac 1+	Tacho Input 1 Pos. (20V max)
6	S3	Sine A -	Tac 1-	Tacho Input 1 Neg. (20 V max)
7	S2	Cosine B+	Tac 2+	Tacho Input 2 Pos. (50V max)
8	S4	Cosine B -	Tac 2-	Tacho Input 2 Neg. (50 V max)
9	R1	Vref f=1/TS, 50mA Max.	POT	Potentiometer Input (5V Max)
10	R2	Vref- f= 1/TS, 50 mA Max.	NC	-
11	NC		NC	
11	NC		NC	
13	HA		HA	Hall sensor A input
14	HB		HB	Hall sensor B input
13	HC		HC	Hall sensor C input
16	LED_2_OUT (AOKLED cathode) is used for LED indication			
17	LED_1_OUT (AOKLED anode) is used for LED indication			

Table 3: Main Feedback Pin Assignments in the Resolver, Tachometer & Potentiometer

The following connection diagrams detailed in Figure 11 through Figure 20 describe the main feedback connections, shown in the tables above.

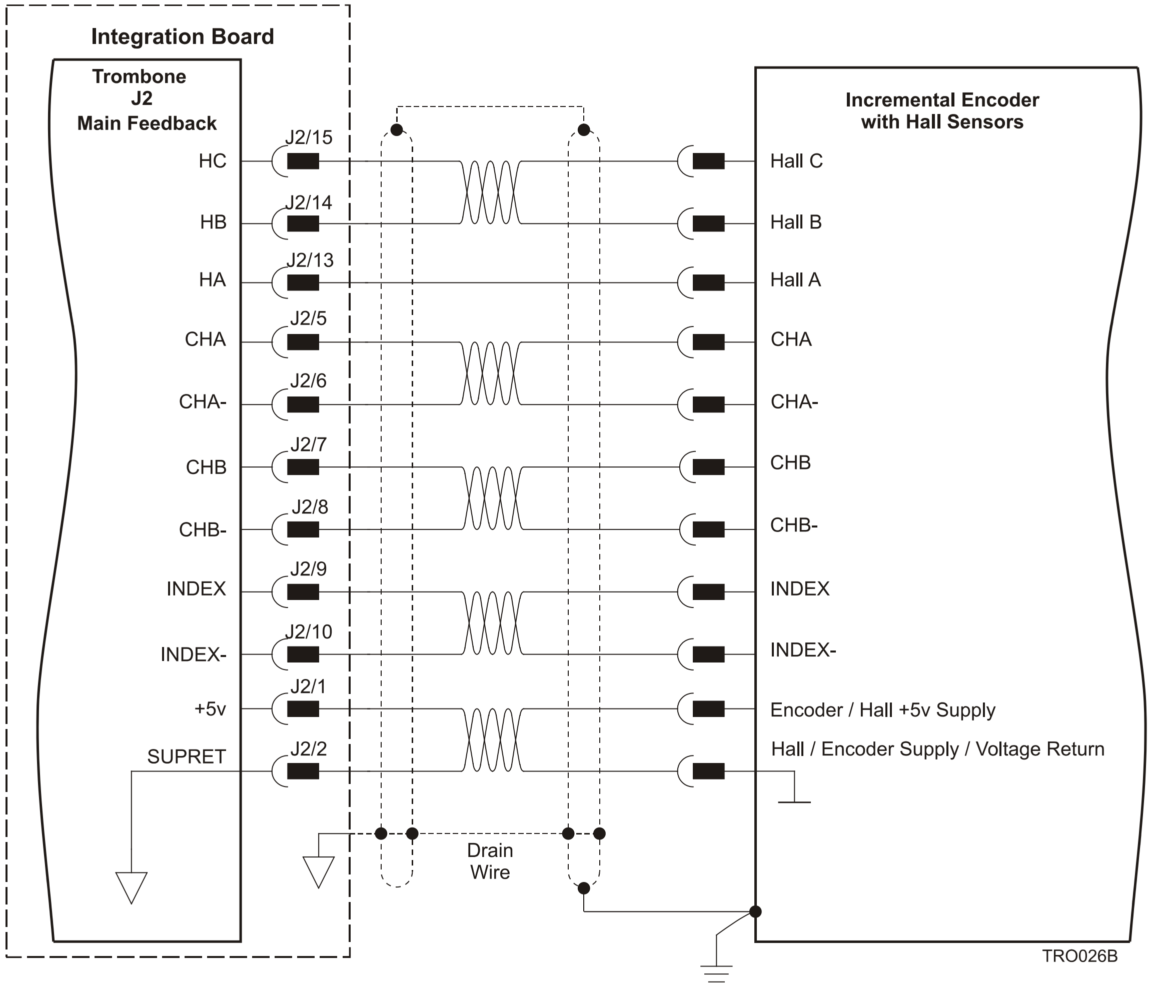


Figure 11: Main Feedback – Incremental Encoder with Digital Hall Sensors Connection Diagram

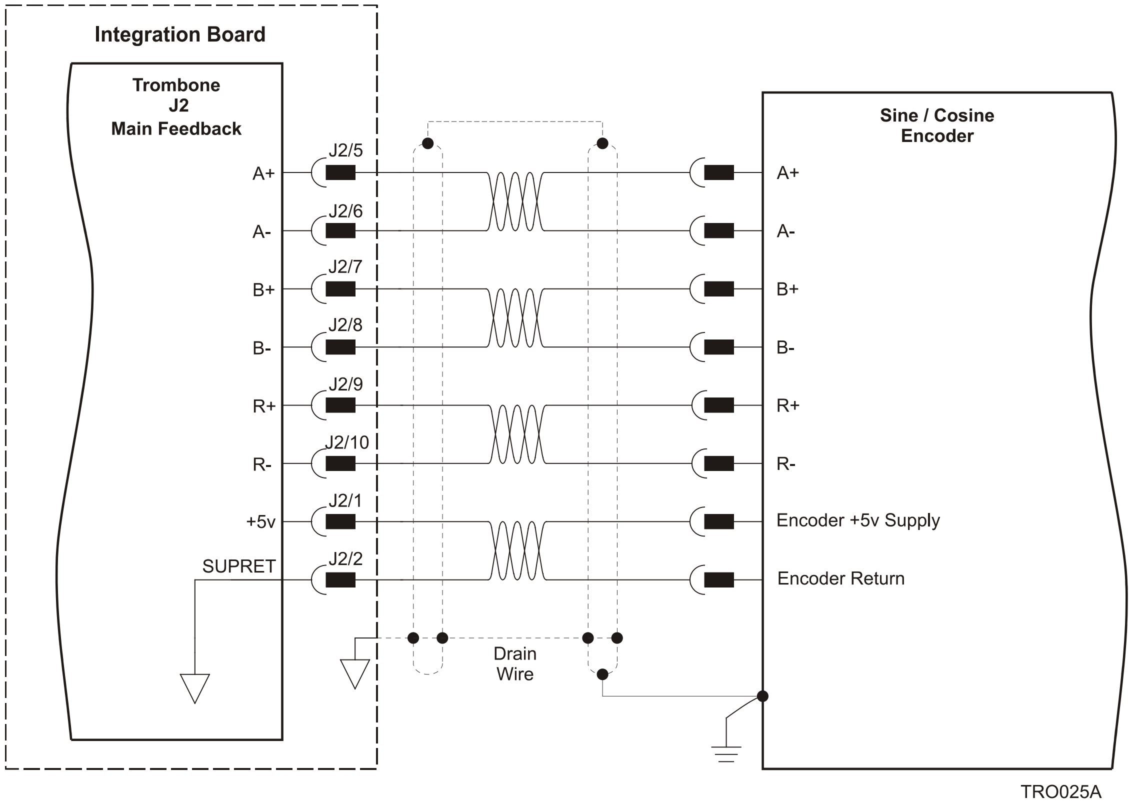


Figure 12: Main Feedback – Interpolated Analog (Sine/Cosine) Encoder Connection Diagram

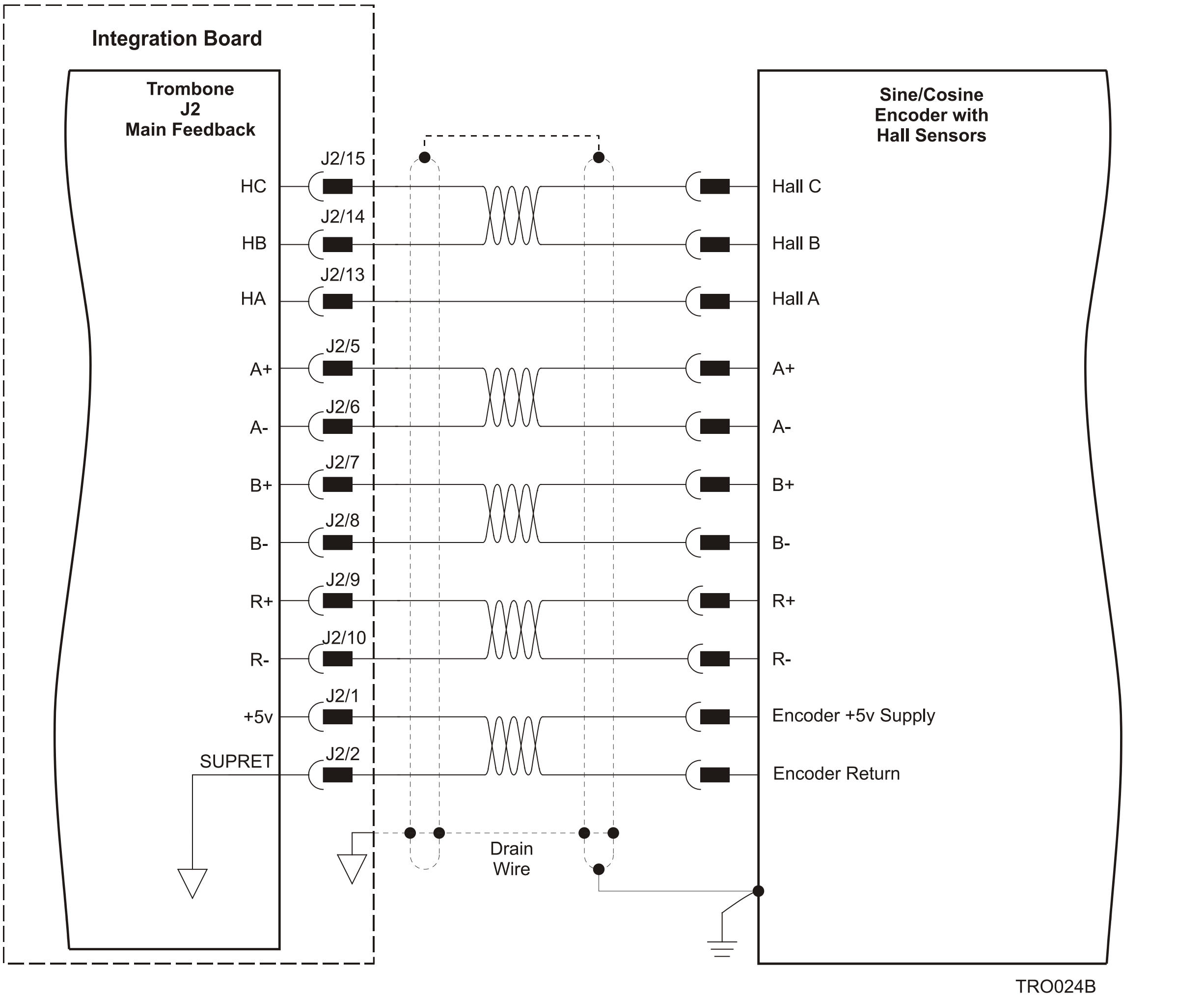


Figure 13: Main Feedback – Interpolated Analog (Sine/Cosine) Encoder with Digital Hall Sensors Connection Diagram

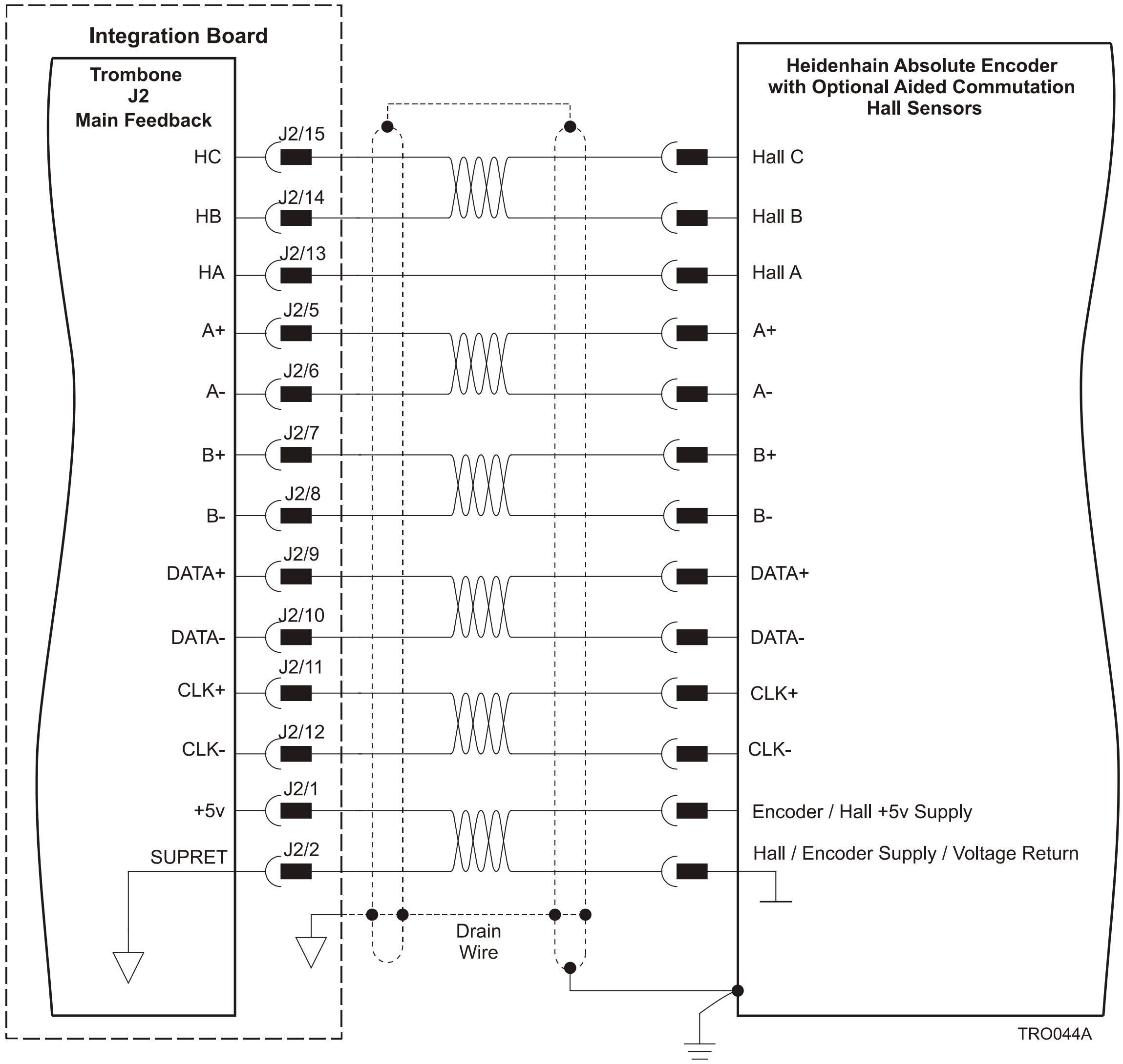


Figure 14: Main Feedback – Heidenhain Absolute Encoder with Digital Hall Sensors Connection Diagram

