ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Elmo Motion Control TUB-20/230GE* at our website: *Click HERE*

SimpIIQ Line

Tuba
Digital Servo Drive
Installation Guide



October 2017 (Ver. 1.503)

Elmo
Motion Control

www.elmomc.com

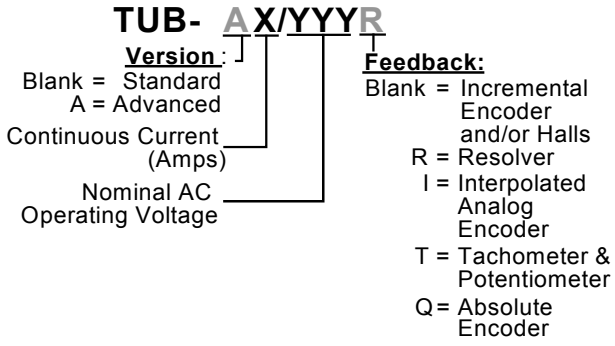
Notice

This guide is delivered subject to the following conditions and restrictions:

- This guide contains proprietary information belonging to Elmo Motion Control Ltd. Such information is supplied solely for the purpose of assisting users of the Tuba servo drive in its installation.
- The text and graphics included in this manual are for the purpose of illustration and reference only. The specifications on which they are based are subject to change without notice.
- Elmo Motion Control and the Elmo Motion Control logo are trademarks of Elmo Motion Control Ltd.
- Information in this document is subject to change without notice.

Document no. MAN-TUBIG (Ver. 1.503)
Copyright © 2017
Elmo Motion Control Ltd.
All rights reserved.

Catalog Number



Revision History

Version	Date	Details
1.0	April 2005	Initial release
1.1	September 2005	BR1 and BR2 connected to DC Link
1.11	September 2006	Correction to Encoder Outputs in Section 4.9.8
1.12	October 2006	Correction to Interpolated Analog Encoder
1.2	March 2007	Added Absolute Encoder information
1.3	April 2008	Updated Power Ratings Table in Section 4.5
1.4	March 2010	MTCR 07-009-56: Added note to Section 3.4.8.1
1.5	July 2012	Formatted according to the new template
1.501	February 2013	Added a caution and recommendation on the type of cleaning solution to use for the Elmo unit.
1.502	July 2014	General format changes
1.503	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
Steinkirchring 1, D-78056, Villingen-Schwenningen
Germany

Tel: +49 (0) 7720-85 77 60 • Fax: +49 (0) 7720-85 77 70 • 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

Table of Contents

Chapter 1: Safety Information 8

1.1. Warnings 9
1.2. Cautions 9
1.3. Directives and Standards 10
1.4. CE Marking Conformance 10
1.5. Warranty Information 10

Chapter 2: Introduction 11

2.1. Drive Description 11
2.2. Product Features 11
2.2.1. Current Control 11
2.2.2. Velocity Control 12
2.2.3. Position Control 12
2.2.4. Advanced Position Control *(Advanced model only)* 12
2.2.5. Communication Options 12
2.2.6. Feedback Options 13
2.2.7. Fault Protection 13
2.3. System Architecture 14
2.4. How to Use this Guide 15

Chapter 3: Installation 16

3.1. Before You Begin 16
3.1.1. Site Requirements 16
3.1.2. Hardware Requirements 16
3.1.2.1. AC Input Requirements 16
3.1.2.2. Recommended Wire Cross-Sections (All Models) 16
3.1.2.3. Power Connectors 17
3.1.2.4. Communication Connectors 17
3.1.2.5. Feedback and I/O Connectors 18
3.1.2.6. Other Items Needed 19
3.2. Unpacking the Drive Components 19
3.3. Mounting the Tuba 20
3.3.1. Mounting Directly onto a Wall 20
3.3.2. Mounting on a DIN Rail 21
3.4. Connecting the Cables 22
3.4.1. Wiring the Tuba 22
3.4.2. Connecting the Power Cables 26
3.4.2.1. Connecting the Motor Cable 27
3.4.2.2. Connecting the Main Power Cable 28
3.4.2.3. Connecting the DC Link Cable 28
3.4.3. Connecting the Auxiliary Supply Cable (24 V) 29

3.4.4. Feedback and Control Cable Assemblies 30
3.4.5. Main Feedback Cable (Feedback A) 30
3.4.6. Main and Auxiliary Feedback Combinations 39
3.4.7. Auxiliary Feedback (FEEDBACK B) 41
3.4.7.1. Main Encoder Buffered Outputs or Emulated Encoder Outputs Option on FEEDBACK B (YA[4]=4) 41
3.4.7.2. Differential Auxiliary Encoder Input Option on FEEDBACK B (YA[4]=2) 43
3.4.7.3. Single-Ended Auxiliary Input Option on FEEDBACK B - (YA[4]=2) 45
3.4.7.4. Pulse-and-Direction Input Option on FEEDBACK B - (YA[4]=0) 47
3.4.8. I/O Cables 50
3.4.8.1. Analog Inputs 50
3.4.8.2. Digital Inputs (on the GENERAL I/O Port) 51
3.4.8.3. Digital Outputs (on the COMMITTED I/O Port) 54
3.4.9. Communication Cables 56
3.4.9.1. RS-232 Communication (on the COMM.1 Port) 56
3.4.9.2. CAN Communication (on the COMM.2 Ports) 57
3.5. Powering Up 59
3.6. Initializing the System 59

Chapter 4: Technical Specifications 60

4.1. Features 60
4.1.1. Motion Control Modes 60
4.1.2. Advanced Positioning Motion Control Modes 60
4.1.3. Advanced Filters and Gain Scheduling 60
4.1.4. Fully Programmable 60
4.1.5. Feedback Options 61
4.1.6. Input/Output 61
4.1.7. Built-In Protection 62
4.2. Tuba Dimensions 63
4.3. Mounting Dimensions 64
4.4. Mechanical Specifications 64
4.5. Power Ratings 65
4.6. Environmental Conditions 65
4.7. Tuba Connections 66
4.7.1. Auxiliary Supply 67
4.8. Control Specifications 67
4.8.1. Current Loop 67
4.8.2. Velocity Loop 68
4.8.3. Position Loop 68
4.9. Feedbacks 69
4.9.1. Feedback Supply Voltage 69
4.9.2. Incremental Encoder Input 69
4.9.3. Digital Halls 70
4.9.4. Interpolated Analog (Sine/Cosine) Encoder 70

4.9.5. Resolver 71
4.9.6. Tachometer 71
4.9.7. Potentiometer 72
4.9.8. Encoder Outputs 72
4.10. I/Os 73
4.10.1. Digital Input Interfaces (on the GENERAL I/O port) 73
4.10.2. Digital Output Interface (on the COMMITTED I/O port) 75
4.10.3. Analog Input 76
4.11. Communications 77
4.12. Pulse-Width Modulation (PWM) 77
4.13. Single-Phase Operation 77
4.14. Compliance with Standards 78

Chapter 1: Safety Information

In order to achieve the optimum, safe operation of the Tuba servo drive, 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 Tuba 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 Tuba 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 Tuba from all voltage sources before it is opened for servicing.
- The Tuba 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 Tuba servo drive contains hot surfaces and electrically-charged components during operation.
- The maximum AC/DC power supply connected to the instrument must comply with the parameters outlined in this guide.
- The TUB-x/230 series is designed to operate from a single-phase 115 VAC source or from a single- or three-phase 230 VAC source.

  The TUB-x/460 series is designed to operate from a three-phase 400 or 460 VAC source. The Tuba can be connected directly to the line voltage. An isolation transformer is not needed.
- The Tuba drive must be connected to an approved 24 VDC auxiliary power supply 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 Tuba, 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 Tuba 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 Tuba 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 Tuba 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 Tuba 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 Tuba 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 Tuba servo drive and the steps for its wiring, installation and powering up. Following these guidelines ensures maximum functionality of the drive and the system to which it is connected.

2.1. Drive Description

The Tuba is a powerful servo drive that operates in digital current, velocity, position and advanced position modes, in conjunction with a permanent-magnet synchronous brushless motor or DC brush motor. The Tuba features flexible sinusoidal and trapezoidal commutation, with vector control. The Tuba can operate as a stand-alone device or as part of a multi-axis network in a distributed configuration.

The Tuba drive is set up and tuned using Elmo's Composer software. This Windows-based application enables users to quickly and simply configure the servo drive for optimal use with their motor.

Power to the various models of Tuba is provided by a 115, 230, 3 x 230, 3 x 400 or 3x 460 VAC source. A separate 24 VDC power supply serves as both the auxiliary supply *and* the backup supply. This enables a safe and economical "power backup" feature that is essential for positioning systems. An auxiliary 24 VDC power supply is required as the Tuba does not operate without one.

Two variations of the Tuba are available: the *Standard* version and the *Advanced* version, which features advanced positioning capabilities. Both versions operate with RS-232 and/or 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 current loop
- Fast event capturing inputs

2.2.4. Advanced Position Control *(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
- PT and PVT motion modes
- Dual (position/velocity) loop
- Fast output compare (OC)

2.2.5. Communication Options

Depending on the application, Tuba 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 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
- Absolute Encoder
- Interpolated Analog (Sine/Cosine) Encoder – up to 250 kHz (analog signal)
  - Internal Interpolation – programmable up to x4096
  - Automatic Correction of:
    - amplitude mismatch
    - phase mismatch
    - signals offset
  - Encoder outputs, buffered, differential.
- Resolver
  - Programmable 10 to 15 bit resolution
  - Up to 512 revolutions per second (RPS)
  - Encoder outputs, buffered, differential
- Tachometer and Potentiometer

  Two inputs for Tachometer Feedback:
  - Up to ±50 VDC
  - Up to ±20 VDC

  Potentiometer Feedback:
  - 0 to 5 V voltage range
  - Resistance: 100 Ω to 1000 Ω
- Elmo drives provide supply voltage for all the feedback options.

2.2.7. Fault Protection

The Tuba 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

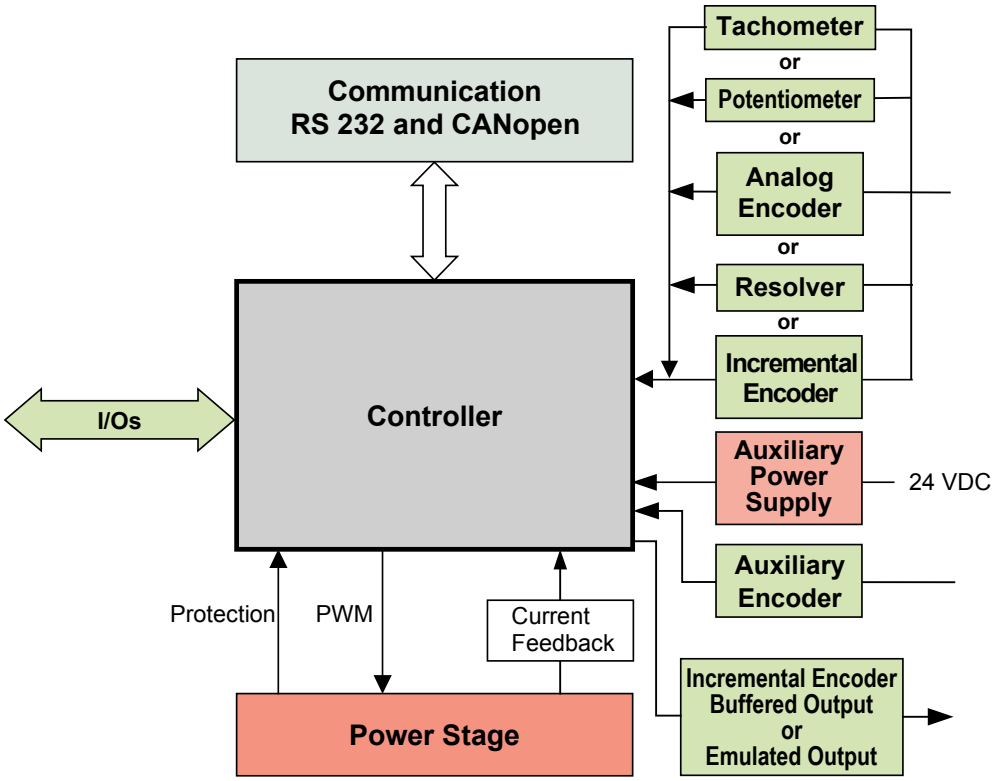


Figure 1: Tuba System Block Diagram

2.4. How to Use this Guide

In order to install and operate your Elmo Tuba 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 Tuba.
- Chapter, *Technical Specifications,* lists all the drive ratings and specifications.

Upon completing the instructions in this guide, your Tuba 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.

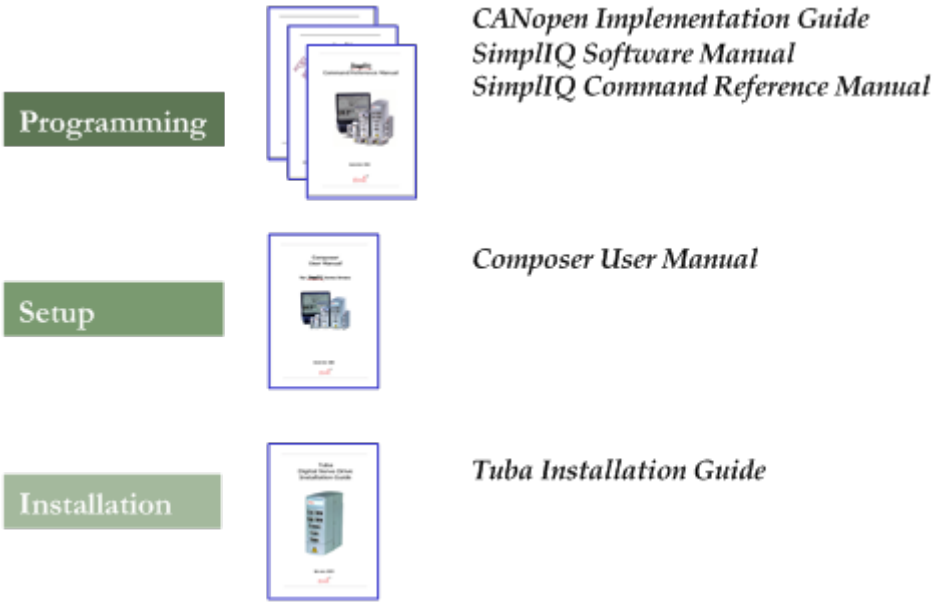


Figure 2: Elmo Documentation Hierarchy

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

- The Composer *Software Manual,* which includes explanations of all the software tools that are part of Elmo's Composer software environment.
- The *SimplIQ Command Reference Manual,* which describes, in detail, each software command used to manipulate the Tuba motion controller.
- The *SimplIQ Software Manual,* which describes the comprehensive software used with the Tuba.

Chapter 3: Installation

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

3.1. Before You Begin

3.1.1. Site Requirements

You can guarantee the safe operation of the Tuba 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 relative humidity	90% non-condensing
Operating area atmosphere	No flammable gases or vapors permitted in area
Models for extended environmental conditions are available.	



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

3.1.2. Hardware Requirements

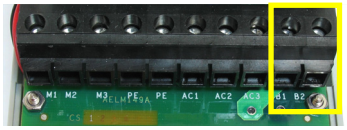
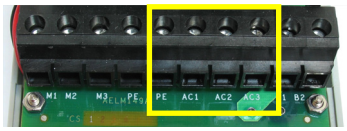
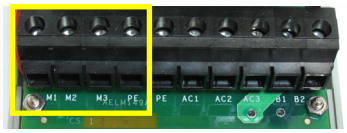
3.1.2.1. AC Input Requirements

Circuit Breakers & Contacts	Three-Phase Supply Voltage	Single-Phase Supply Voltage
Circuit breaker current rating	150% to 200% of drive current	200% to 300% of drive current
Circuit breaker voltage rating	250 VAC / 480 VAC depending upon operating AC voltage	
Contactor	Up to 150% of drive current	Up to 200% of drive current

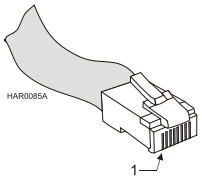
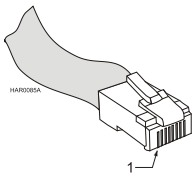
3.1.2.2. Recommended Wire Cross-Sections (All Models)

Feature	Connection	Details
AC input	AC1, AC2, AC3	4 to 5 mm^2, 10 to 12 AWG
Motor	M1, M2, M3	4 to 5 mm^2, 10 to 12 AWG
Protective earth	PE, PE	4 to 5 mm^2, 10 to 12 AWG
Auxiliary power	24V +, –	0.5 to 1 mm^2, 18 to 20 AWG

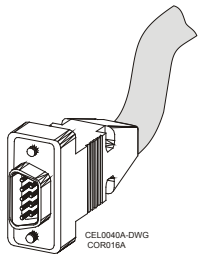
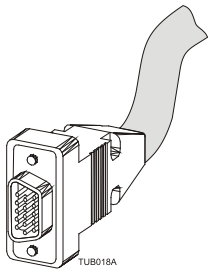
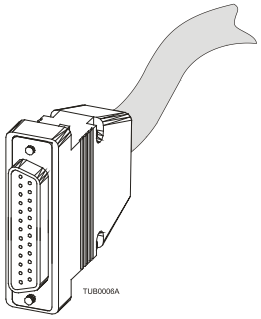
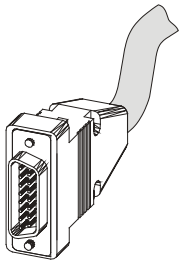
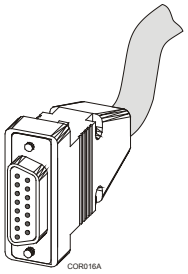
3.1.2.3. Power Connectors

Component	Connector	Described in Section	Photo
External DC Link Cable	**B1, B2 on External DC Link Cable**	3.4.2.3	
Main Power Cable	**PE, AC1, AC2, and AC3 on Power Connector**	3.4.2.2	
Motor Cable	**M1, M2, M3, PE on Power Connector**	3.4.2.1	
Auxiliary Power Cable	**24V +, -**	3.4.3	

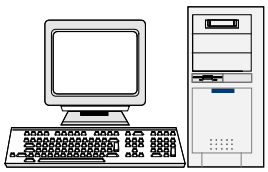
3.1.2.4. Communication Connectors

Component	Port on Tuba	Described in Section	Diagram
RS232 Communication Cable	**COMM. 1**	3.4.9.1	
CAN Communication cable(s)	**COMM. 2**	3.4.9.2	

3.1.2.5. Feedback and I/O Connectors

Component	Port on Tuba	Described in Section	Diagram
Analog Inputs (if needed)	**ANALOG I/O**	3.4.8.1	
Digital Outputs Cable (if needed)	**COMMITTED I/O**	3.4.8.2	
Digital Inputs Cable (if needed)	**GENERAL I/O**	3.4.8.3	
Main Feedback Cable	**FEEDBACK A**	3.4.5	
Auxiliary Feedback Cable (if needed)	**FEEDBACK B**	3.4.7	

3.1.2.6. Other Items Needed

Component	Diagram
PC for drive setup and tuning	
Motor data sheet or manual	

3.2. Unpacking the Drive Components

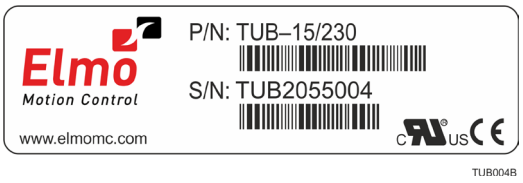
Before you begin working with the Tuba system, verify that you have all of its components, as follows:

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

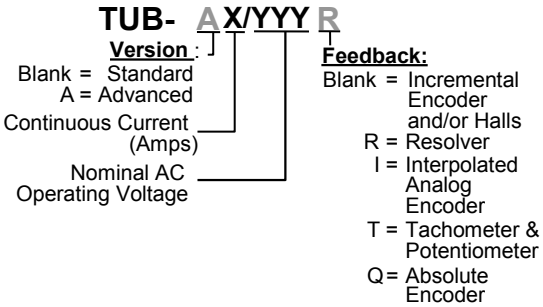
The Tuba is shipped in a cardboard box with Styrofoam protection.

To unpack the Tuba:

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



The P/N number at the top gives the type designation as follows:



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

3.3. Mounting the Tuba

The Tuba has been designed for two standard mounting options:

- Attaching directly to the wall with screws
- Mounting on a DIN rail

With either type of mounting, be sure to leave about 10 cm (4 in) above and below the instrument for heat dissipation.

3.3.1. Mounting Directly onto a Wall

The vertical mounting strip at the back of the Tuba enables you to screw the drive directly into a wall.

To mount the Tuba with the mounting strip:

1. On the back of the drive, push the mounting strip up until it clicks and locks. The top lip (with the hole) should be exposed.

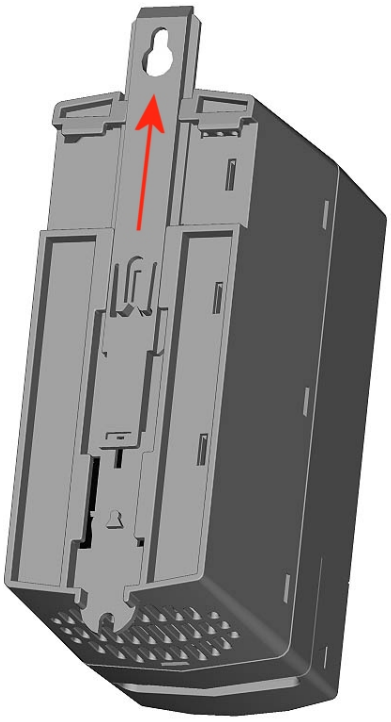


Figure 3*:* Extending the Mounting Strip

2. Mount the Tuba vertically onto the wall with two screws, one through the top hole of the mounting strip and one at the bottom.

3.3.2. Mounting on a DIN Rail

At the top rear of the Tuba, a horizontal groove lets you quickly and easily snap the drive onto a DIN rail in your work area.

To mount the Tuba on a DIN rail:

1. Be sure that the vertical mounting strip (with the hole at the top) is pressed down fully and does not protrude from the top of the instrument.

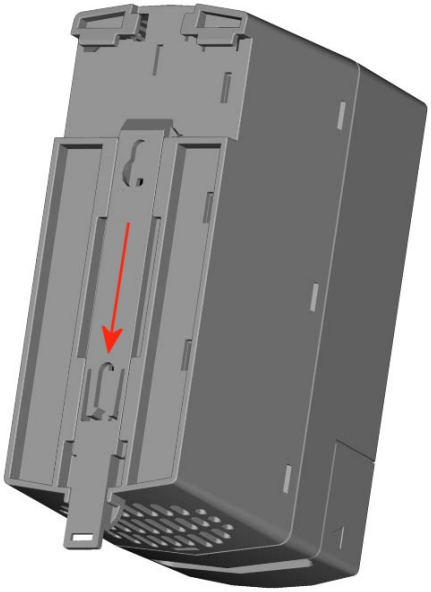


Figure 4: Mounting Strip Pressed Down

2. Tilt the Tuba back towards the top part of the DIN rail.

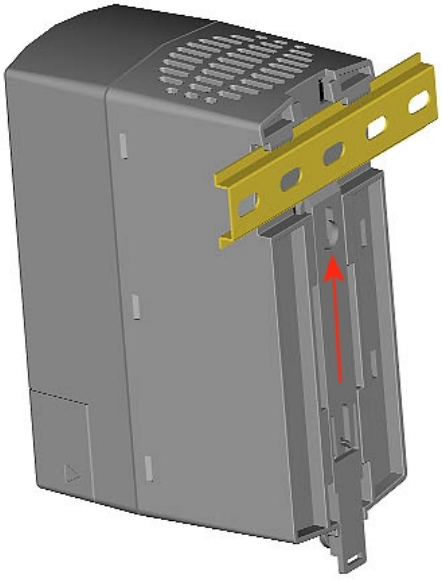


Figure 5: Attaching Top Part of Mounting Groove to a DIN Rail

3. Press the Tuba down to a vertical position until it clicks onto the DIN rail.



Figure 6: Tuba Mounted on a DIN Rail

3.4. Connecting the Cables

The Tuba has 11 connectors.

3.4.1. Wiring the Tuba

Once the Tuba is mounted, you are ready to wire the device. Proper wiring, grounding and shielding are essential for ensuring safe, immune and optimal servo performance of the Tuba.



Caution:
Follow these instructions to ensure safe and proper wiring:

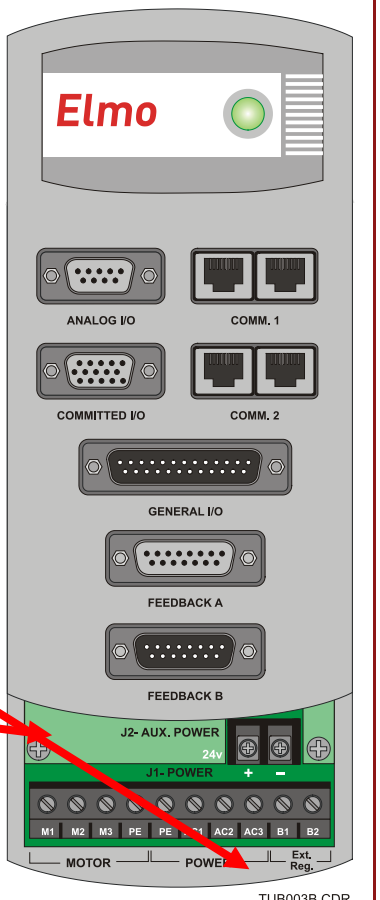
- Use twisted pair shielded cables for control, feedback and communication connections. For best results, the cable should have an aluminum foil shield covered by copper braid, and should contain a drain wire.

  The drain wire is a non-insulated wire that is in contact with parts of the cable, usually the shield. It is used to terminate the shield and as a grounding connection.

- The impedance of the wire must be as low as possible. The size of the wire must be thicker than actually required by the carrying current. A 24, 26 or 28 AWG wire for control and feedback cables is satisfactory although 24 AWG is recommended.
- Use shielded wires for motor connections as well. If the wires are long, ensure that the capacitance between the wires is not too high: C < 30 nF is satisfactory for most applications.
- Keep all wires and cables as short as possible.

- Keep the motor wires as far away as possible from the feedback, control and communication cables.
- Ensure that in normal operating conditions, the shielded wires and drain *carry no current.* The only time these conductors carry current is under abnormal conditions, when electrical equipment has become a potential shock or fire hazard while conducting external EMI interferences directly to ground, in order to prevent them from affecting the drive. Failing to meet this requirement can result in drive/controller/host failure.
- After completing the wiring, carefully inspect all wires to ensure tightness, good solder joints and general safety.