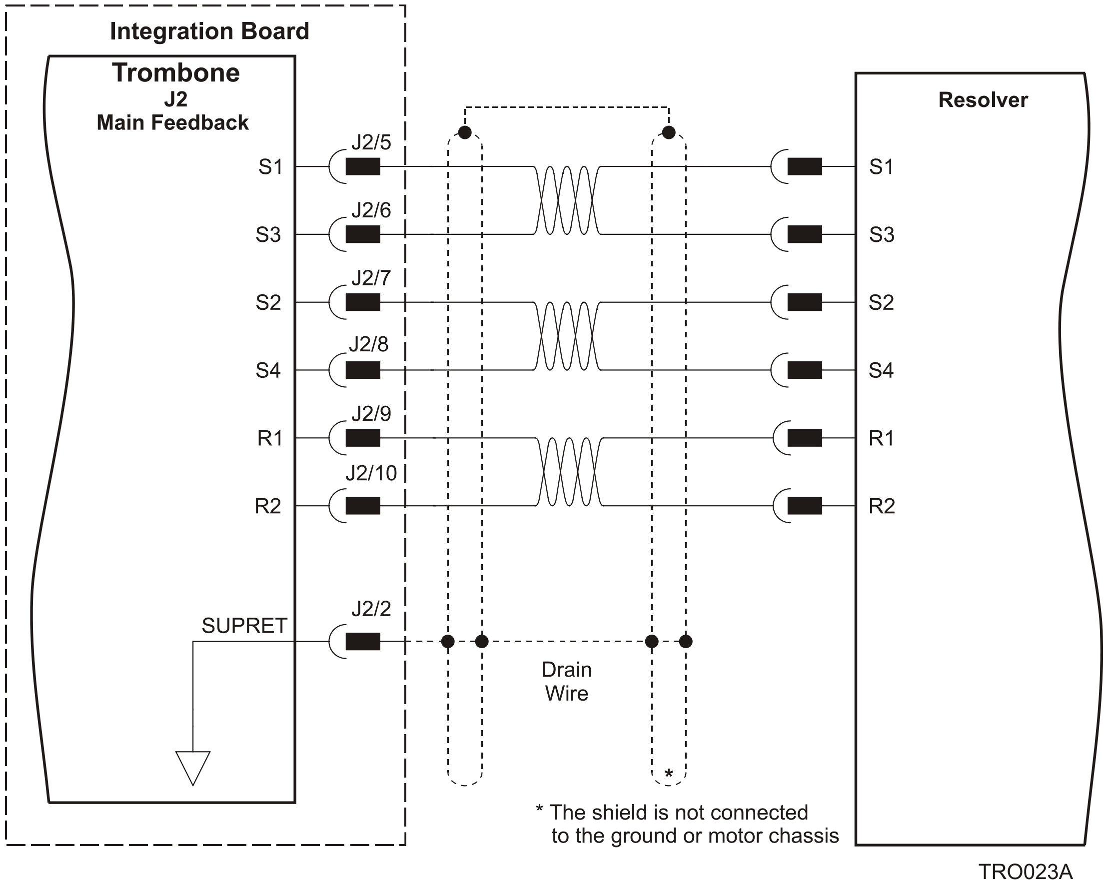


Figure 15: Main Feedback – Resolver Connection Diagram

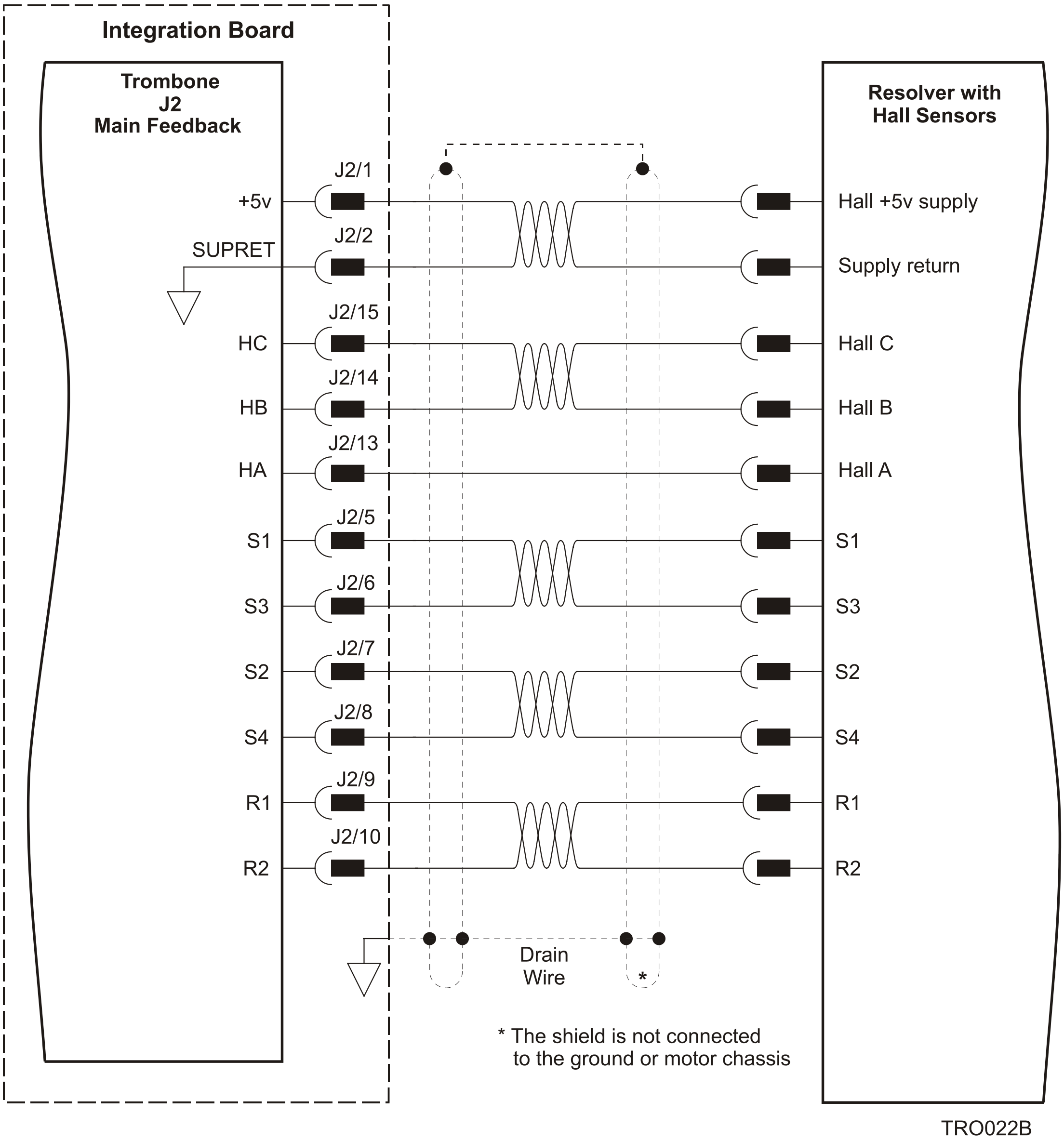


Figure 16: Main Feedback – Resolver and Digital Hall Sensors Connection Diagram

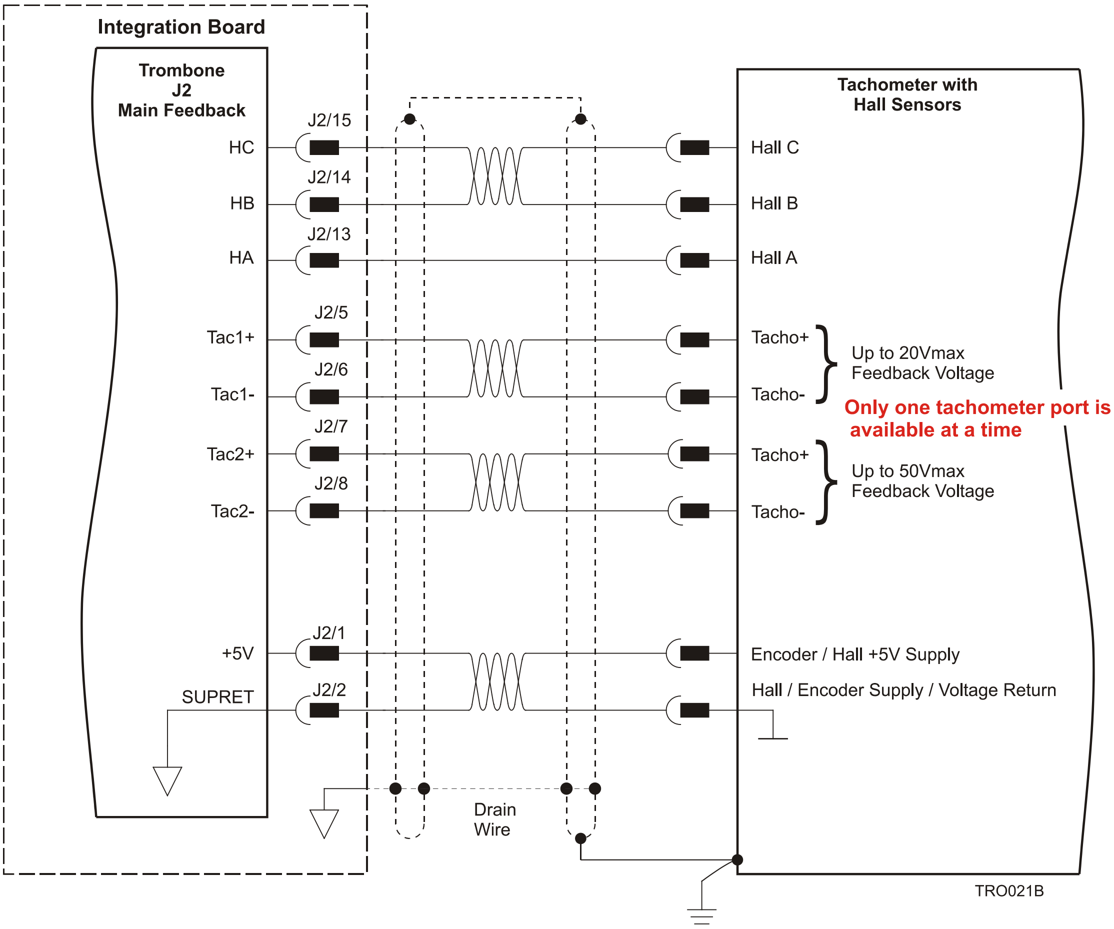


Figure 17: Main Feedback – Tachometer Feedback with Digital Hall Sensors (Connection Diagram for Brushless Motors)

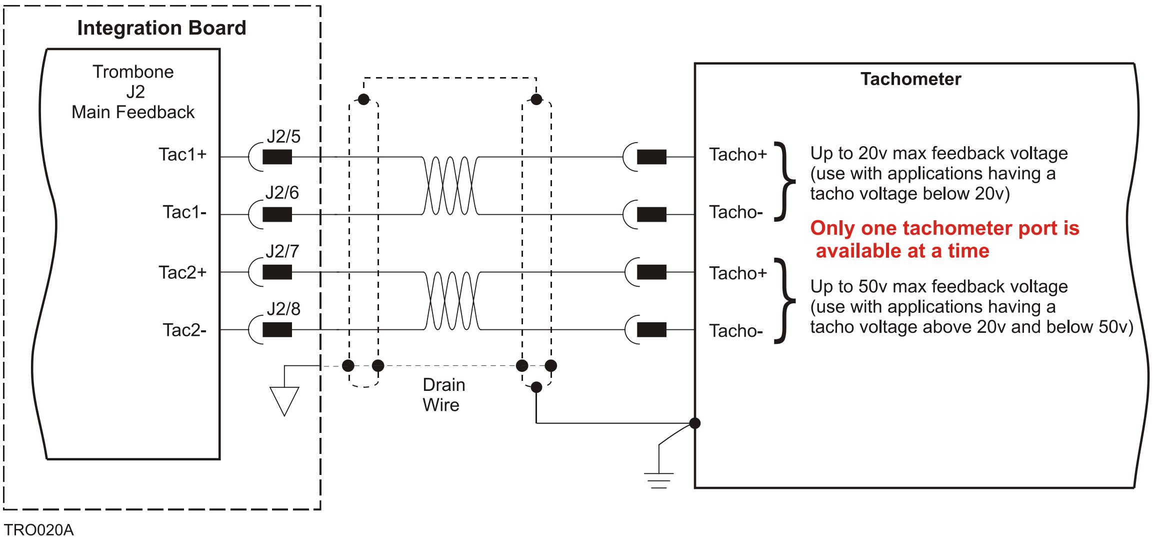


Figure 18: Main Feedback – Tachometer Feedback Connection Diagram for Brush Motors