The Tuba has the following connectors:

Type	Function	Port on Tuba	Connector Location
8-Pin RJ-45 x 2	RS-232	COMM. 1	
9-Pin D-Sub socket	Analog Input	ANALOG I/O	
8-Pin RJ-45 x 2	CAN (In/Out)	COMM. 2	
15-Pin high-density D-Sub socket	Digital Outputs	COMMITTED I/O	
25-Pin D-Sub plug	Digital Inputs	GENERAL I/O	
15-Pin D-Sub socket	Main Feedback	FEEDBACK A	
15-Pin D-Sub plug	Auxiliary Feedback	FEEDBACK B	
2-Pin terminal strip Molex	Auxiliary Power Supply	24V +, -	
10-Pin terminal block Molex	Mains, Motor Power & DC Link	B1, B2, M1, M2, M3, PE, PE, AC1, AC2, AC3	

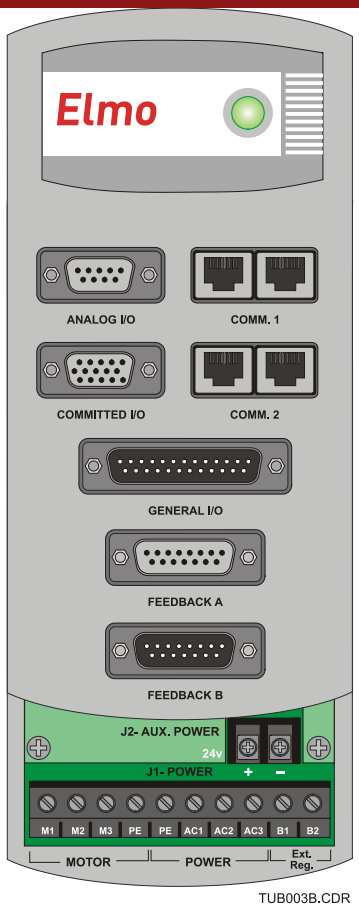
Type	Function	Port on Tuba	Connector Location
			

Table 1: Connectors on the Tuba

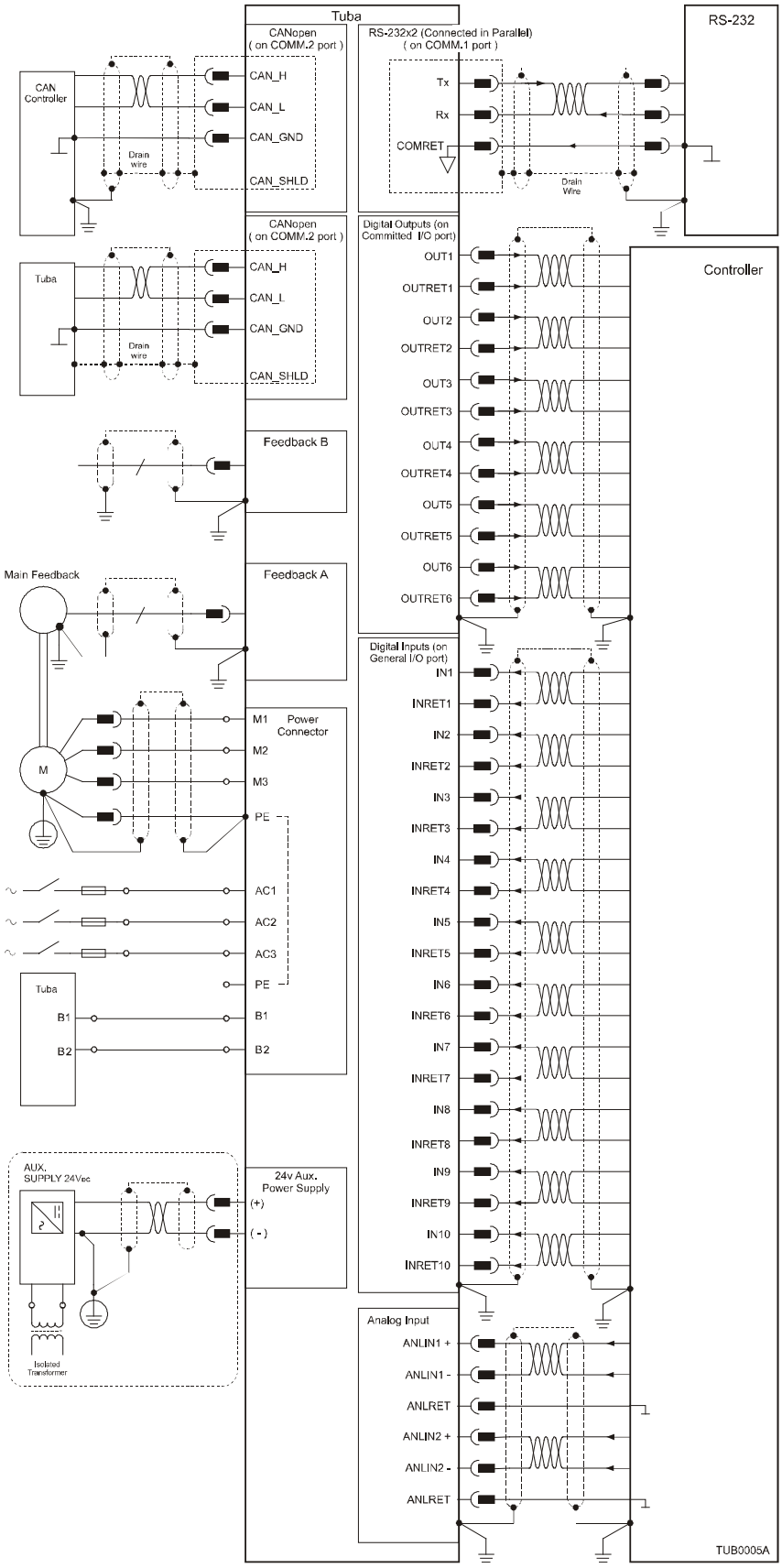


Figure 7: Tuba Detailed Connection Diagram

3.4.2. Connecting the Power Cables

Access the power terminal connections on the Tuba servo drive by removing the front safety cover located at the bottom of the front panel of the unit, as shown below:

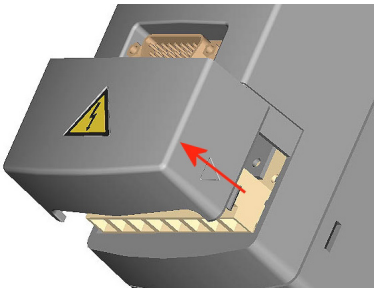


Figure 8: Removable Bottom Panel

After removing the safety cover, the power terminal connections are visible, as follows:

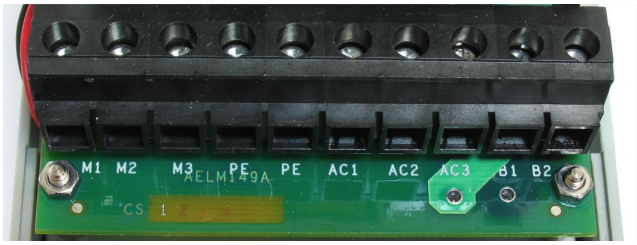
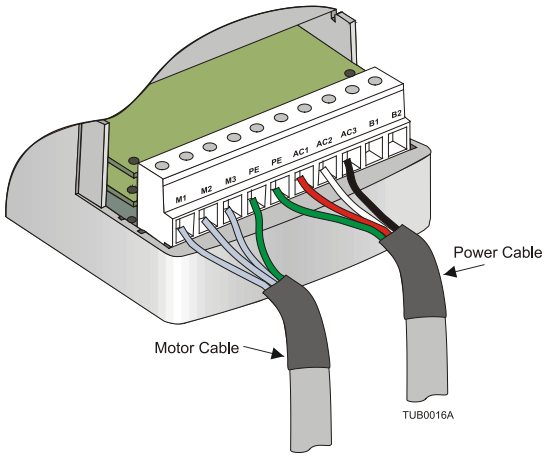


Figure 9: Tuba Power Connectors

The main power connector, which is located at the bottom of the Tuba, has the following pins:

Pin	Function	Cable		Pin Positions
B1	DC Link (+)	DC Link		
B2	DC Link (-)	DC Link		
AC3	Phase 3	Power		
AC2	Phase 2	Power		
AC1	Phase 1	Power		
PE	Protective earth	Power		
		AC Motor Cable	**DC Motor Cable**	
PE	Protective earth	Motor	Motor	
M3	Motor phase	Motor	N/C*	
M2	Motor phase	Motor	Motor	
M1	Motor phase	Motor	Motor*	

Note: When connecting several motors, all must be wired in an identical manner.

*On prototype versions of the Tuba, M3 was connected to the Motor and M1 was not.

Table 2: Connector for Main Power and Motor Cables

3.4.2.1. Connecting the Motor Cable

Connect the motor power cable to the M1, M2, M3 and PE terminals of the main power connector. The phase connection order is arbitrary because the Composer will establish the proper commutation automatically during setup. However, if you plan to copy the set-up to other drives, then the phase order on all copy drives must be the same.

Notes for connecting the motor cables:

- For best noise immunity, it is highly recommended to use a shielded (not twisted) cable for the motor connection. A 4-wire shielded cable should be used. The gauge is determined by the actual current consumption of the motor.
- The fourth wire should be used for the ground connection between the motor and the PE terminal of the Tuba.
- Connect the shield of the cable to the closest ground connection at the motor end.
- Connect the shield of the cable to the PE terminal on the Tuba.
- Be sure that the motor chassis is properly grounded.

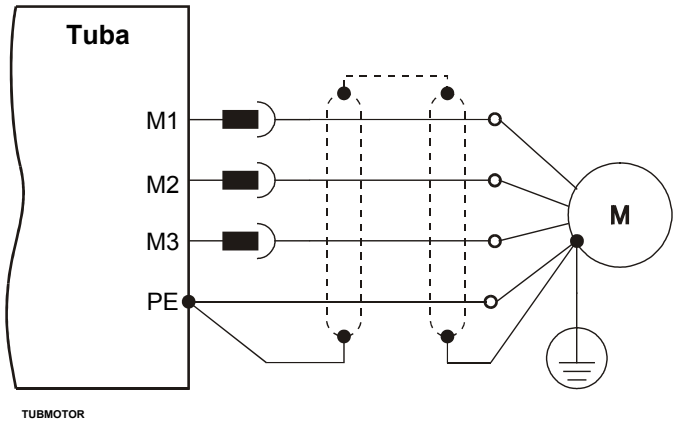


Figure 10: AC Motor Power Connection Diagram

3.4.2.2. Connecting the Main Power Cable

Connect the main power supply cable to the AC1, AC2 and AC3 terminals of the main power connector. Connect the Protective Earth wire to the nearest PE terminal on the terminal block.

Notes for connecting the AC power cable:

- For best noise immunity, a shielded (not twisted) cable is recommended (not mandatory) for the AC power supply cable. A 4-wire shielded cable should be used. The gauge is determined by the actual current consumption of the motor.
- Connect the four wires to the AC power leads of the source.
- For safety requirements, the fourth wire must be used for the protective earth connection (connected to the PE terminal).

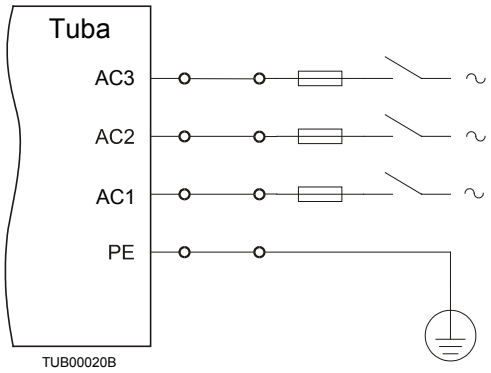


Figure 11: Main Power Supply Connection Diagram

3.4.2.3. Connecting the DC Link Cable

Each Tuba contains a shunt. Its purpose is to "absorb" regenerated energy created by the motor during braking and convert that energy into heat. If the energy regenerated by the motor exceeds the capacity of the shunt, the drive is switched off and an over-voltage error message is sent.

To prevent this from happening, the capacity of the shunt system can be extended by connecting the shunts of several Tubas in parallel. When two or more Tubas are connected, by DC Link cables, the regenerated energy is distributed equally among the drives. This spreads the energy spikes over several shunts and enables a specific Tuba to continue normal operation.

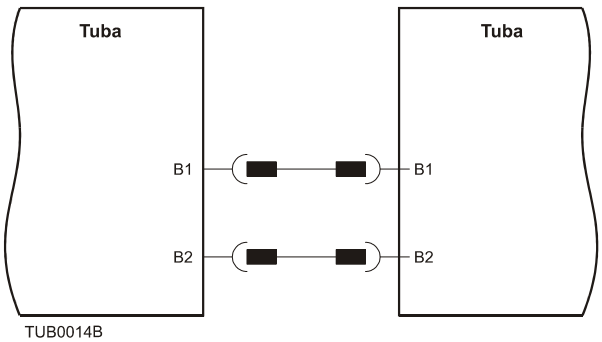


Figure 12: The Tuba's External DC Link Option

Note: Tuba 1 and 2 must have an identical voltage rating.

3.4.3. Connecting the Auxiliary Supply Cable (24 V)

Connect the auxiliary supply to the 24 VDC terminal block on the bottom of the Tuba.
Remember, you are working with DC power; so be sure to exercise caution.

Notes for 24 VDC auxiliary supply connections:

- Use a 24 AWG twisted pair shielded cable. For best results the shield should have aluminum foil covered by copper braid.
- The 24 VDC auxiliary power supply must meet all safety standards and must be separated from hazardous live voltages using reinforced or double insulation in accordance with approved safety standards.
- For safety reasons, connect the return of the 24 VDC source to the closest ground.
- Connect the cable shield to the closest ground near the 24 VDC source.
- Before applying power, first verify the polarity of the connection.

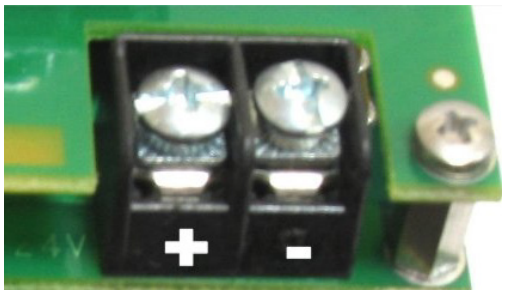
Pin	Signal	Function	Pin Positions
[+]	+24VDC	+24 VDC auxiliary supply	
[-]	RET24VDC	Return (common) of the 24 VDC auxiliary supply	

Table 3: Auxiliary Power Supply

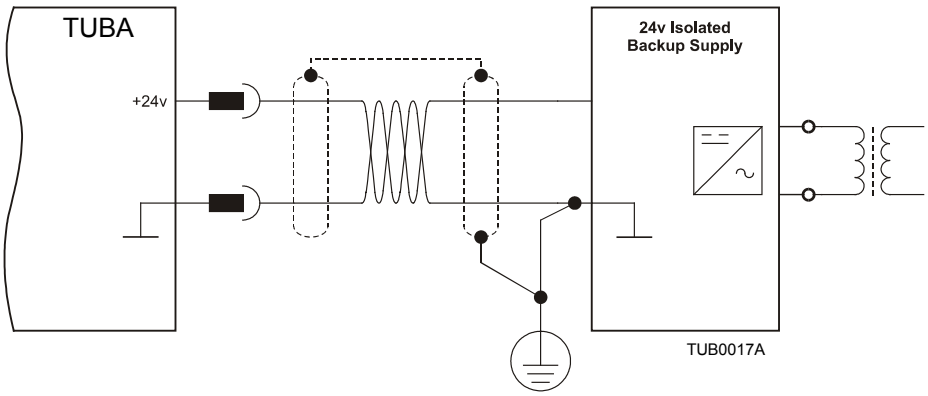


Figure 13: Auxiliary Supply (24v) Connection Diagram

3.4.4. Feedback and Control Cable Assemblies

The Tuba features easy-to-use D-Sub type connections for all Control and Feedback cables. Below are instructions and diagrams describing how to assemble those cables.

- Use 24, 26 or 28 AWG twisted-pair shielded cables (24 AWG cable is recommended). For best results, the shield should have aluminum foil covered by copper braid.
- Use only a D-Sub connector with a **metal housing**.
- Attach the braid shield tightly to the metal housing of the D-type connector.
- On the motor side connections, ground the shield to the motor chassis.
- On controller side connections, follow the controller manufacturer's recommendations concerning the shield.

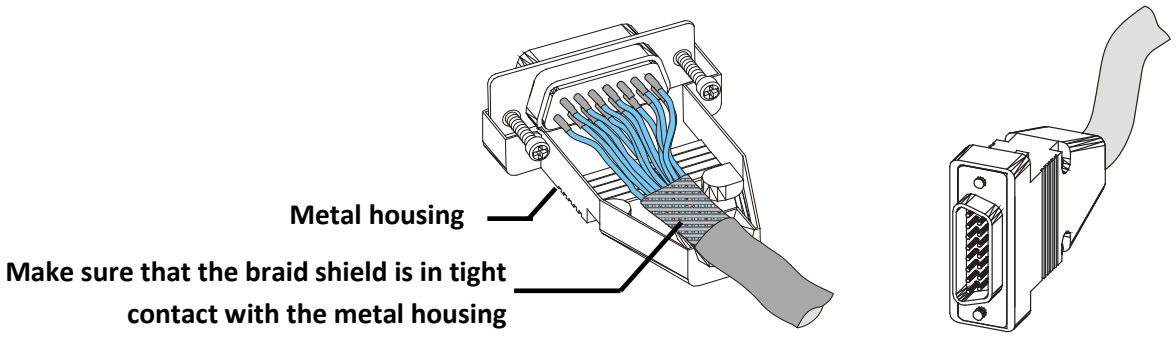


Figure 14: Feedback and Control Cable Assemblies

Note: All D-Sub type connectors, used with the Tuba, should be assembled in this way.

3.4.5. Main Feedback Cable (Feedback A)

The main feedback cable is used to transfer feedback data from the motor to the drive.

The Tuba accepts the following 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 and Potentiometer
- Absolute encoder

FEEDBACK A on the front of the Tuba has a 15-pin D-Sub socket. Connect the Main Feedback cable from the motor to FEEDBACK A using a 15-pin, D-Sub plug with a metal housing. When assembling the Main Feedback cable, follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies).

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

Table 4: Main Feedback Cable Pin Assignments (Part A)

Absolute Encoders			
	TUB-XX/YYYQ		
Pin	**Signal**	**Heidenhain**	**Stegmann**
1	HC	Hall C	Hall C
2	HA	Hall A	Hall A
3	SUPRET	Supply return	Supply return
4	+5V	EnDat (Heidenhain) Encoder +5 supply	Halls supply +5V
5	A-	Sine A complement	Sine A
6	A+	Sine A	Sine A complement
7	DATA-	Data complement	Data complement
8	DATA+	DATA	DATA
9	SUPRET	Supply return	Supply return
10	HB	Hall B	Hall B
11	CLK-	CLOCK complement	-
12	+8V	-	Stegmann Encoder +8V supply 8 V @90 mA maximum
13	CLK+	CLOCK	-
14	B-	Cosine B complement	Cosine B complement
15	B+	Cosine B	Cosine B

Table 5: Main Feedback Cable Pin Assignments (Part B)

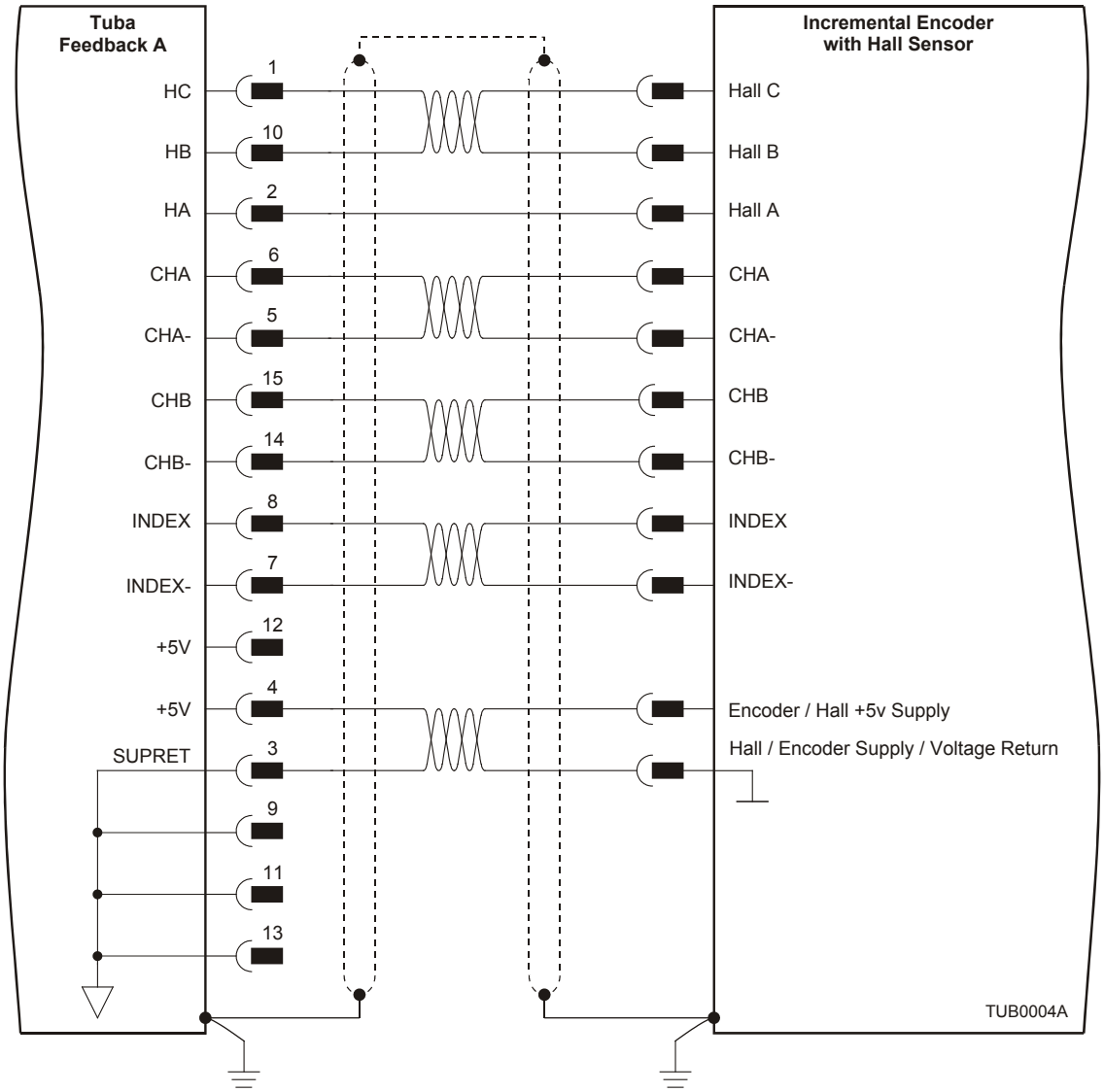


Figure 15: Main Feedback- Incremental Encoder with Digital Hall Sensor - Connection Diagram

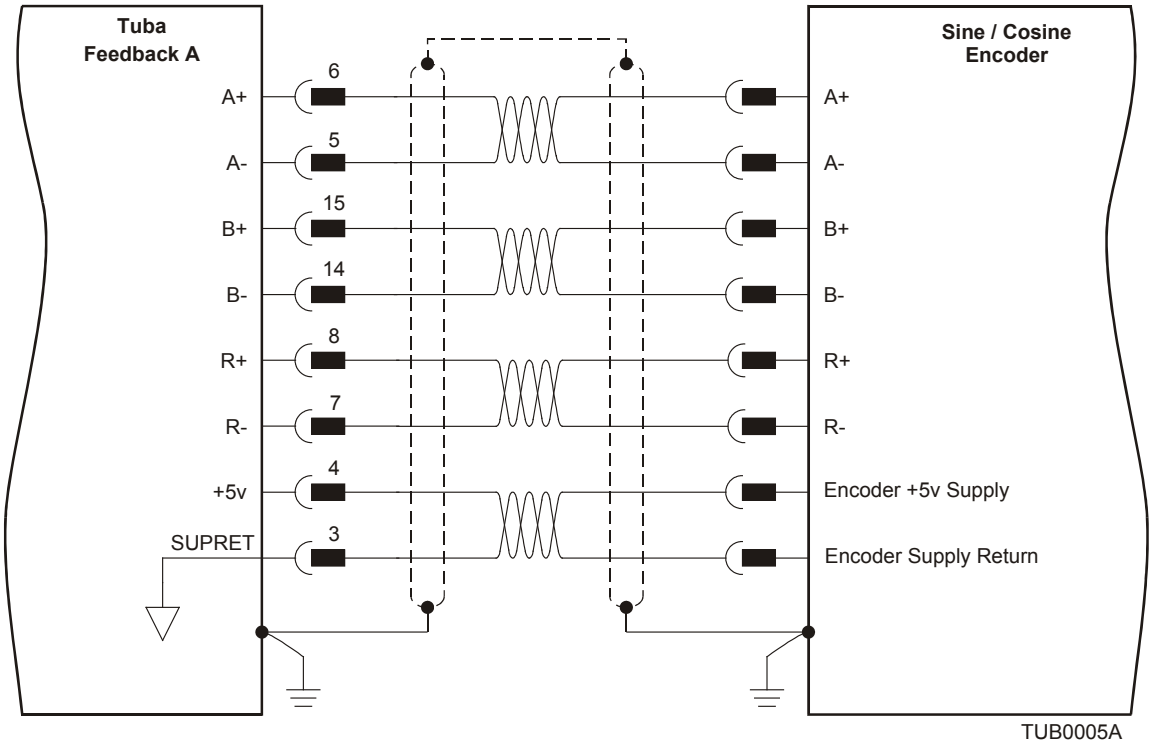


Figure 16: Main Feedback – Interpolated Analog (Sine/Cosine) Encoder Connection Diagram