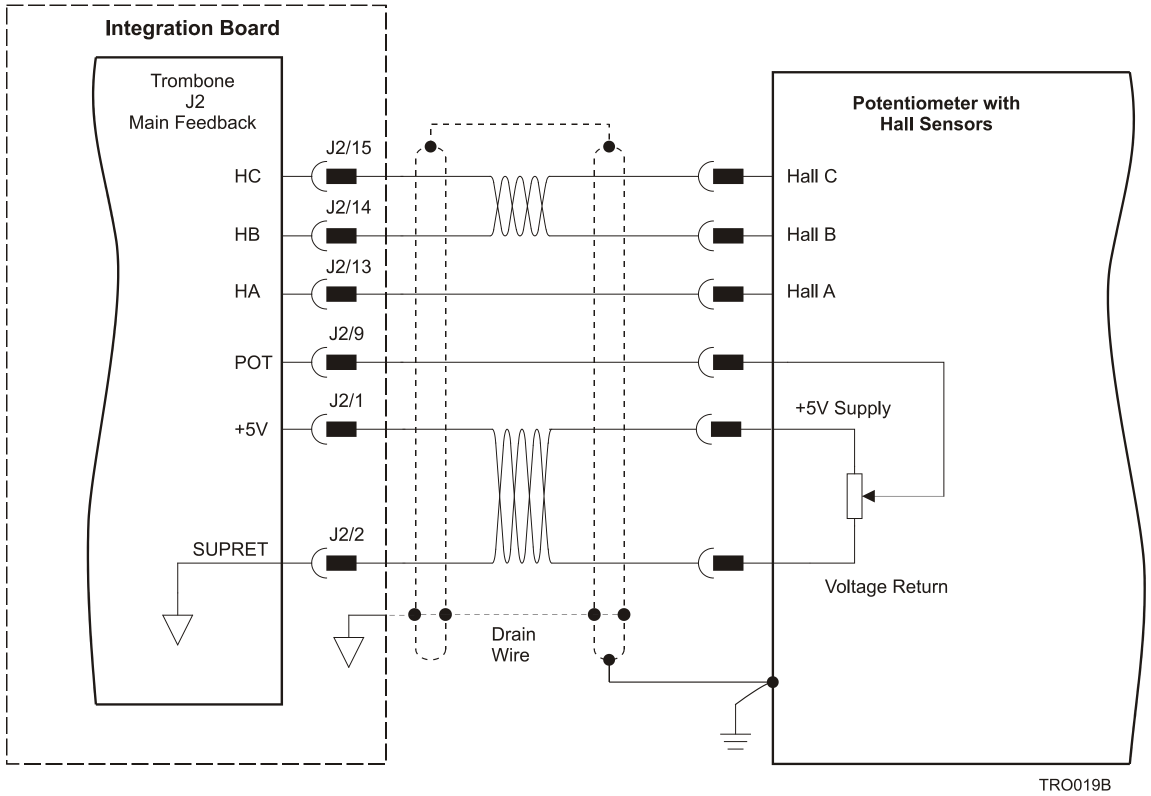


Figure 19: Main Feedback – Potentiometer Feedback with Digital Hall Sensors (Connection Diagram for Brushless Motors)

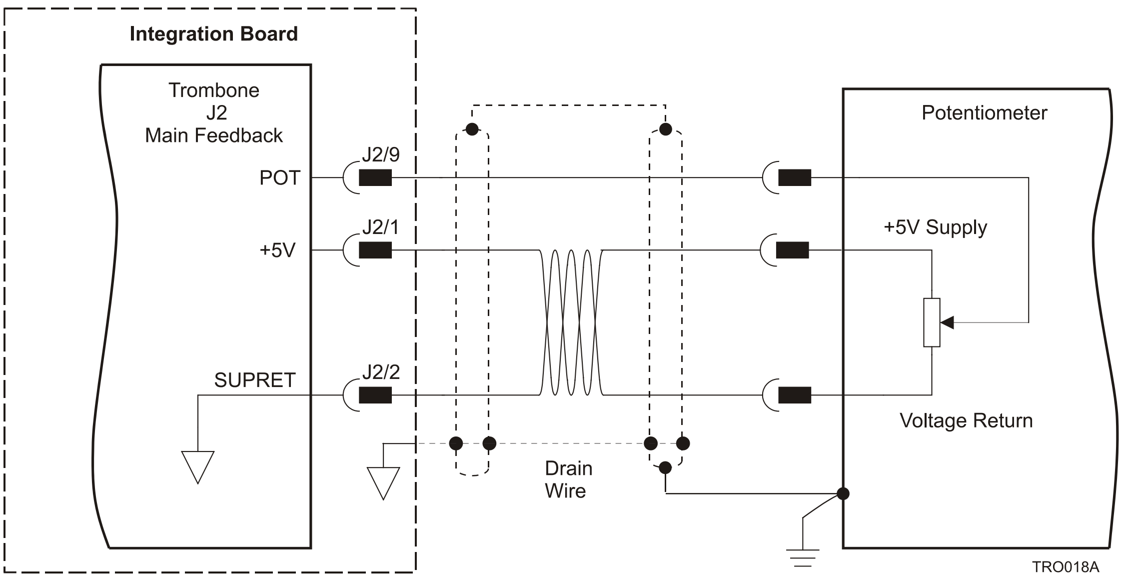


Figure 20: Main Feedback – Potentiometer Feedback Connection Diagram for Brush Motors and Voice Coils

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, interpolated analog encoder, tachometer, potentiometer or absolute encoder as the main feedback device.

   This option can be used in the following scenarios:

   - The Trombone is used as a current Servo-Drive to provide position data to the position controller.
   - The Trombone is used in velocity mode to provide position data to the position controller.
   - The Trombone is used as a master in follower or ECAM mode.

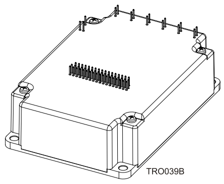
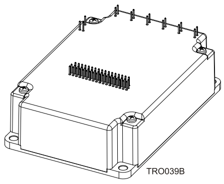
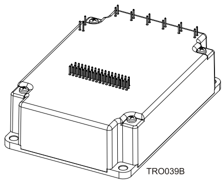
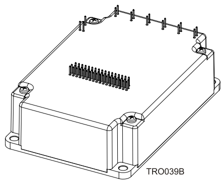
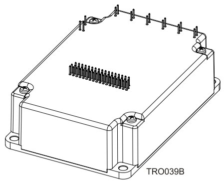
b. **Single-ended auxiliary encoder input**, for the input of position data of the master encoder in follower or ECAM mode.

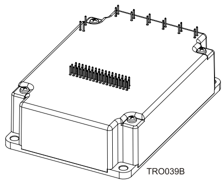
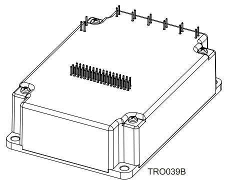
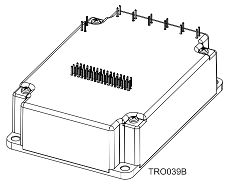
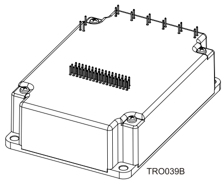
c. **Pulse-and-direction input**, for single-ended input of pulse-and-direction position commands.

When using one of the auxiliary feedback options, the relevant functionality is selected by the software 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 Trombone 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	Main Feedback: Incremental Encoder  Aux. Feedback: There is no Aux. Feedback output option, when an Incremental Encoder is the main feedback device.	Main Feedback Input: Incremental Encoder or Analog Encoder or Resolver or Absolute encoder or Tachometer or Potentiometer  Aux. Feedback: Single-ended Incremental Encoder Input	Main Feedback Input: Incremental Encoder or Analog Encoder or Resolver or Absolute encoder or Tachometer or Potentiometer  Aux. Feedback: Single-ended Pulse and Direction Commands
Interpolated Analog (Sine/Cosine) Encoder Input	1. Main Feedback: Analog Encoder  Aux. Feedback: Analog Encoder position data, emulated in single-ended, un-buffered incremental Encoder format		
Resolver Input	2. Main Feedback: Resolver  Aux. Feedback: Resolver position data emulated in single-ended un-buffered Incremental Encoder format		

<table>
<tr><th>Main Feedback</th><th colspan="3">Auxiliary Feedback</th></tr>
<tr><td>Software Setting</td><td>YA[4] = 4
(Aux. Feedback: output)</td><td>YA[4] = 2
(Aux. Feedback: input)</td><td>YA[4] = 0
(Aux. Feedback: input)</td></tr>
<tr><td>Absolute Encoder Input</td><td>3. Main Feedback:
Absolute Encoder

Aux. Feedback:
Absolute position data emulated in single-ended un-buffered Incremental Encoder format</td><td rowspan="2">Main Feedback Input:
Incremental Encoder
or Analog Encoder
or Resolver
or Absolute Encoder
or Tachometer
or Potentiometer

Aux. Feedback:
Single-ended Incremental Encoder Input</td><td rowspan="2">Main Feedback Input:
Incremental Encoder
or Analog Encoder
or Resolver
or Absolute Encoder
or Tachometer
or Potentiometer

Aux. Feedback:
Single-ended Pulse and Direction Commands</td></tr>
<tr><td>Potentiometer or Tachometer Input</td><td>4. Main Feedback:
Potentiometer or Tachometer

Aux. Feedback:
Tachometer or Potentiometer position data, emulated in single-ended un-buffered Incremental Encoder format</td></tr>
<tr><td>Typical Applications</td><td>1. Analog Encoder applications where position data is required in the Encoder's quadrature format.
2. Resolver applications where position data is required in the Encoder's quadrature format.
3. Tachometer or potentiometer applications where position data is required in the Encoder's quadrature format.
4. Absolute Encoder applications where position data is required by means of a digital word</td><td>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.</td><td>Any application where two feedbacks are used by the drive.
The Auxiliary Feedback port serves as an input for Pulse & Direction Commands.</td></tr>
</table>

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

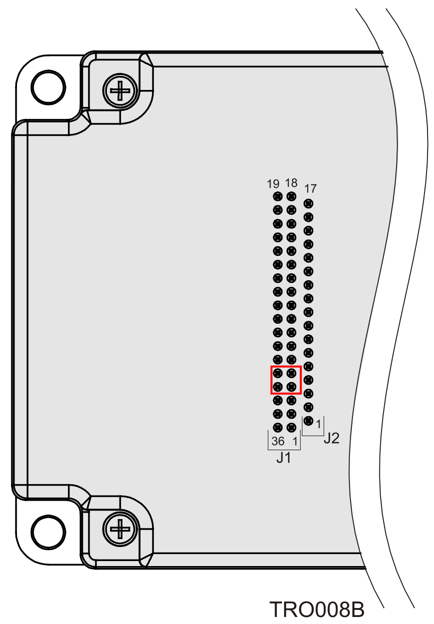
Pin (J1)	Signal	Function	Pin Positions
32	COMRET	Common return	
33	INDEXO	Auxiliary index output	
5	CHBO	Auxiliary Channel B output	
4	CHAO	Auxiliary Channel A output	
Note: The Emulated Encoder Output Option (Figure 21, Figure 22 (recommended)) is only available when using a resolver, absolute encoder, analog encoder, tachometer or potentiometer as the main feedback device. The Trombone's Auxiliary Feedback is single-ended. When mounted on an integration board, circuitry can be added to make it differential (Figure 23 (highly recommended)).			