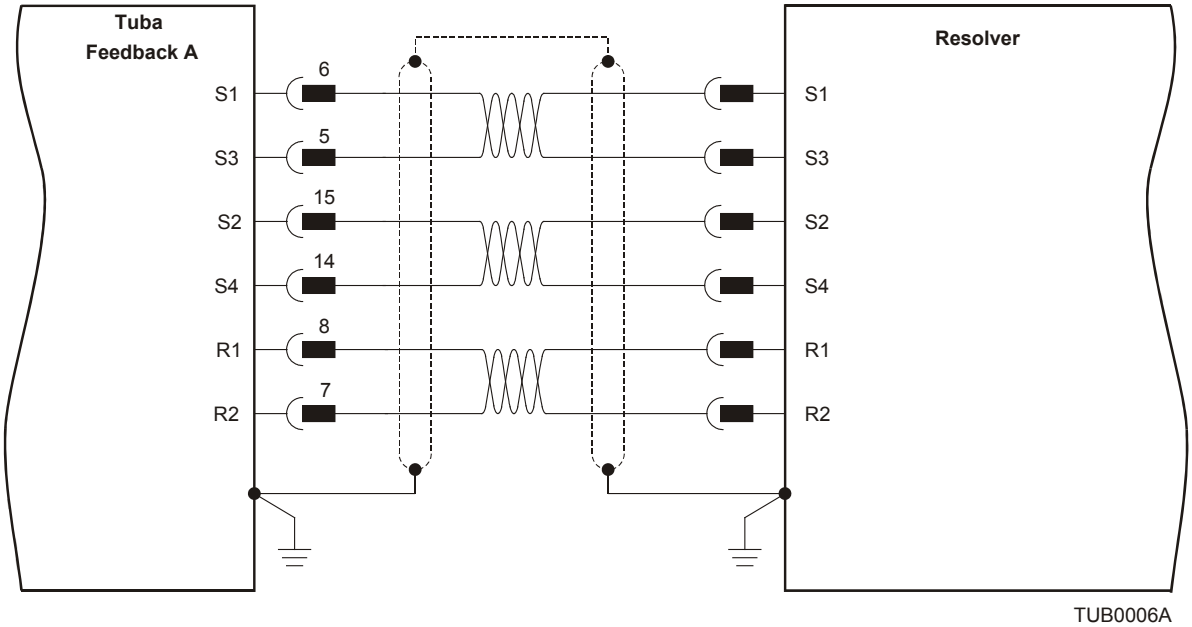


Figure 17: Main Feedback – Resolver Connection Diagram

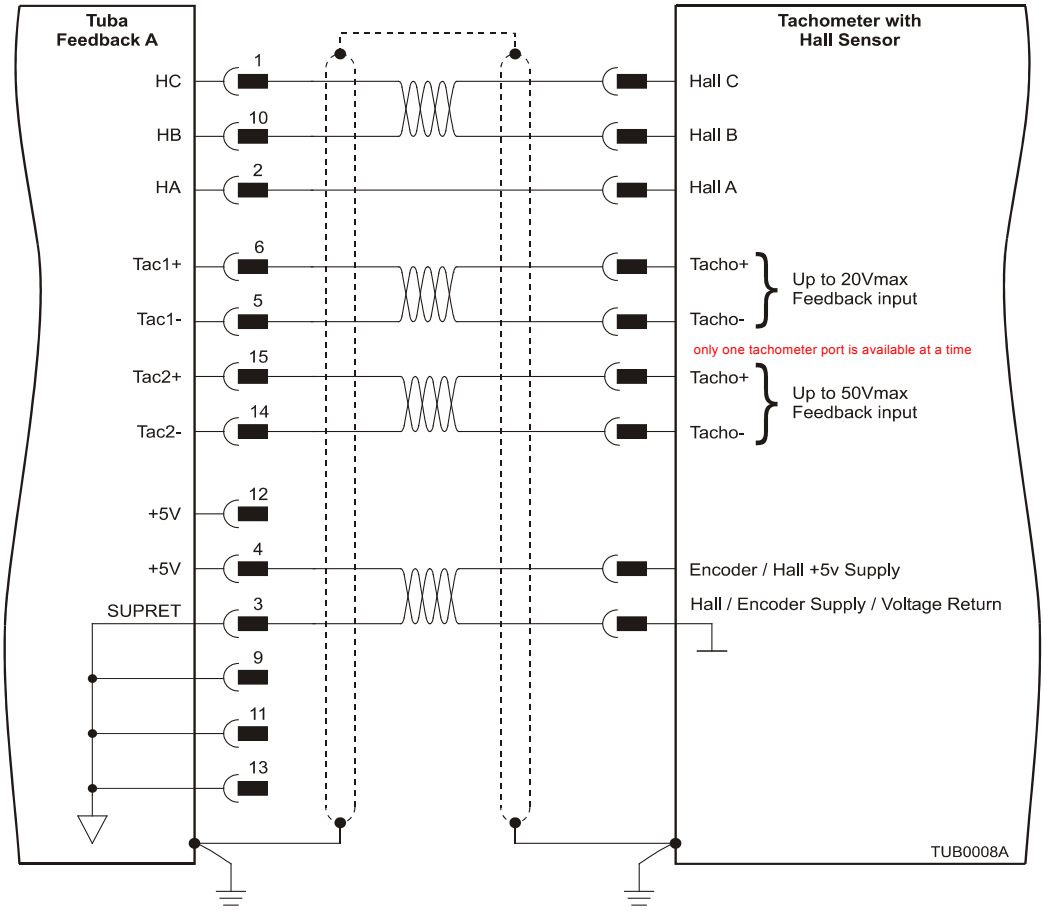


Figure 18: Main Feedback – Tachometer Feedback with Digital Hall Sensor Connection Diagram for Brushless Motors

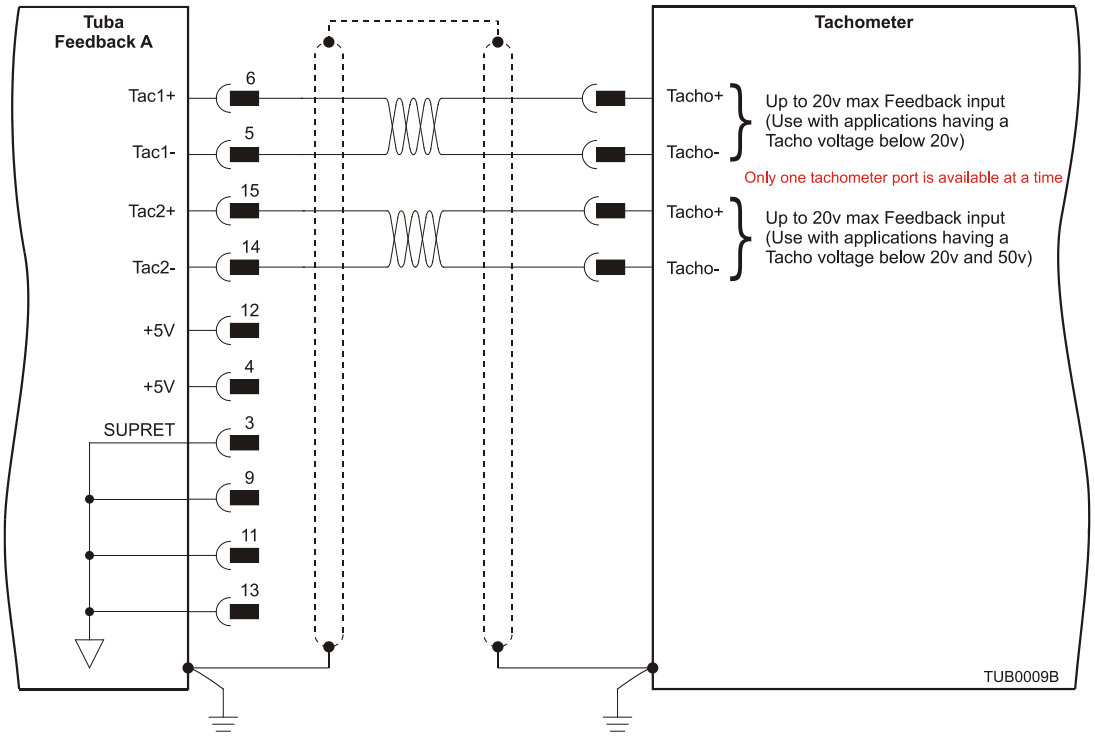


Figure 19: Main Feedback – Tachometer Feedback Connection Diagram

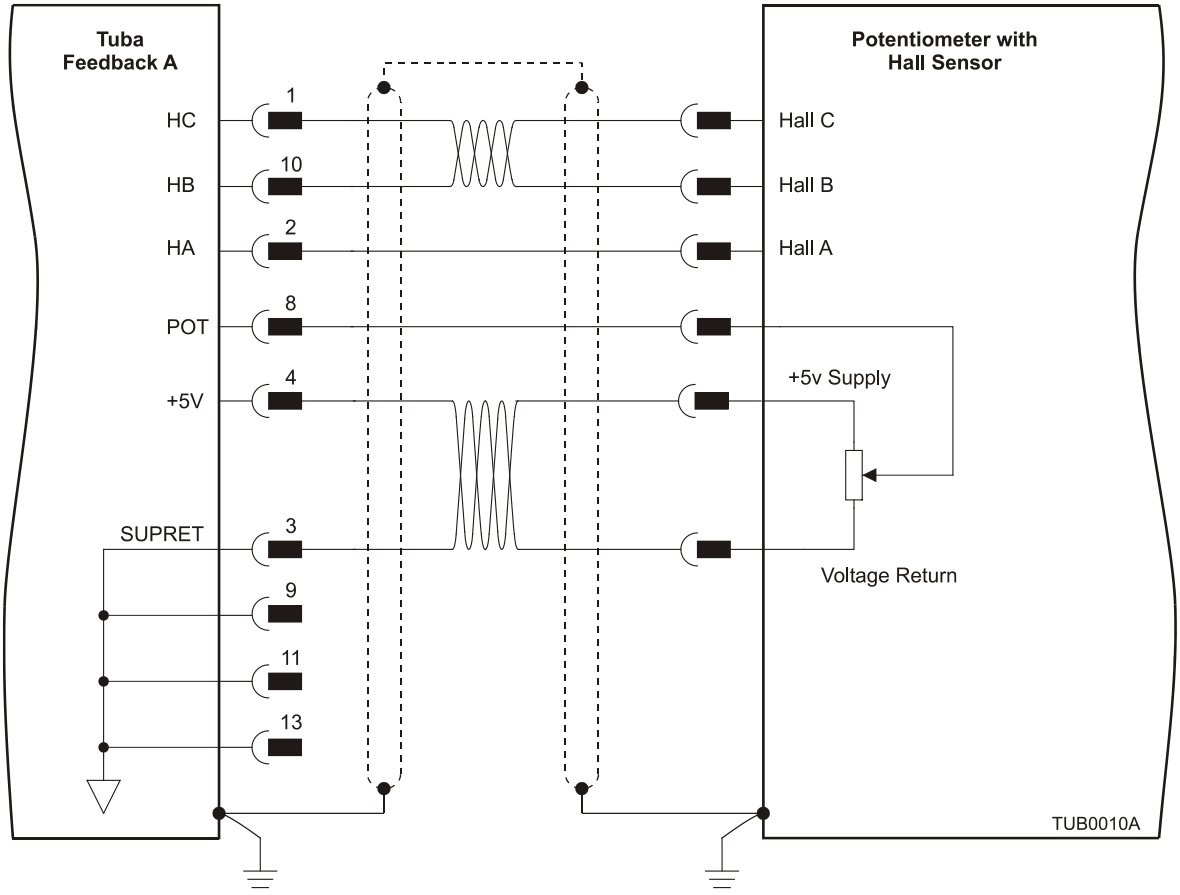


Figure 20: Main Feedback – Potentiometer Feedback with Digital Hall Sensors Connection Diagram for Brushless Motors