Table 4: Emulated Single-Ended Encoder Output Pin Assignments

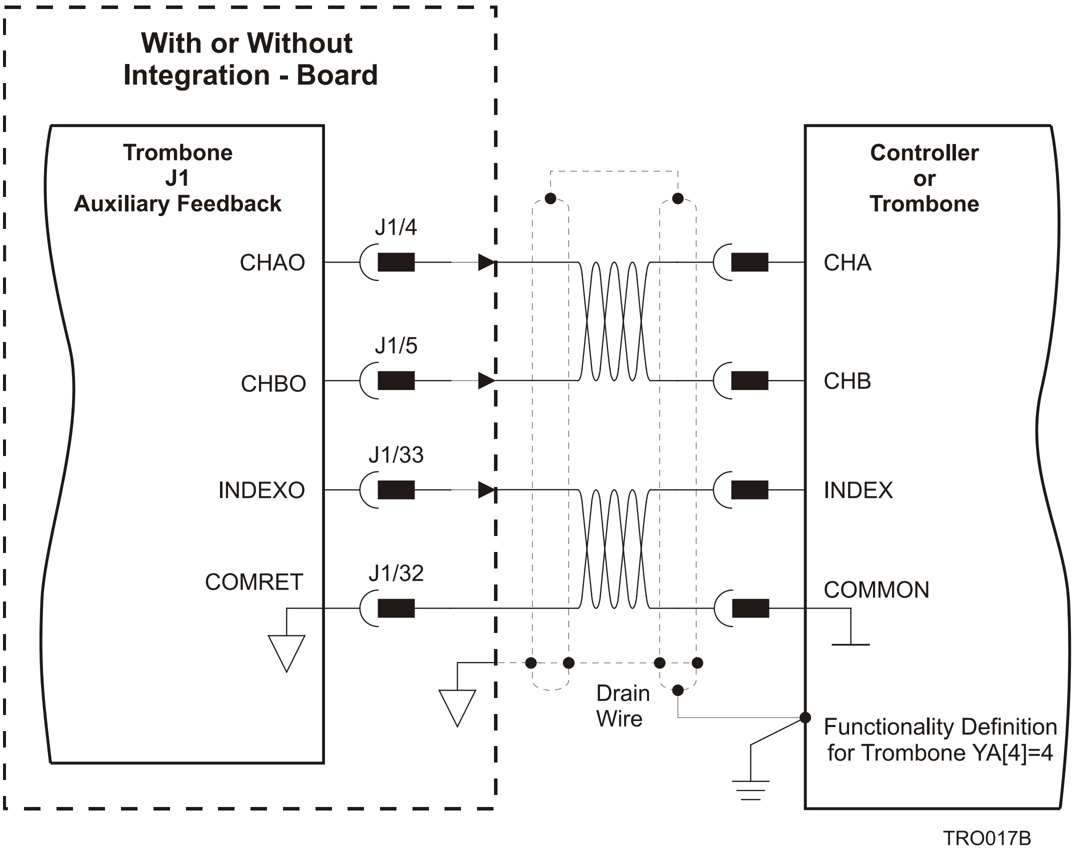


Figure 21: Emulated Encoder Direct Output – Acceptable Connection Diagram

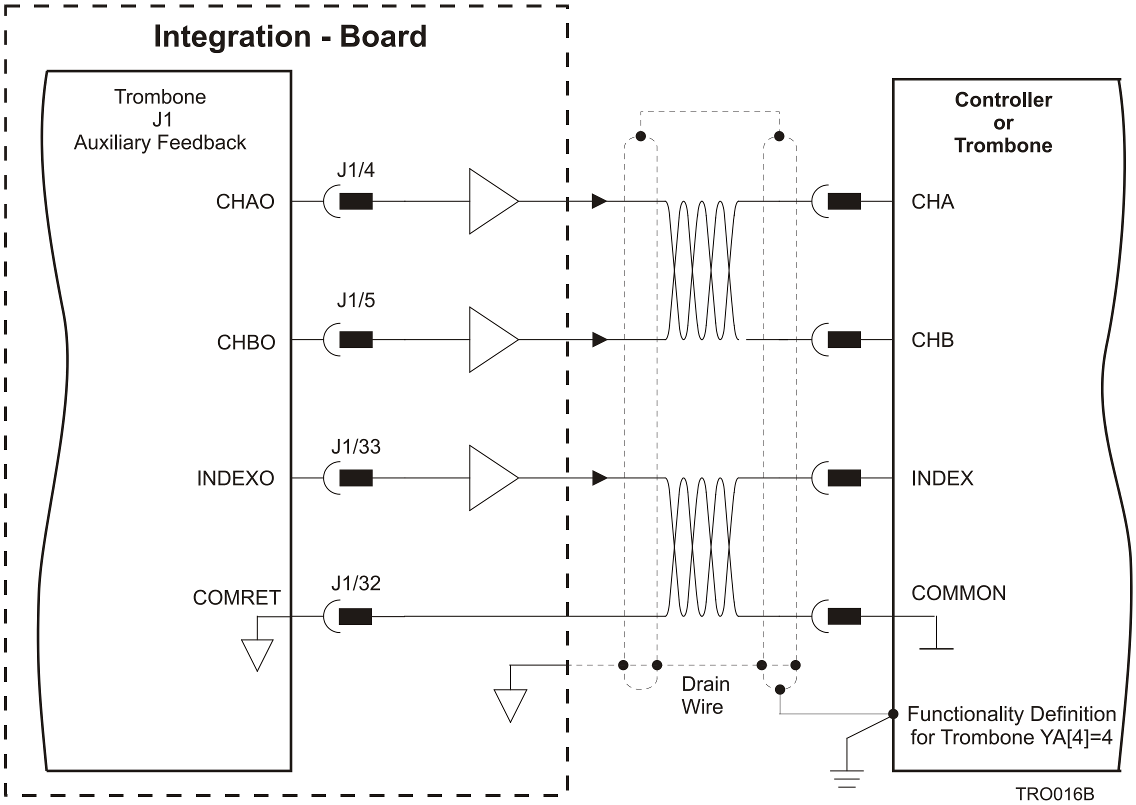


Figure 22: Emulated Encoder Buffered Output – Recommended Connection Diagram

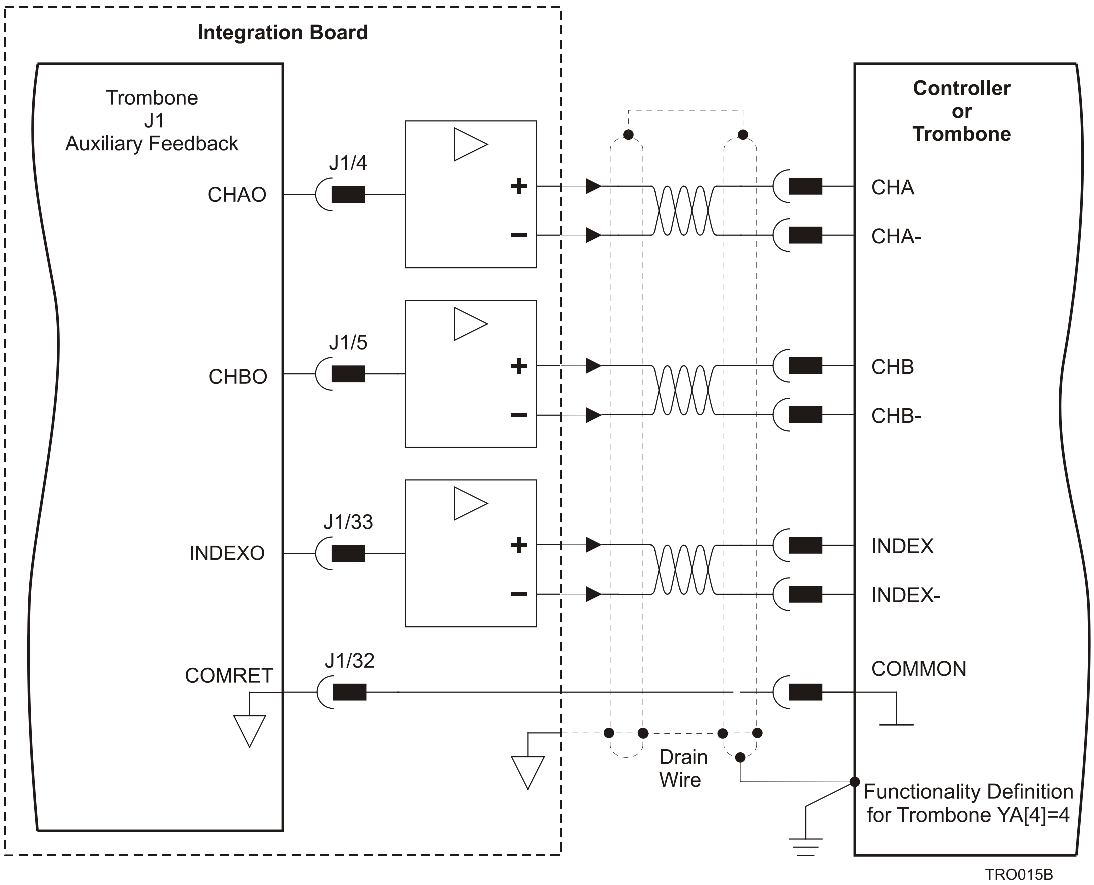


Figure 23: Emulated Encoder Differential Output – Highly Recommended Connection Diagram

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

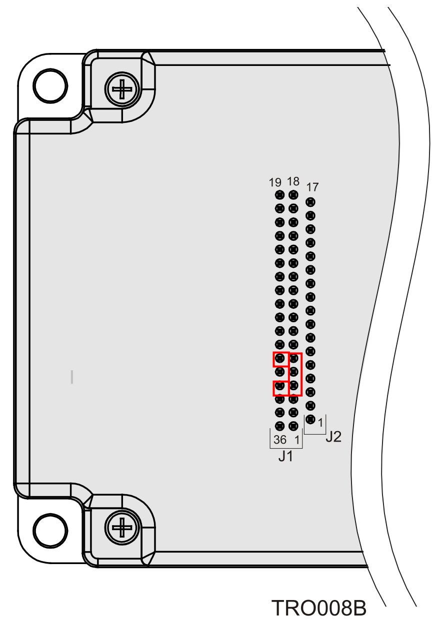
Pin (J1)	Signal	Function	Pin Positions
31	+5 V	Encoder supply voltage	
6	SUPRET	Supply return	
33	INDEX	Auxiliary index input	
5	CHB	Auxiliary channel B input	
4	CHA	Auxiliary channel A input	
Note: The Trombone's Auxiliary Feedback is single-ended (Figure 24, Figure 25 (recommended)). When mounted on an integration board, circuitry can be added to make it differential (Figure 26 (highly recommended)).			