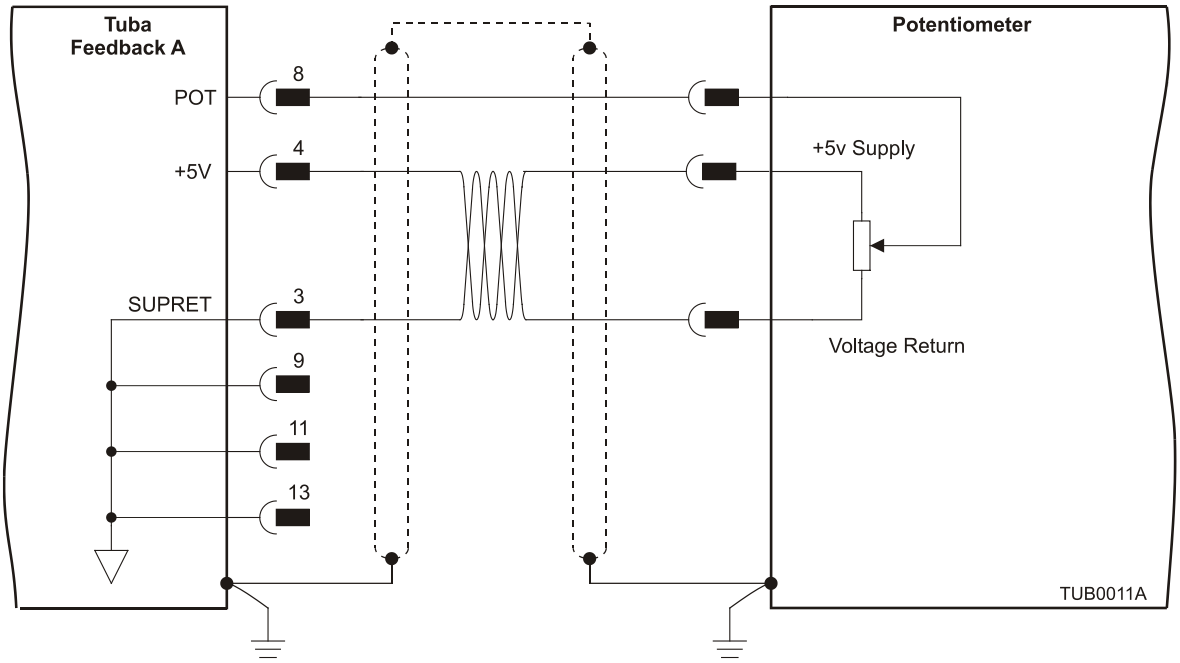


Figure 21: Main Feedback – Potentiometer Feedback Connection Diagram

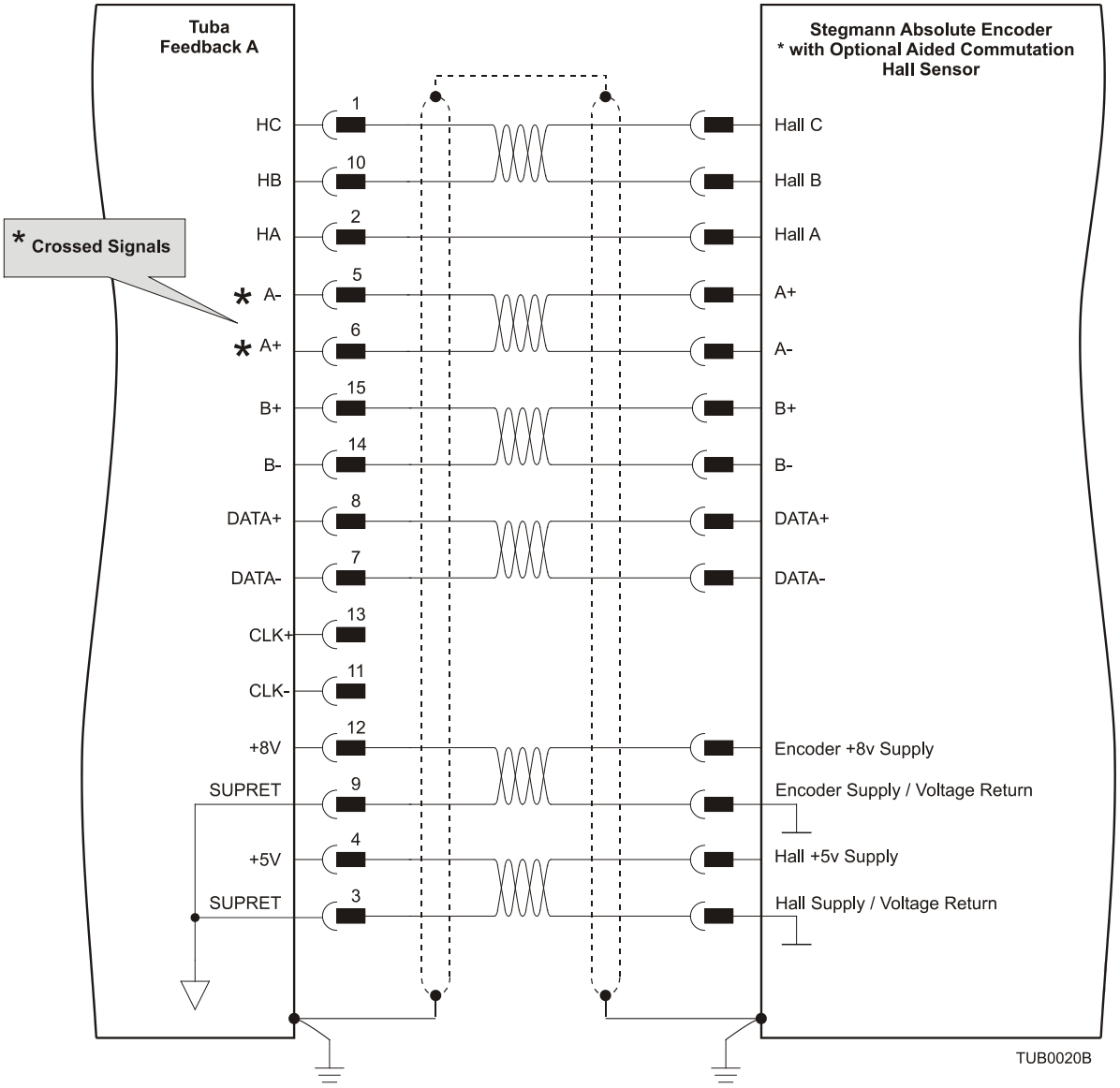


Figure 22: Main Feedback – Stegmann Feedback Connection Diagram

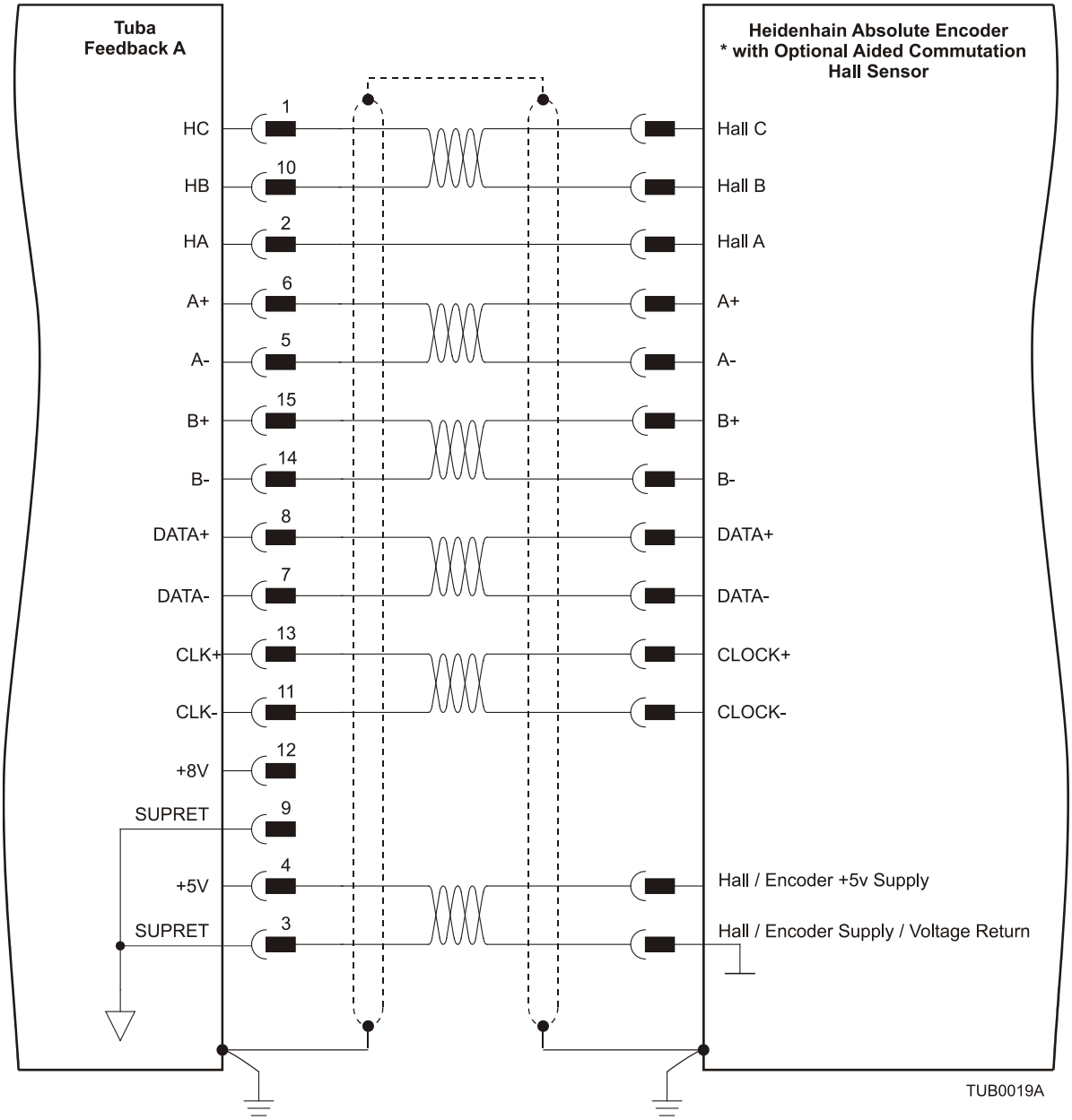
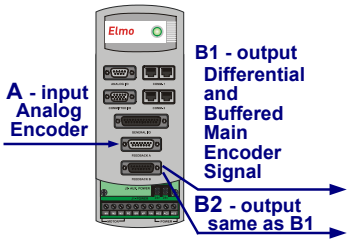
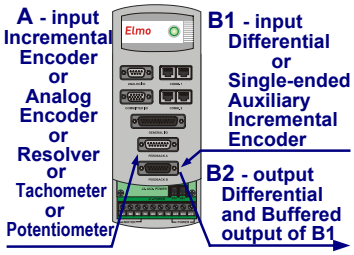
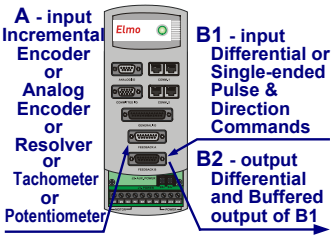
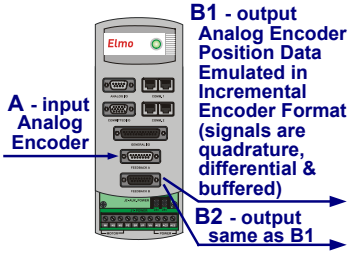
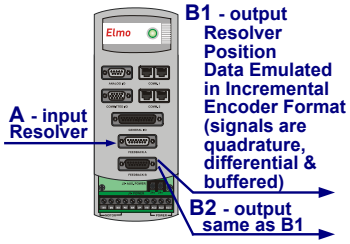
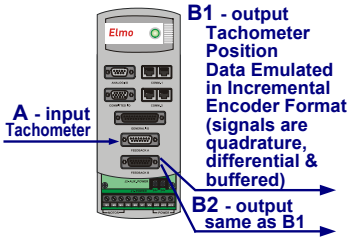
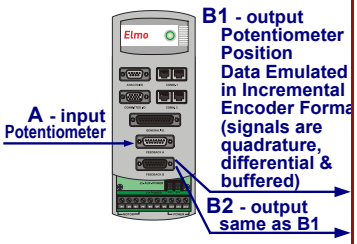
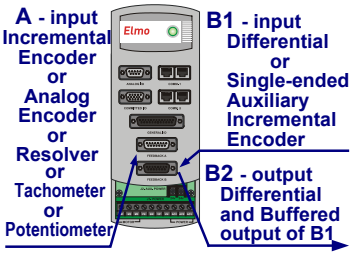
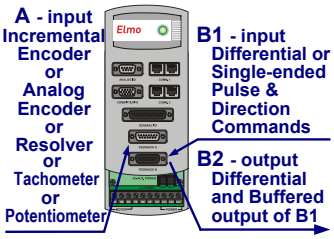


Figure 23: Main Feedback – Heidenhain Feedback Connection Diagram

3.4.6. 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 Tuba, FEEDBACK B has two ports, Port B1 and Port B2. When used in combination with the Main Feedback port, FEEDBACK A, the ports can be set, by software, as follows:

<table>
<tr><th>SW Setting
FEEDBACK A</th><th colspan="3">FEEDBACK B Ports B1 and B2</th></tr>
<tr><th></th><th>YA[4] = 4</th><th>YA[4] = 2</th><th>YA[4] = 0</th></tr>
<tr><td>Incremental Encoder Input</td><td>★

</td><td rowspan="4">Note: Feedback Ports B1 and B2 are not to be confused with the DC Link connectors on the 10-pin terminal block.

</td><td>
</td></tr>
<tr><td>Interpolated Analog (Sin/Cos) Encoder Input</td><td>✶

</td></tr>
<tr><td>Resolver Input</td><td>✸

</td></tr>
<tr><td>Tachometer Input</td><td>◆

</td></tr>
</table>

SW Setting / FEEDBACK A	FEEDBACK B Ports B1 and B2		
	YA[4] = 4	YA[4] = 2	YA[4] = 0
Potentiometer Input	◈  	 	
Typical Applications	★ Any application where the main encoder is used, not only for the drive, but also for other purposes such as position controllers and/or other drives. ✶ 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 Applications where position data is required in the Encoder's quadrature format. ◈ Potentiometer applications where position data is required in the Encoder's quadrature format.	Any application where two feedbacks are used by the drive. Port B1 serves as an input for the auxiliary incremental encoder (differential or single-ended). Port B2 is used to output differential buffered Auxiliary Incremental Encoder signals. For applications such as Follower, ECAM, or Dual Loop.	Port B1 serves as an input for Pulse & Direction commands (differential or single-ended). Port B2 is used to output differential buffered Pulse & Direction signals.

3.4.7. Auxiliary Feedback (FEEDBACK B)

When using one of the auxiliary feedback options, the relevant functionality of FEEDBACK B ports are software selected for that option. Refer to the Tuba *Command Reference Manual* for detailed information about FEEDBACK B setup.

3.4.7.1. Main Encoder Buffered Outputs or Emulated Encoder Outputs Option on FEEDBACK B (YA[4]=4)

Through FEEDBACK B (Ports B1 and B2) the Tuba can provide **two simultaneous buffered main, or emulated, encoder signals** to other controllers or drives. This option can be used when:

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

Below are the signals on the Auxiliary Feedback ports when set up to run as a buffered outputs or emulated outputs of the main feedback (on FEEDBACK A):

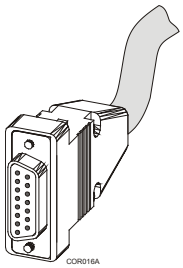
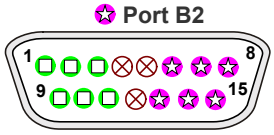
Port	Pin	Signal	Function	Pin Positions
B1	1	INDEX	Auxiliary index high *output*	 **15-Pin D-Sub Socket**
B1	2	CHB	Auxiliary Channel B high *output*	
B1	3	CHA	Auxiliary Channel A high *output*	
PWR	4	+5V	Encoder supply voltage	
PWR	5	SUPRET	Encoder supply voltage return	
B2	6	CHAO	Buffered Channel A output	
B2	7	CHBO	Buffered Channel B output	
B2	8	INDEXO	Buffered Index output	
B1	9	INDEX-	Auxiliary Index low *output*	 **15-Pin D-Sub Plug on Tuba**
B1	10	CHB-	Auxiliary Channel B low *output*	
B1	11	CHA-	Auxiliary Channel A low *output*	
PWR	12	SUPRET	Supply return	
B2	13	CHAO-	Buffered Channel A complement output	
B2	14	CHBO-	Buffered Channel B complement output	
B2	15	INDEXO-	Buffered Index complement output	

Table 6: Main Encoder Buffered Outputs or Emulated Encoder Outputs on FEEDBACK B - Pin Assignments

FEEDBACK B, on the front of the Tuba, has a 15-pin D-Sub plug. Connect the Auxiliary Feedback cable, from the controller or other device, to FEEDBACK B using a 15-pin D-Sub socket with a metal housing. When assembling the Auxiliary Feedback cable, follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies).

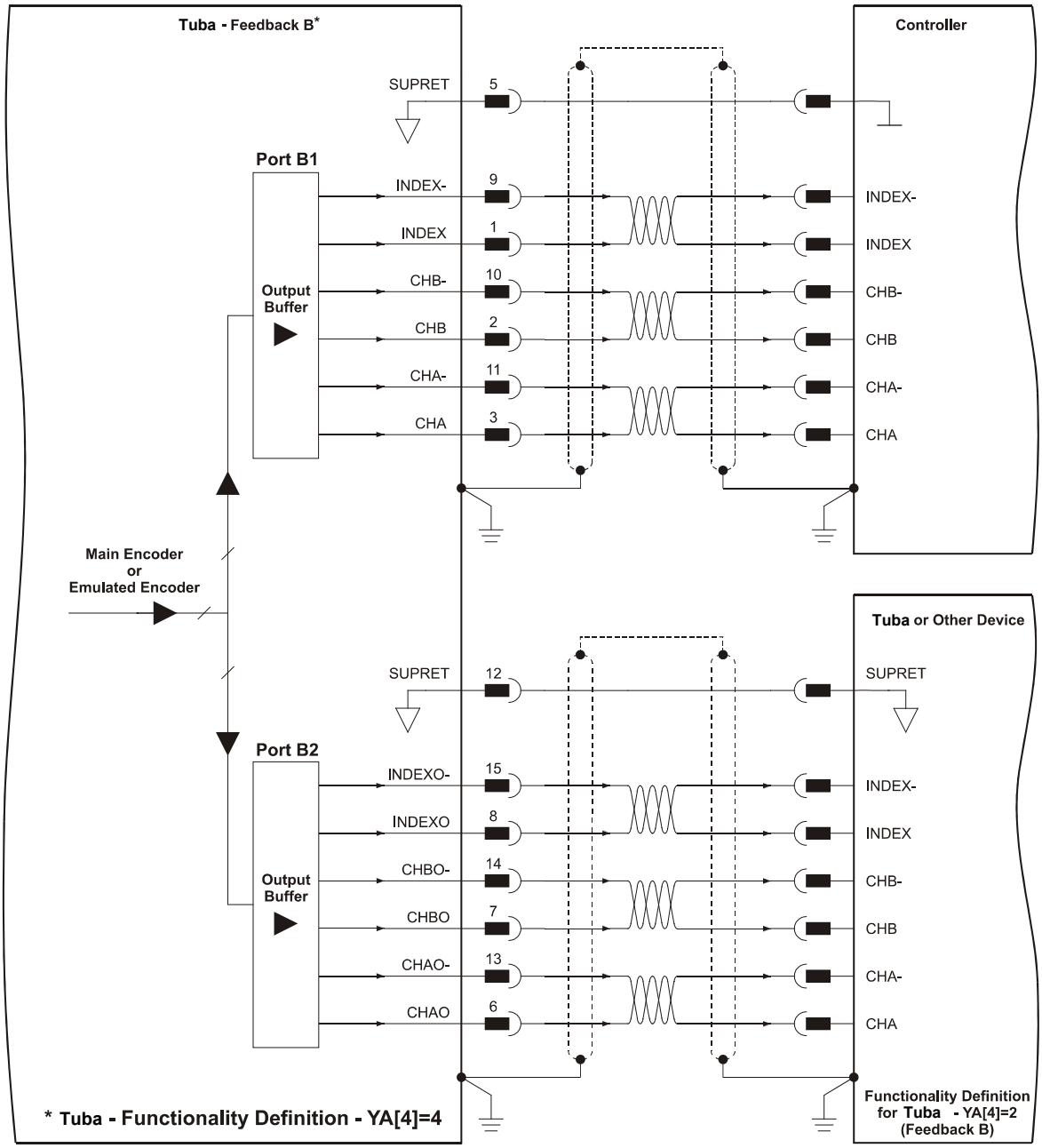


Figure 24: Main Encoder Buffered Output or Emulated Encoder Output on FEEDBACK B - Connection Diagram

3.4.7.2. Differential Auxiliary Encoder Input Option on FEEDBACK B (YA[4]=2)

The Tuba can be used as a slave by receiving the position of the master encoder data (on Port B1) in Follower or ECAM mode. In this mode Port B2 provides **differential buffered auxiliary outputs** for the next slave axis in follower or ECAM mode.

Below are the signals on the Auxiliary Feedback port when set up to run as a differential auxiliary encoder input:

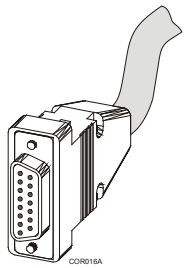
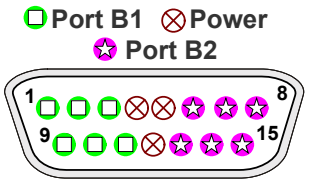
Port	Pin	Signal	Function	Pin Positions
B1	1	INDEX	Auxiliary Index high *input*	 **15-Pin D-Sub Socket**
B1	2	CHB	Auxiliary Channel B high *input*	
B1	3	CHA	Auxiliary Channel A high *input*	
PWR	4	+5V	Encoder supply voltage	
PWR	5	SUPRET	Encoder Supply return	
B2	6	CHAO	Buffered Channel A output	
B2	7	CHBO	Buffered Channel B output	
B2	8	INDEXO	Buffered Index output	
B1	9	INDEX-	Auxiliary Index low *input*	 **15-Pin D-Sub Plug on Tuba**
B1	10	CHB-	Auxiliary Channel B low *input*	
B1	11	CHA-	Auxiliary Channel A low *input*	
PWR	12	SUPRET	Supply return	
B2	13	CHAO-	Buffered Channel A complement output	
B2	14	CHBO-	Buffered Channel B complement output	
B2	15	INDEXO-	Buffered Index complement output	

Table 7: Differential Auxiliary Encoder Input Option on FEEDBACK B Pin Assignments

FEEDBACK B on the front of the Tuba has a 15-pin D-Sub plug. Connect the Auxiliary Feedback cable from the feedback device to FEEDBACK B using a 15-pin D-Sub socket with a metal housing. When assembling the Auxiliary Feedback cable, follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies).

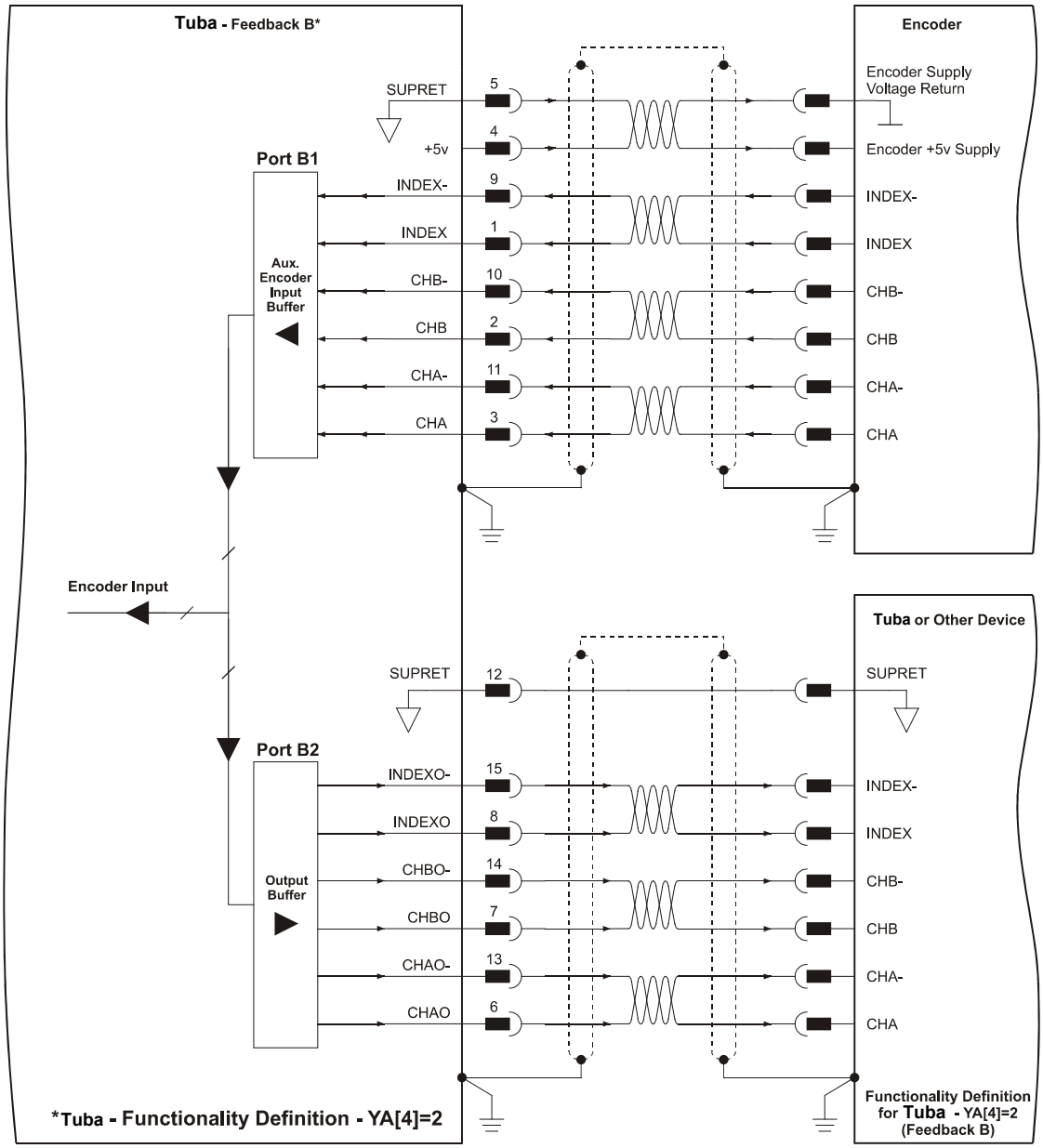


Figure 25: Differential Auxiliary Encoder Input Option on FEEDBACK B - Connection Diagram

3.4.7.3. Single-Ended Auxiliary Input Option on FEEDBACK B - (YA[4]=2)

The Tuba can be used as a slave by receiving the position data of the master encoder (on Port B1) in Follower or ECAM mode. In this mode Port B2 provides **differential buffered auxiliary outputs** for the next slave axis in Follower or ECAM mode.

Below are the signals on the Auxiliary Feedback ports when set up to run as a single-ended auxiliary encoder input:

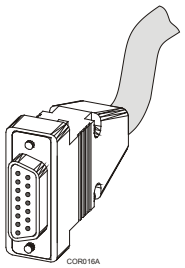
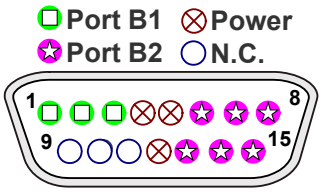
Port	Pin	Signal	Function	Pin Positions
B1	1	INDEX	Auxiliary Index *input*	 **15-Pin D-Sub Socket**
B1	2	CHB	Auxiliary Channel B *input*	
B1	3	CHA	Auxiliary Channel A *input*	
PWR	4	+5V	Encoder Supply Voltage	
PWR	5	SUPRET	Encoder Supply return	
B2	6	CHAO	Buffered Channel A output	
B2	7	CHBO	Buffered Channel B output	
B2	8	INDEXO	Buffered Index output	
-	9	-	Do not connect this pin	 **15-Pin D-Sub Plug on Tuba**
-	10	-	Do not connect this pin	
-	11	-	Do not connect this pin	
PWR	12	SUPRET	Supply return	
B2	13	CHAO-	Buffered Channel A complement output	
B2	14	CHBO-	Buffered Channel B complement output	
B2	15	INDEXO-	Buffered Index complement output	

Table 8: Single-Ended Auxiliary Encoder Option on FEEDBACK B - Pin Assignments

FEEDBACK B on the front of the Tuba has a 15-pin D-Sub plug. Connect the Auxiliary Feedback cable from the feedback device to FEEDBACK B using a 15-pin D-Sub socket with a metal housing. When assembling the Auxiliary Feedback cable, follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies).

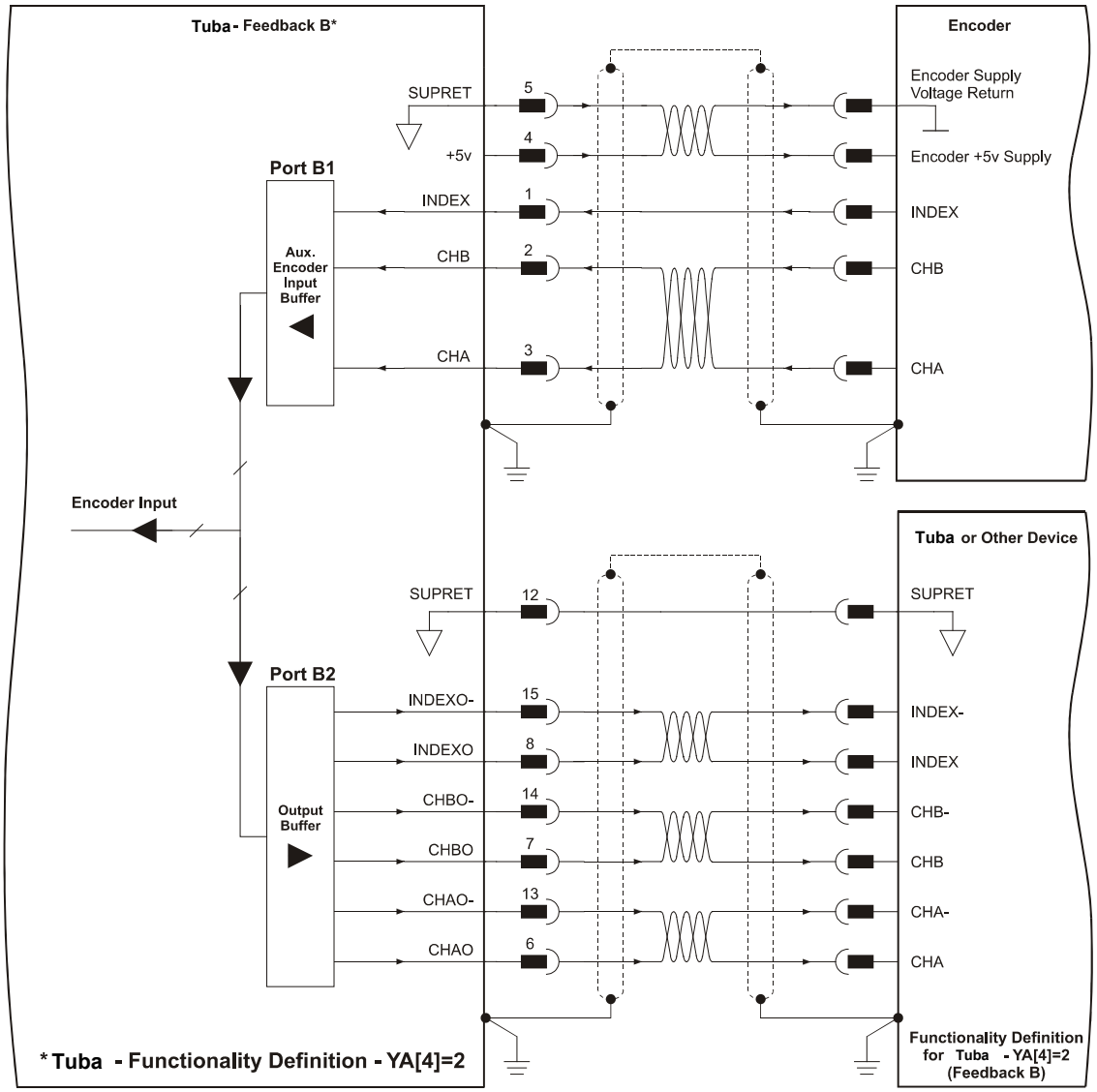


Figure 26: Single-Ended Auxiliary Input Option on FEEDBACK B - Connection Diagram

3.4.7.4. Pulse-and-Direction Input Option on FEEDBACK B - (YA[4]=0)

This mode is used for input of differential or single-ended pulse-and-direction position commands on Port B1. In this mode Port B2 provides **differential buffered pulse-and-direction outputs** for another axis.