Table 5: Single-Ended Auxiliary Encoder Pin Assignment

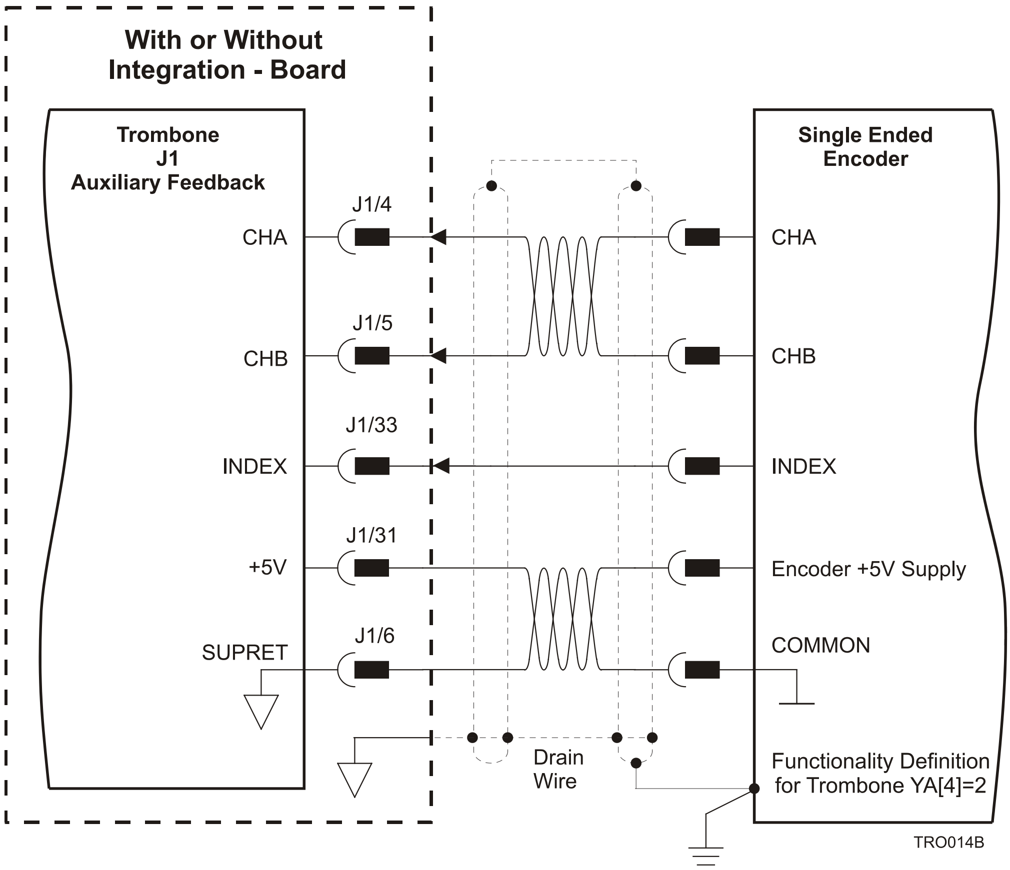


Figure 24: Single-Ended Auxiliary Encoder Input - Acceptable Connection Diagram

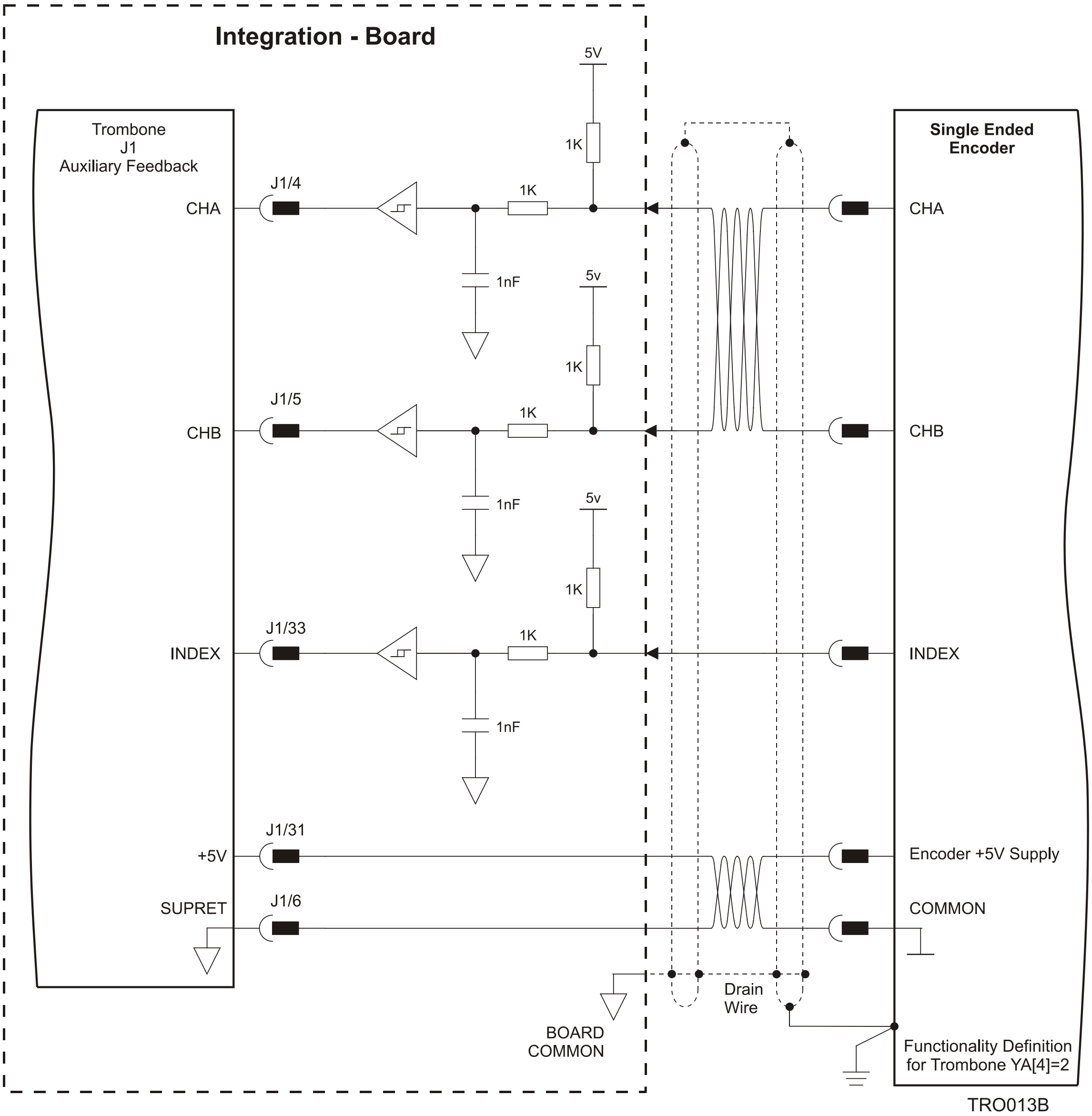


Figure 25: Single-Ended Auxiliary Encoder Input - Recommended Connection Diagram

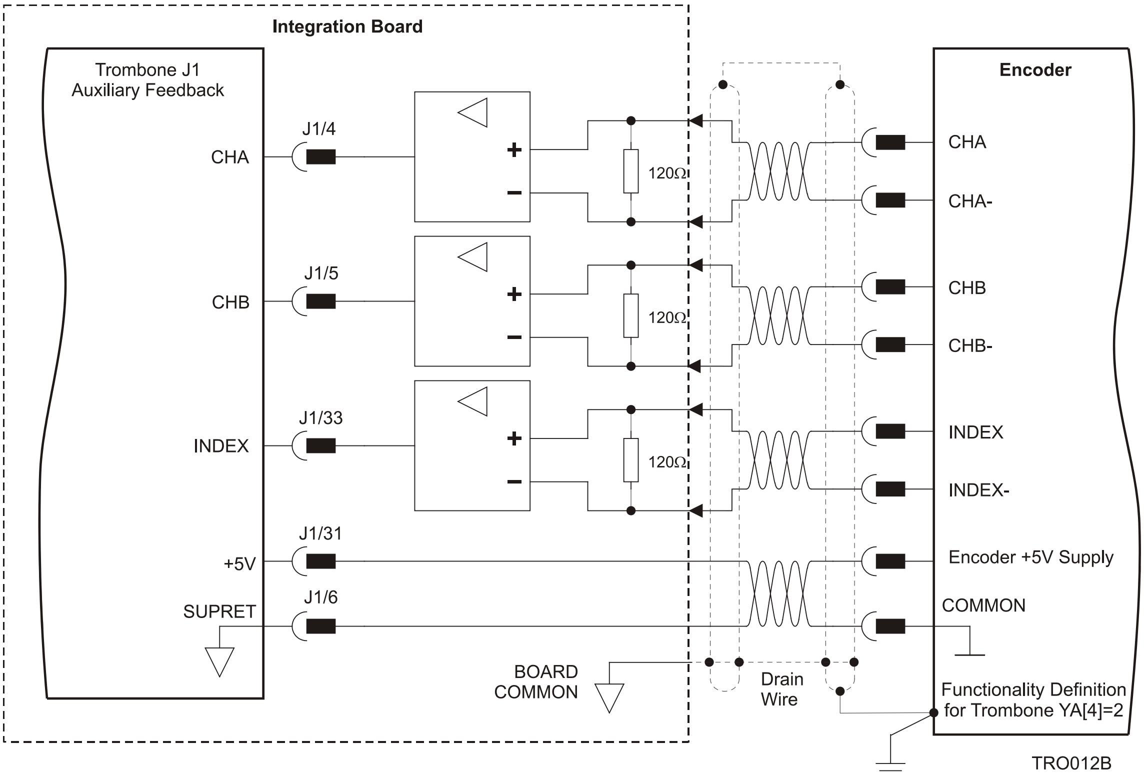


Figure 26: Differential Auxiliary Encoder Input – Highly Recommended Connection Diagram

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

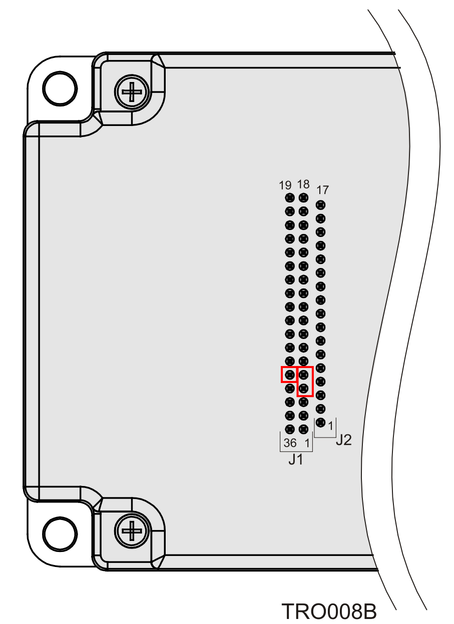
Pin (J1)	Signal	Function	Pin Positions
32	COMRET	Common return	
5	DIR/CHB	Direction input (push/pull 5 V or open collector)	
4	PULS/CHA	Pulse input (push/pull 5 V or open collector)	
Note: The Trombone's Auxiliary Feedback is single-ended (Figure 27, Figure 28 (recommended)). When mounted on an integration board, circuitry can be added to make it differential (Figure 29 (highly recommended)).			

Table 6: Pulse-and-Direction Pin Assignments

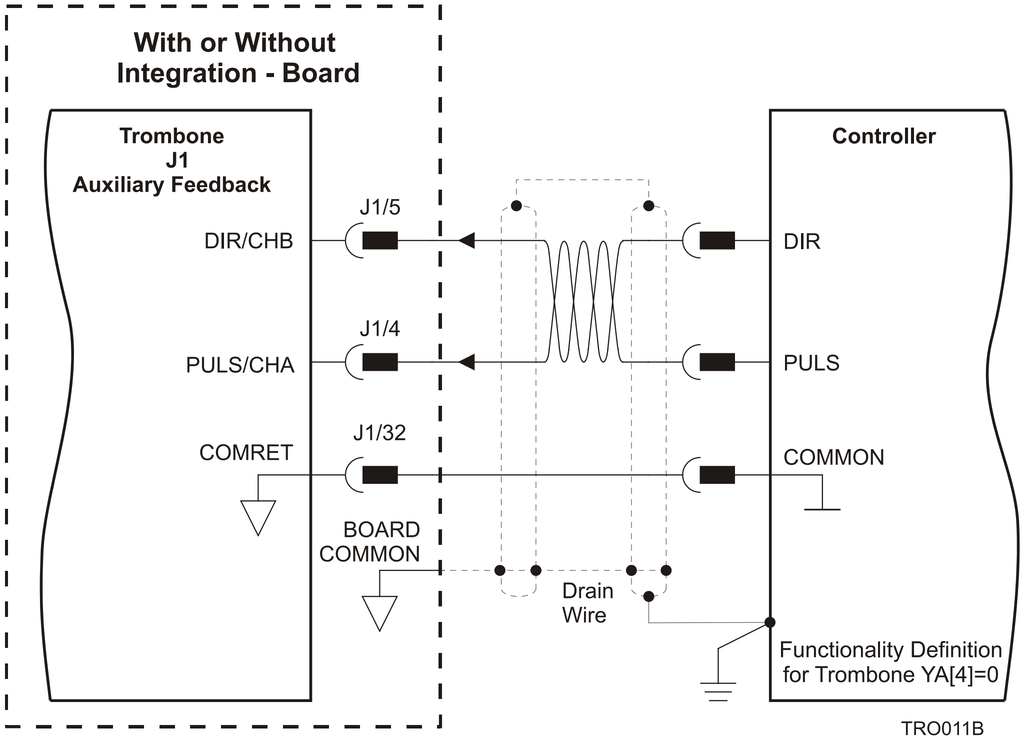


Figure 27: Pulse-and-Direction Auxiliary Encoder Input – Direct Connection Diagram, Acceptable

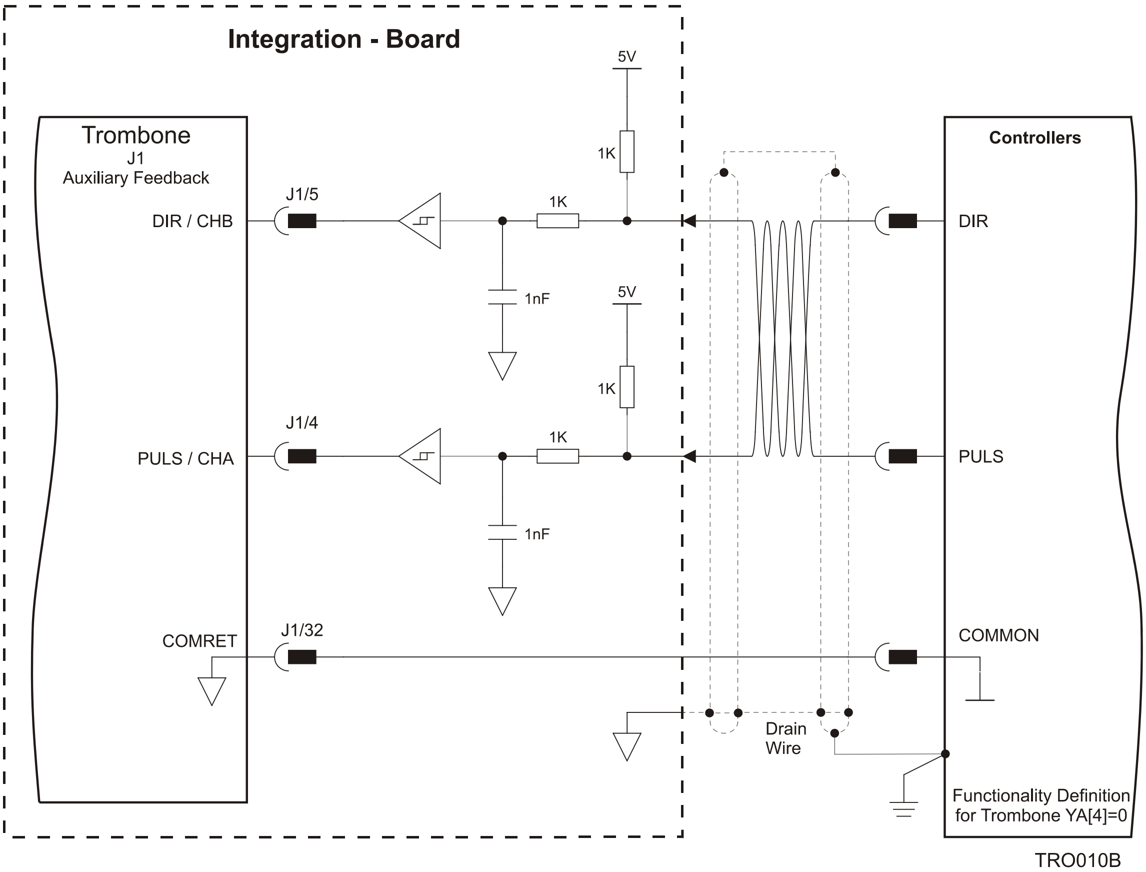


Figure 28: Pulse-and-Direction Auxiliary Encoder Input – Buffered Connection Diagram, Recommended

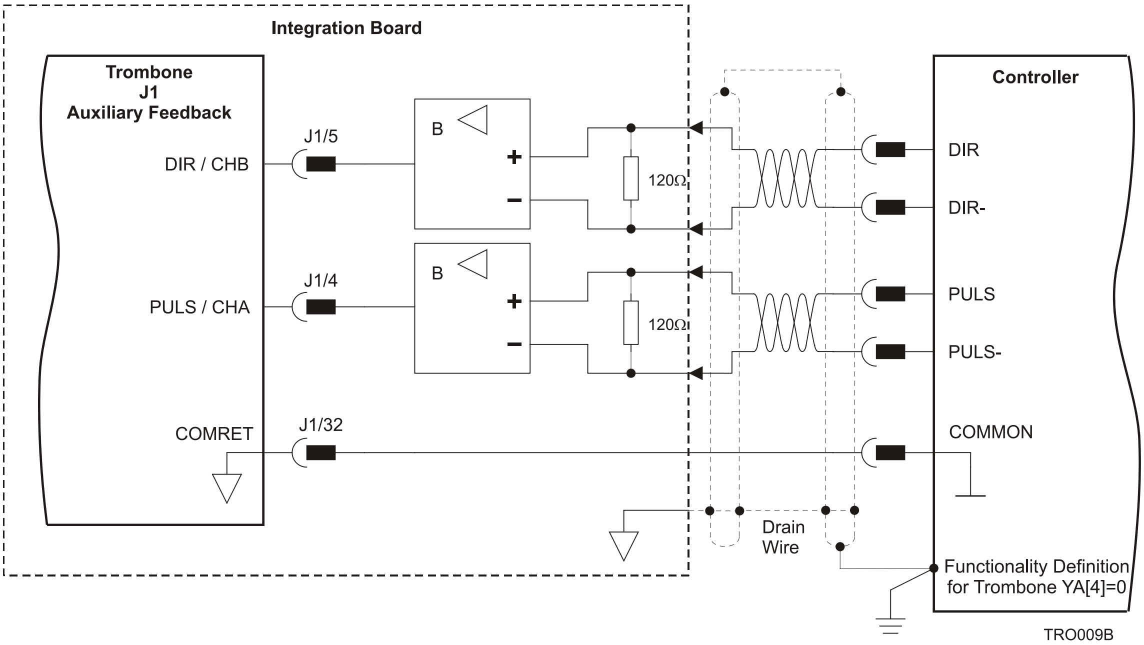


Figure 29: Pulse-and-Direction Auxiliary Encoder Input – Differential Connection Diagram, Highly Recommended

3.11. User I/Os

The Trombone has 6 Digital Inputs, 4 Digital Outputs, and 1 Analog Input

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

Table 7: Various I/O Distributions

3.11.1. Digital Input

Each of the pins below can function as an independent input (Figure 30, Figure 31).

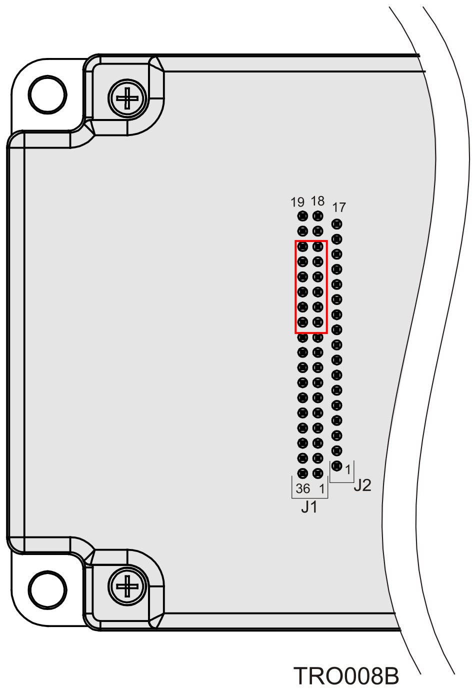
Pin (J1)	Signal	Function	Pin Positions
11	IN1	Programmable input 1 (general purpose, RLS, FLS, INH)	
12	IN2	Programmable input 2 (general purpose, RLS, FLS, INH)	
13	IN3	Programmable input 3 (general purpose, RLS, FLS, INH)	
14	IN4	Programmable input 4 (general purpose, RLS, FLS, INH)	
15	IN5	Hi-Speed 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)	
21	INRET6	Programmable input 6 return	
22	INRET5	Programmable input 5 return	
23	INRET4	Programmable input 4 return	
24	INRET3	Programmable input 3 return	
25	INRET2	Programmable input 2 return	
26	INRET1	Programmable input 1 return	

Table 8: Digital Input Pin Assignments

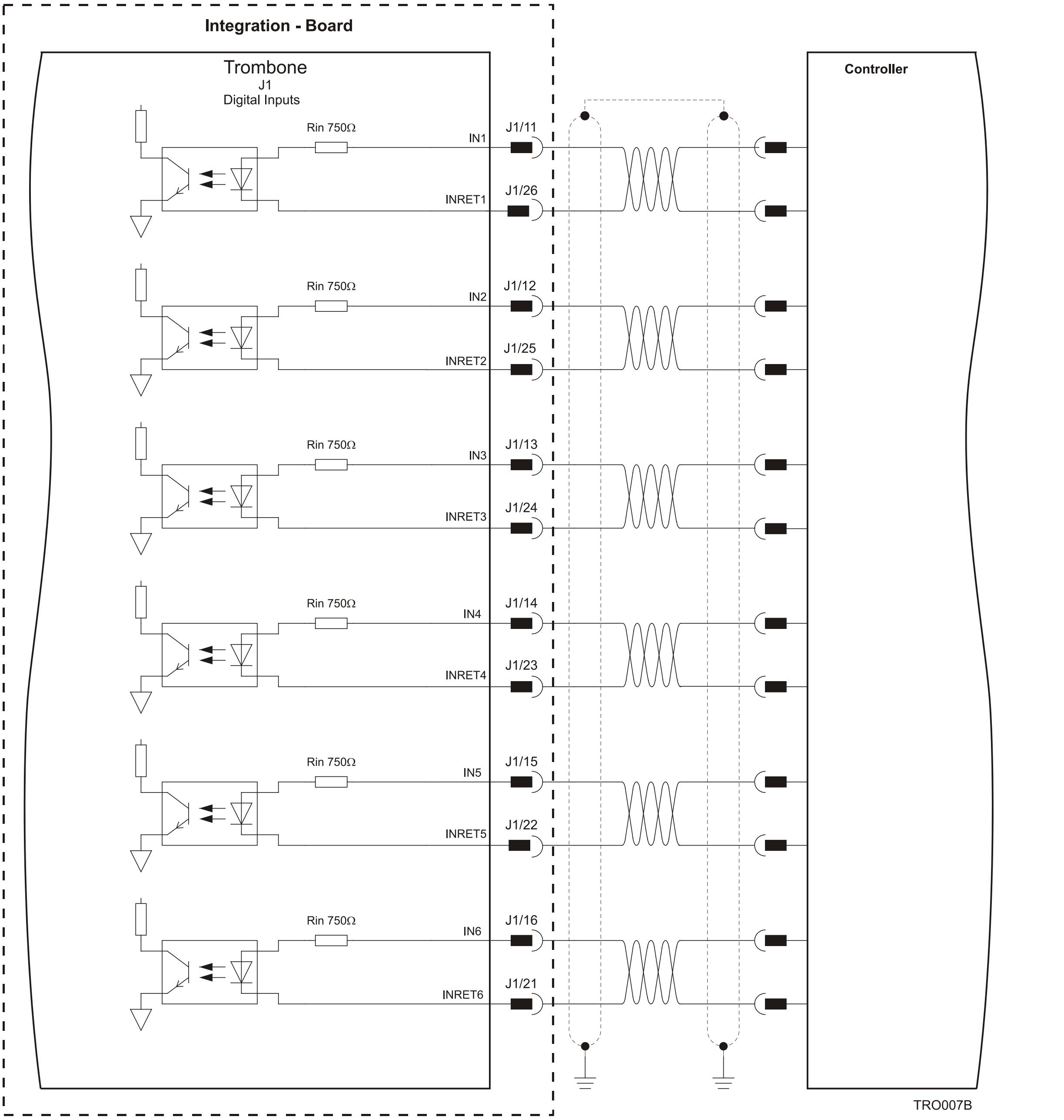


Figure 30: Digital Input Connection Diagram – 5V Level

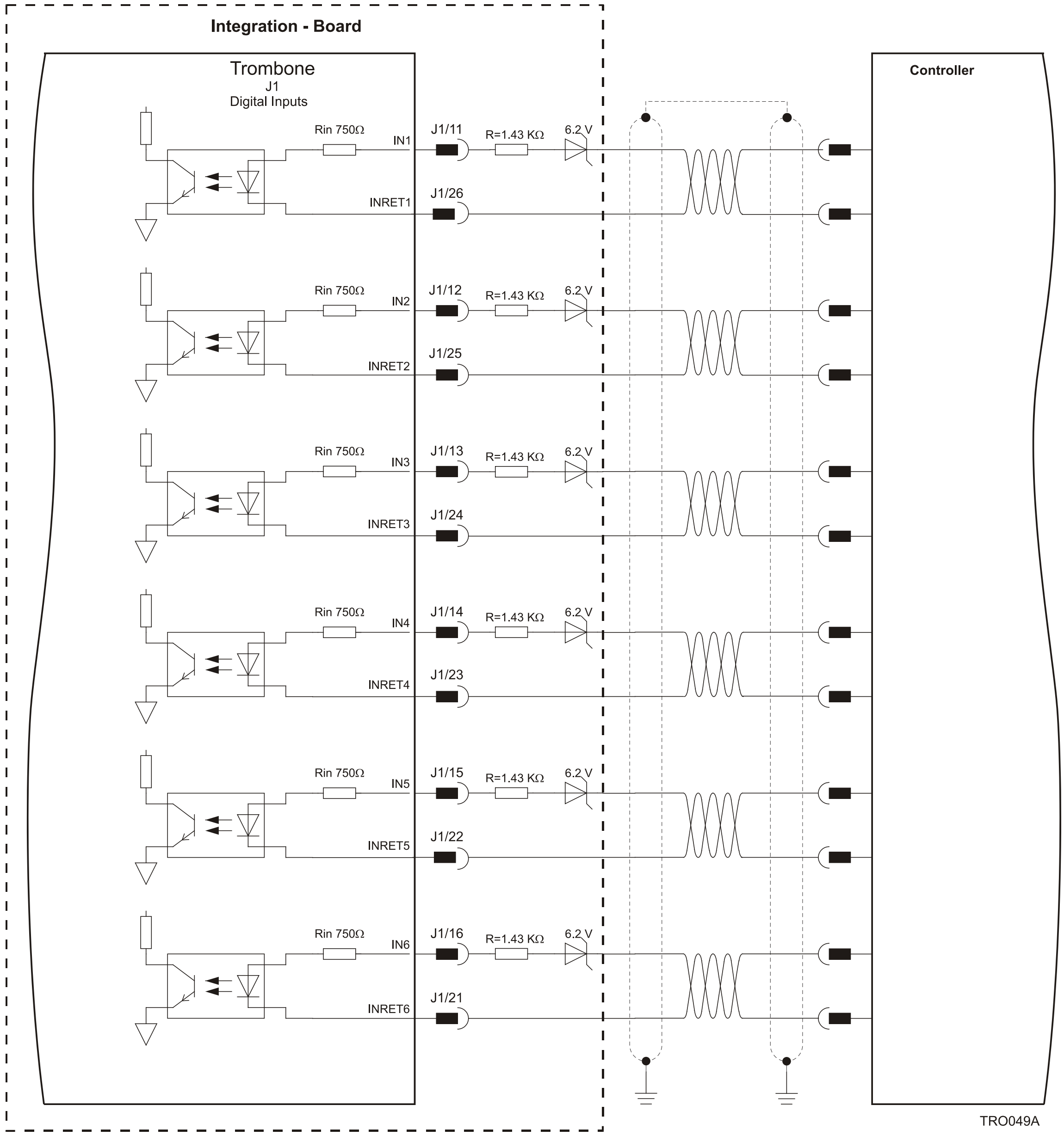


Figure 31: Digital Input Connection Diagram -PLC

3.11.2. Digital Output

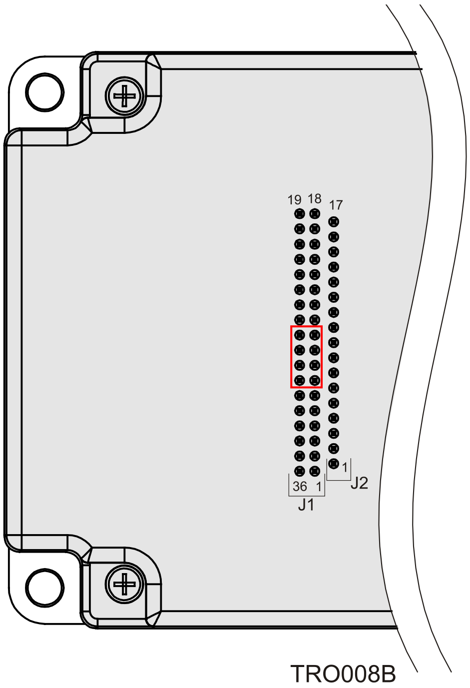
Pin (J1)	Signal	Function	Pin Positions
7	OUT1	High-Speed Programmable digital output 1	
8	OUT2	Programmable digital output 2	
9	OUT3	Programmable digital output 3	
10	OUT4	Programmable digital output 4	
30	OUTRET1	Programmable digital output 1 return	
29	OUTRET2	Programmable digital output 2 return	
28	OUTRET3	Programmable digital output 3 return	
27	OUTRET4	Programmable digital output 4 return	

Table 9: Digital Output Pin Assignment

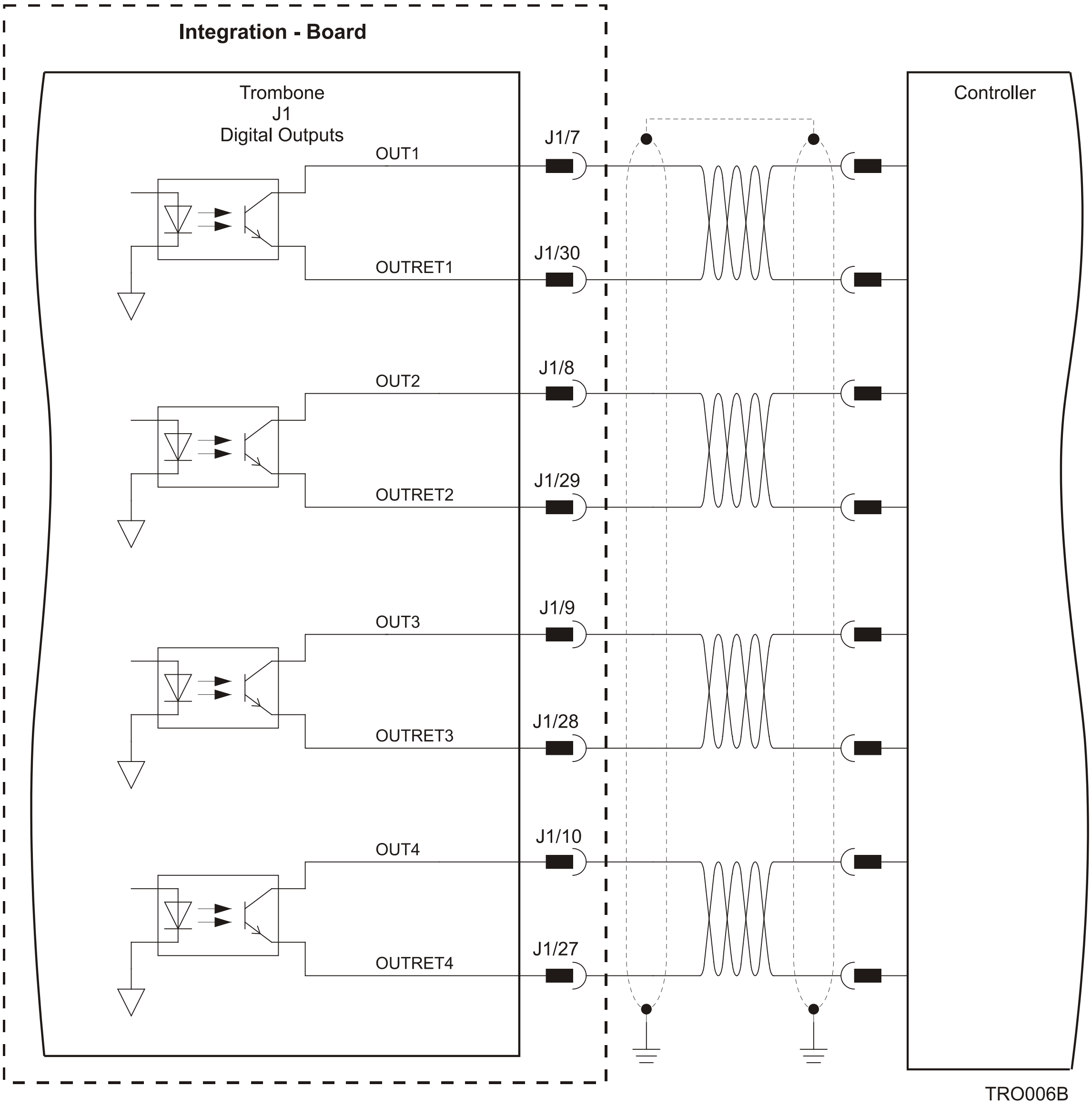


Figure 32: Digital Output Connection Diagram

3.11.3. Analog Input

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

Table 10: Analog Input Pin Assignments

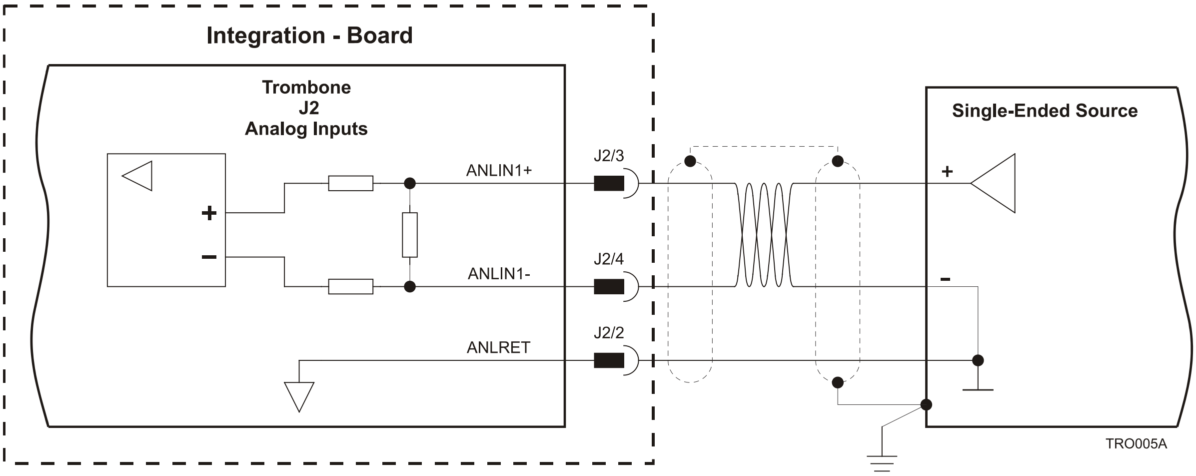


Figure 33: Analog Input with Single-Ended Source

3.12. Communications

The communication interface may differ according to the user's hardware. The Trombone 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 Trombone 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

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
1	RS232_Rx	RS-232 receive
2	RS232_Tx	RS-232 transmit
3	RS232_COMRET	Communication return

Table 11: RS-232 Pin Assignments

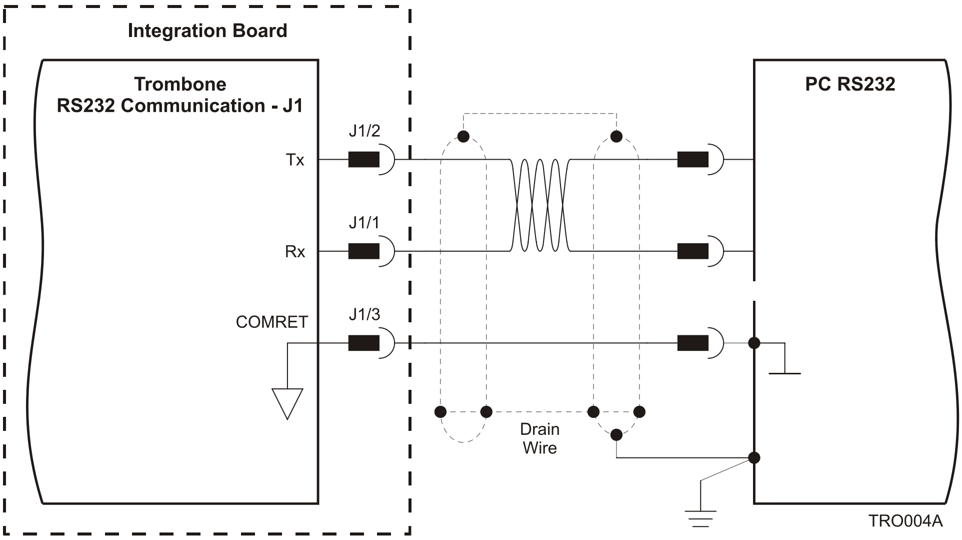


Figure 34: RS-232 Connection Diagram

3.12.2. CAN Communication

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 Trombone's CAN port is non-isolated.

Pin (J1)	Signal	Function
34	CAN_RET	CAN ground
35	CAN_L	CAN_L bus line (dominant low)
36	CAN_H	CAN_H bus line (dominant high)

Table 12: CAN – Pin Assignments

Note: The CAN_RET terminal must always be used and connected, to provide electrical immunity.

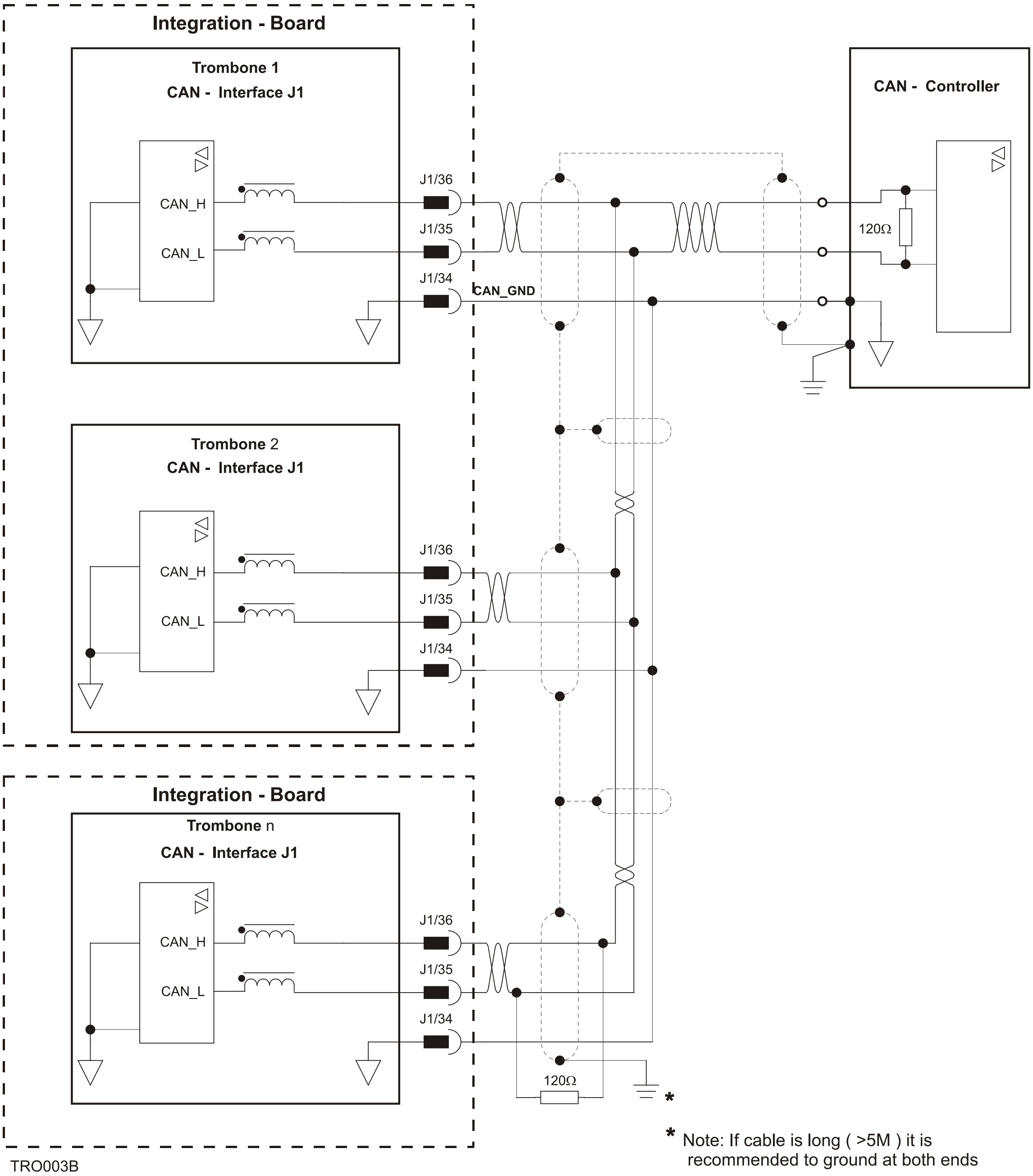


Figure 35: CAN Network Diagram

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 Trombone is connected to its peripheral devices, it is ready to be powered up.

Caution:

Before applying power, ensure that:

1. The DC supply is within the specified range.
2. The proper plus-minus connections are in order.
3. The VN- is not connected to the PE nor to the Neutral, when working with a non-isolated power supply.

3.13.1. Initializing the System

After the Trombone 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*.

3.14. Heat Dissipation

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

3.14.1. Trombone Thermal Data

- Heat dissipation capability (θ): Approximately 5.5 °C/W
- Thermal time constant: Approximately 600 seconds (thermal time constant means that the Trombone will reach 2/3 of its final temperature after 10 minutes)
- Shut-off temperature: 86 °C to 88 °C (measured on the heat sink)

3.14.2. Heat Dissipation Data

Heat Dissipation is shown graphically below:

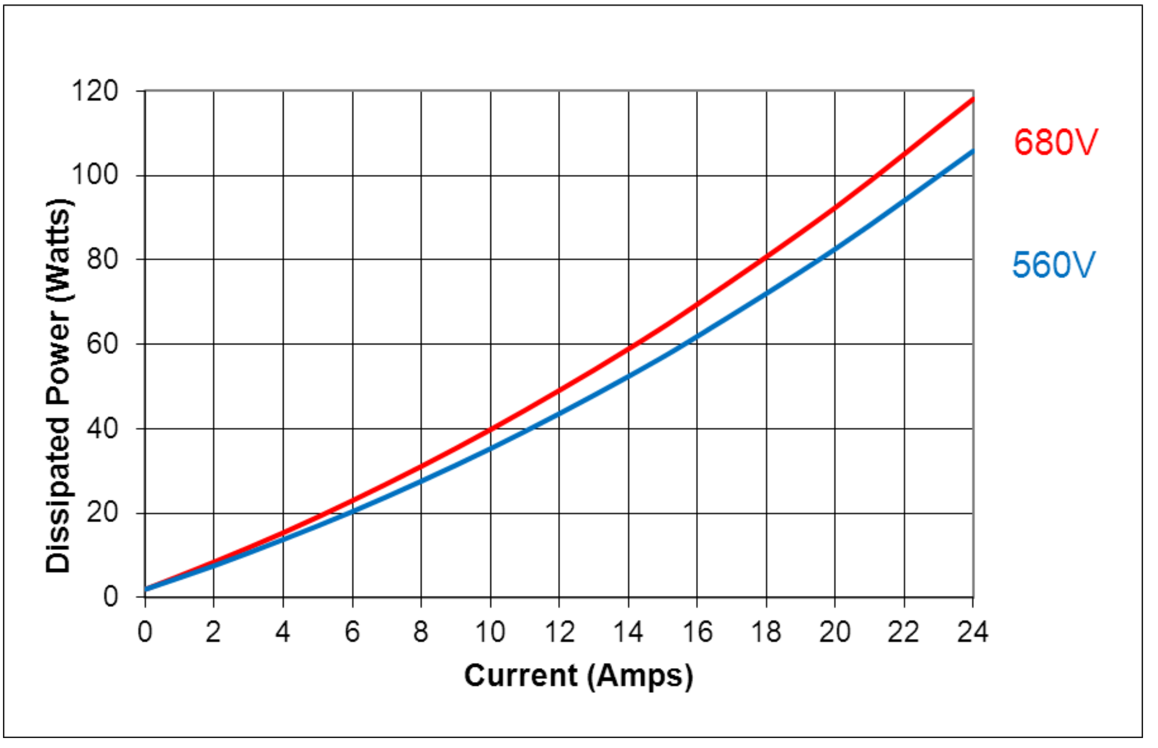


Figure 36: Dissipation versus Current Graph for 560 and 680 VDC

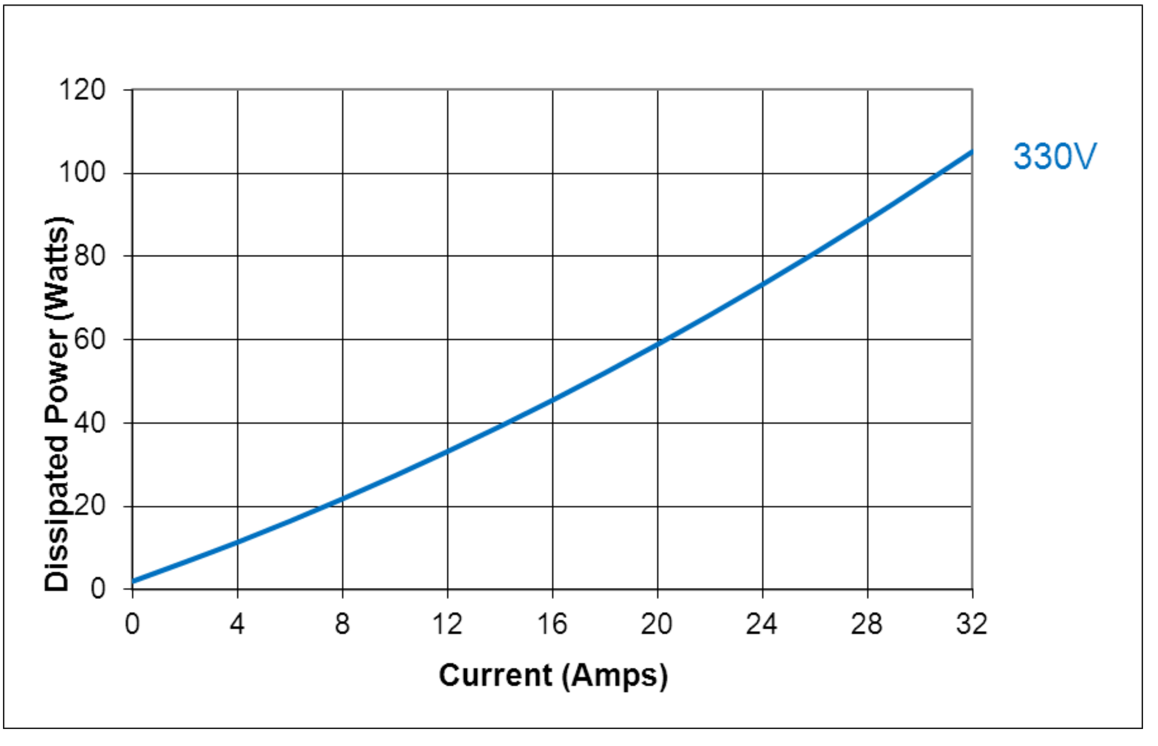


Figure 37: Dissipation versus Current Graph for 330 VDC

3.14.3. 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 heat sink:

1. Allow maximum heat sink temperature to be 80 °C or less (shunt down is 6 °C to 8 °C higher).
2. Determine the ambient operating temperature of the Trombone as ≤ 40 °C.
3. Calculate the allowable temperature increase according to the following example: For an ambient temperature of 40 °C, ΔT = 80 to 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.

Chapter 4: Technical Specifications

This chapter provides detailed technical information regarding the Trombone. 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 Trombone'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, pulse-width modulation (PWM), digital (software) 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
- 32 KB memory in Advanced models ('A' prefix)

4.1.5. Feedback Options

- Incremental Encoder – up to 20 Megacounts (5 Megapulses) per second
- Digital Halls – up to 2 kHz
- Absolute Encoder
- Incremental Encoder with Digital Halls for commutation – up to 20 Megacounts 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 outputs of the analog encoder: single-ended and unbuffered
- Analog Hall sensor
- Resolver
  - Programmable 10 to 15 bit resolution
  - Up to 512 revolutions per seconds (RPS)
  - Emulated outputs of the resolver: single-ended and unbuffered
- Auxiliary encoder inputs (ECAM, follower, etc.) single-ended, unbuffered
- Tachometer & Potentiometer
- The Trombone can provide power (5 V, 2 x 200 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
  - Servo-Drive 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, and a warning can be initiated x degrees before temperature disable is activated.
  - Over-/under-voltage
  - Loss of feedback
  - Following error
  - Current limits

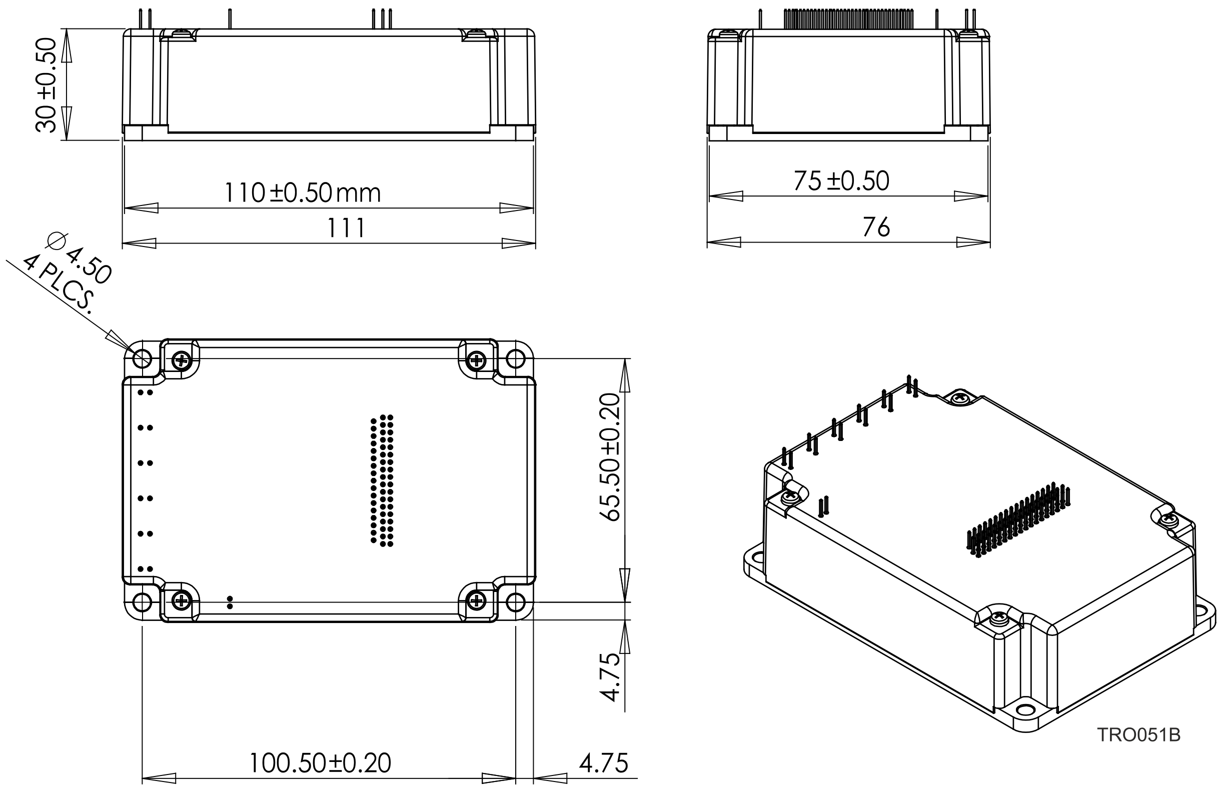
4.1.8. Status Indication

- By software/composer interface during continuous communication
- Output for a bi-color LED - to be implemented via user external LED.

4.1.9. 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. Dimensions



4.3. Power Ratings

Feature	Units	12/400	16/400	R17/400	R22/400	8/800	12/800	R11/800	R16/800
Minimum supply voltage	VDC	S suffix in P/N*: 50 No S suffix in P/N: 100				S suffix in P/N*: 95+			
Nominal supply voltage	VDC	325				560 for 400 VAC 680 for 480 VAC			
Maximum supply voltage	VDC	400				780			
Maximum continuous power output	W	Up to 10 kW of continuous qualitative power							
Efficiency at rated power (at nominal conditions)	%	> 98							
Auxiliary supply voltage option	VDC	18 V to 30 V Only for Control Supply S suffix Model							
Auxiliary power supply	VA	≤5 VA without external loading ≤8 VA with full external loading							
Continuous current limit (Ic) Amplitude sinusoidal/DC trapezoidal commutation	A	12	16	17	22	8	12	11	16
Sinusoidal continuous RMS current limit (Ic)	A	8.5	11.3	12	15.5	5.7	8.5	7.8	11.3
Peak current limit	A	2 x Ic		No peak		2 x Ic		No peak	
Weight	g (oz)	250 g (8.8 oz)							
Dimensions	mm (in)	111 x 76 x 30 (4.33" x 2.95" x 1.18")							
Digital in/Digital out/ Analog in		6/4/1							
Mounting method		PCB Mounted							

*See page 17 for details on the part number. The S suffix appears in models where there is a 24 V control supply. If there is no S suffix, the control power supply operates from the main power.

Note on current ratings: The current ratings of the Trombone 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.

4.3.1. Auxiliary Supply

This table applies only to the models with an S suffix. See page 17 for further details on the part number.

Feature	Details
Auxiliary power supply	Isolated DC source only
Auxiliary supply input voltage	18 to 30 VDC
Auxiliary supply input power	< 8 VA (This includes the 5 V/2 x 200 mA load for the main and auxiliary encoders)

Note: An S-type drive will not operate unless it has the Aux. supply (**Mandatory**).

4.4. Environmental Conditions

Feature	Details
Operating ambient temperature according to IEC60068-2-2	0 °C to 40 °C (32 °F to 104 °F)
Storage temperature	-20 °C to +85 °C (-4 °F to +185 °F)
Maximum non-condensing humidity according to IEC60068-2-78	95%
Maximum Operating Altitude	2,000 m (6562 feet)
Mechanical Shock according to IEC60068-2-27	15g / 11ms Half Sine
Vibration according to IEC60068-2-6	5 Hz ≤ f ≤ 10 Hz: ±10mm 10 Hz ≤ f ≤ 57 Hz: 4G 57 Hz ≤ f ≤ 500 Hz:5G
Feature	Details

4.5. Control Specifications

4.5.1. 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 loop sampling time	Programmable 100 to 200 μsec
Current loop sampling rate	Default 10 kHz

4.5.2. 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 • Absolute Encoder • 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 loop sampling time	140 to 200 µsec (twice the current loop sample time)
Velocity loop 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.

4.5.3. 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 loop sampling time	280 to 400 µsec (four times the current loop sample time)
Position loop sampling rate	Up to 4 kHz; default 2.75 kHz

4.6. Feedbacks

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

4.6.1. Feedback Supply Voltage

The Trombone has two feedback ports (Main and Auxiliary). It supplies voltage 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

4.6.2. Main Feedback Options

4.6.2.1. 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

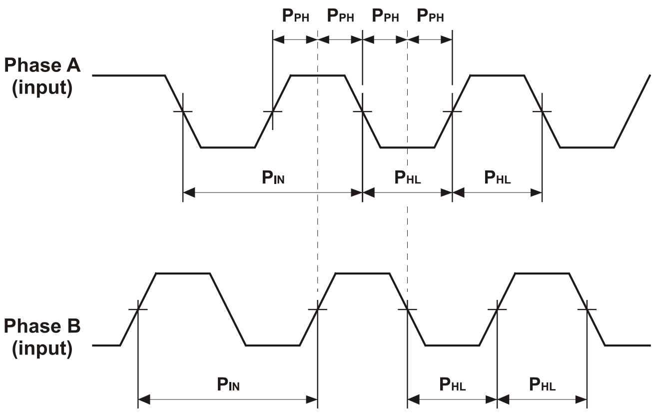


Figure 38: Main Feedback - Encoder Phase Diagram

4.6.2.2. 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

4.6.2.3. 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 Megacounts/sec "internally"
Automatic error correction	Signal amplitudes mismatch Signal phase shift Signal offsets
Encoder outputs	See Auxiliary Encoder Outputs specifications (4.6.3)

4.6.2.4. Absolute Serial Encoder

Feature	Details
Encoder format	• NRZ (Panasonic) • EnDAT 2.21 (with analogue Sin/Cos) • Stegmann in DC-TRO/SOL-TRO
Interface	• RS-485 • Clock – Differential output line • Data – Differential bidirectional line
Input Resistance	Differential 120 Ω
Transmission Rate	Up to 2.5 MHz

4.6.2.5. 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 Trombone
Reference current	up to ±50 mA
Encoder outputs	See Auxiliary Encoder Output specifications (4.6.3)

4.6.2.6. 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 a Tachometer of less than 20 V.
TAC2+/TAC2- is used in applications with a Tachometer of 20 V to 50 V.

4.6.2.7. Potentiometer

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

4.6.3. 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 following: • Analog encoder • Resolver • Absolute encoder • Tachometer • 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

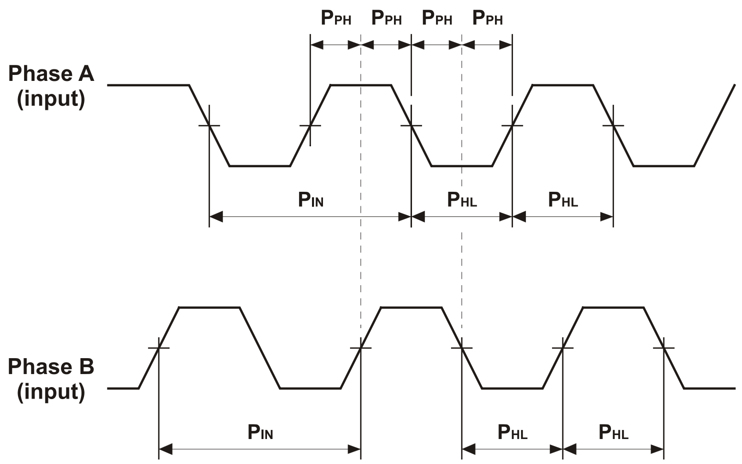


Figure 39: Auxiliary Feedback - Encoder Phase Diagram

4.6.4. 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

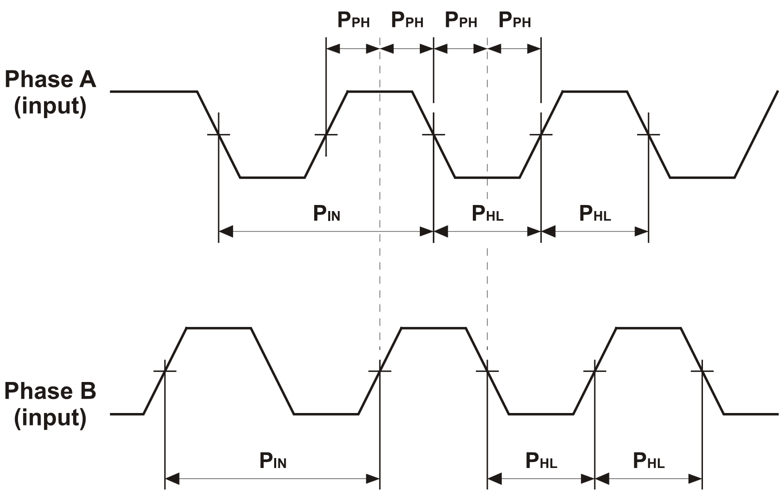


Figure 40: Auxiliary Feedback - Encoder Phase Diagram

4.7. I/Os

The Trombone has:

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

4.7.1. Digital Input Interfaces

The digital inputs are 5 V level compatible by default, but can be configured to PLC level, on the integration board.

Feature	Details
Type of input	• Optically isolated • Each input has its own return
Input current for all inputs	Iin = 4.7 mA @ Vin = 5 V
High-level input voltage	3.0 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 < 4 x TS 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	Capture Time (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 the same value as the digital filter (EF) of the main encoder. • The highest speed is achieved when turning on optocouplers.

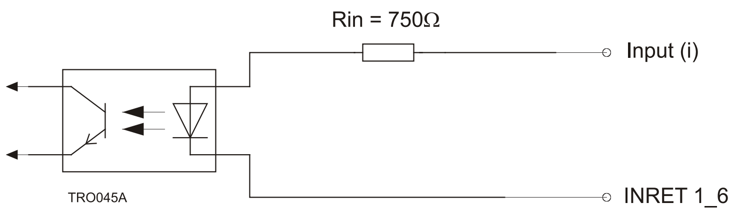


Figure 41: Digital Input Schematic

4.7.2. Digital Output Interface

Feature	Details
Type of output	• Optically isolated • Open collector and open emitter • Each output has its own return
Maximum supply output (VCC)	30 V
Max. output current I_{out} (max) (V_{out} = Low)	I_{out} (max) ≤ 8 mA
VOL at maximum output voltage (low level)	V_{out} (on) ≤ 0.4 V
R_L	The external resistor R_L must be selected to limit the output current to no more than 8 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 42: Digital Output Schematic

4.7.3. 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

4.8. 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:** • DS 305 **Device Profile** (drive and motion control)**:** • DS 402

4.9. 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)

4.10. 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

Specification	Details
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)