Below are the signals on the Auxiliary Feedback ports when set up to run as a single-ended pulse-and-direction input:

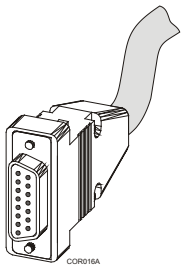
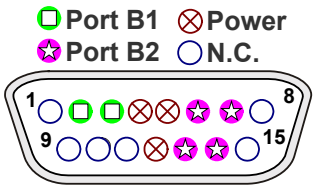
Port	Pin	Signal	Function	Pin Positions
-	1	N.C.	Do not connect this pin.	 15-Pin D-Sub Socket
B1	2	DIR/CHB	Direction/Auxiliary Channel B high *input*	
B1	3	PULS/CHA	Pulse/Auxiliary Channel A high *input*	
PWR	4	+5V	Encoder supply voltage	
PWR	5	SUPRET	Encoder supply return	
B2	6	CHAO	Buffered Channel A output	
B2	7	CHBO	Buffered Channel B output	
-	8	N.C.	Do not connect this pin.	
-	9	N.C.	Do not connect this pin.	 15-Pin D-Sub Plug
-	10	N.C.	Do not connect this pin.	
-	11	N.C.	Do not connect this pin.	
PWR	12	SUPRET	Supply Return	
B2	13	CHAO-	Buffered Channel A complement output	
B2	14	CHBO-	Buffered Channel B complement output	
-	15	N.C.	Do not connect this pin.	

Table 9: Single-Ended Pulse-and-Direction Auxiliary Encoder Pin Assignment on FEEDBACK B

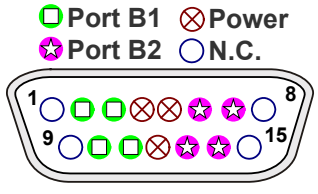
Port	Pin	Signal	Function	Pin Position
	1 to 9		Same as table above	 15-Pin D-Sub Plug
B1	10	DIR-/CHB-	Direction/Auxiliary Channel B low *input*	
B1	11	PULS-/CHA-	Pulse/Auxiliary Channel A low *input*	
	12 to 15		Same as table above	

Table 10: Differential Pulse-and-Direction Auxiliary Encoder Pin Assignment on FEEDBACK B

FEEDBACK B on the front of the Tuba has a 15-pin D-Sub plug. Connect the Auxiliary Feedback cable from the Pulse and Direction Controller to FEEDBACK B using a 15-pin D-Sub socket with a metal housing. When assembling the Auxiliary Feedback cable, follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies).

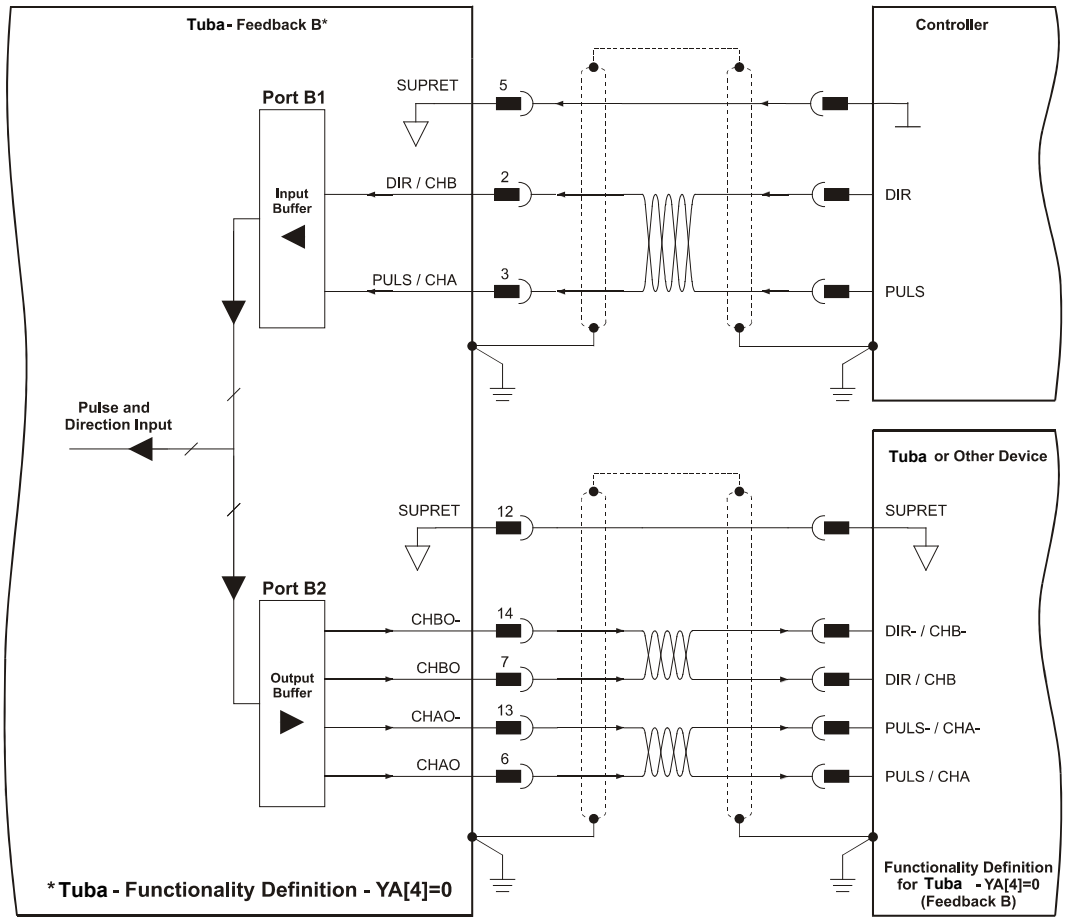


Figure 27: Single-Ended Pulse-and-Direction Input Option on FEEDBACK B - Connection Diagram

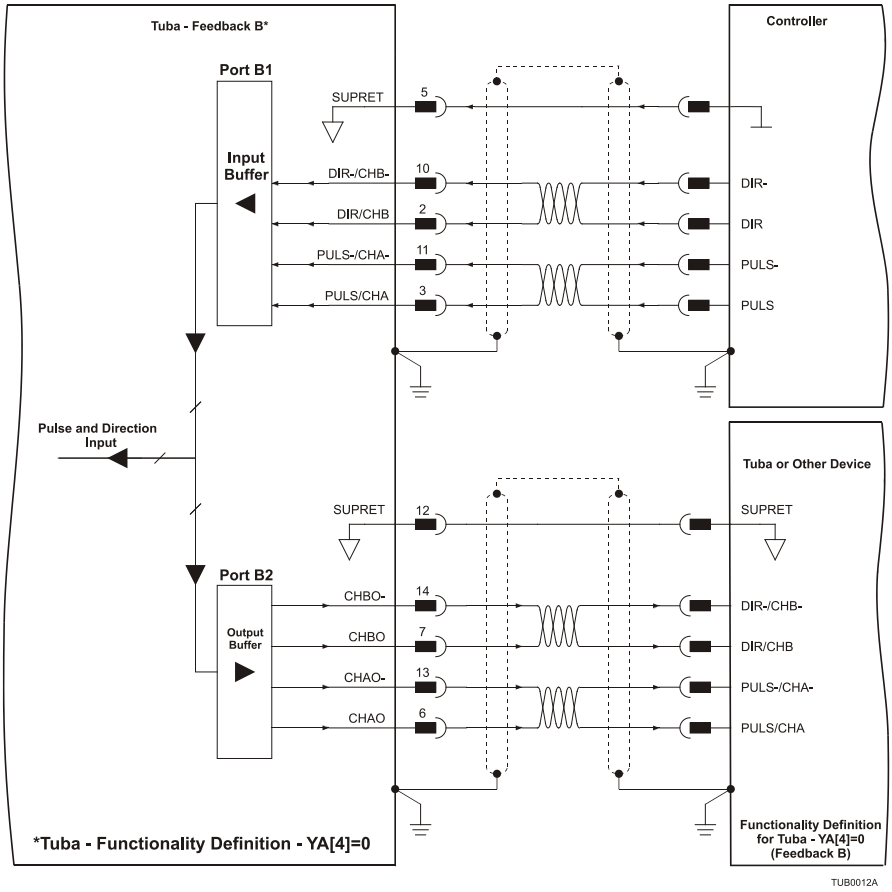


Figure 28: Differential Pulse-and-Direction Input Option on FEEDBACK B - Connection Diagram

3.4.8. I/O Cables

The Tuba has three I/O ports (*ANALOG INPUTS, DIGITAL INPUTS and DIGITAL OUTPUTS*) which can be used to connect 2 analog inputs, 10 separate digital inputs and 6 separate digital outputs:

LABEL / I/O	ANALOG INPUTS	GENERAL I/O	COMMITTED I/O	Total
Analog Input	2	-	-	2
Digital Input	-	10	-	10
Digital Output	-	-	6	6

3.4.8.1. Analog Inputs

The Tuba servo drive is equipped with two differential, freely-programmable analog inputs. The ANALOG INPUTS port has a 9-pin D-Sub socket. When assembling an I/O cable for analog input follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies) using a 9-pin D-Sub plug with a metal case.

Note: Analog Inputs 1 and 2 are functionally identical. However, note that the velocity and current commands can only be given on Analog Input 1.

The pins are described below.

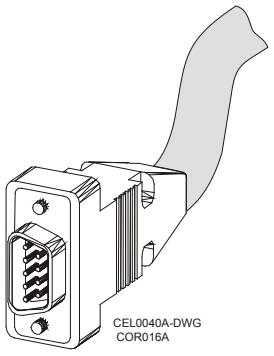
Pin #	Signal	Function	Pin Positions
1	ANLIN1+	Analog input 1 - positive	
2	ANLIN1-	Analog input 1 - negative	
3	SUPRET	Supply return	
4	ANLIN2+	Analog input 2 - positive	
5	ANLIN2-	Analog input 2 - negative	
6	ANLRET	Analog return	
7, 8	N/A	—	
9	ANLRET	Analog return	

Table 11: Analog Input Pin Assignments

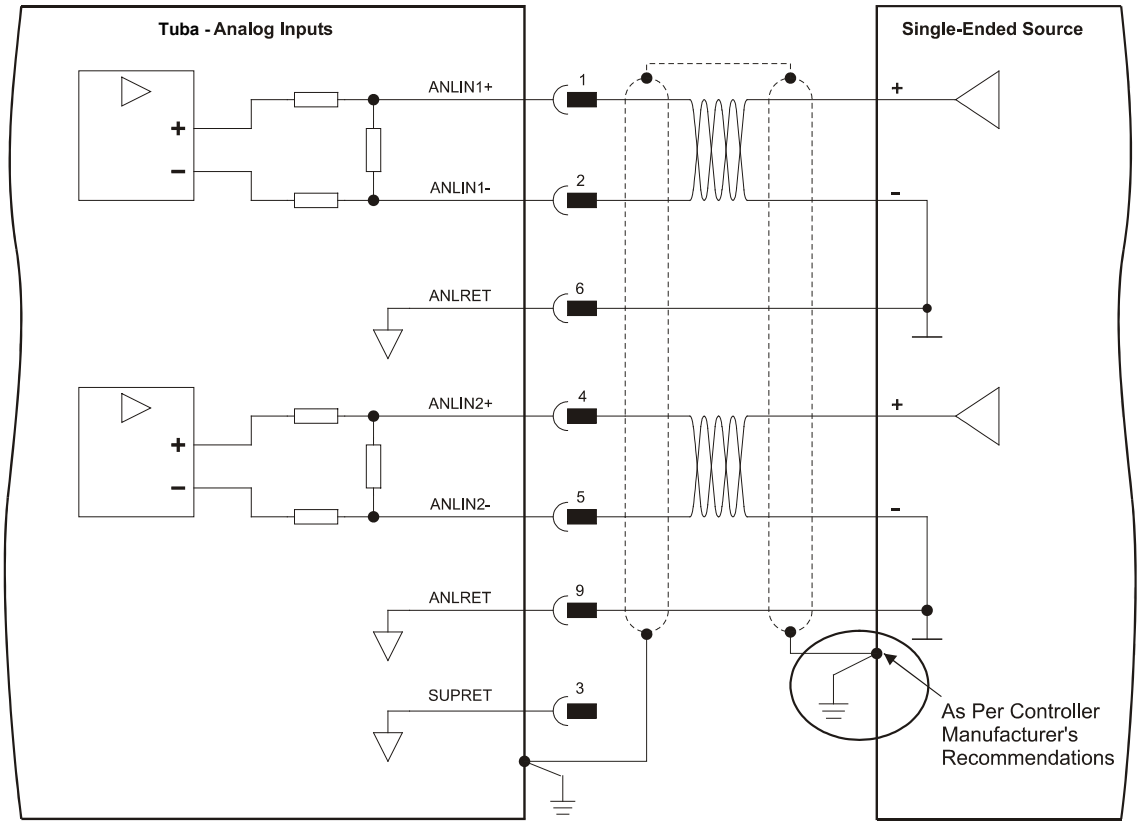
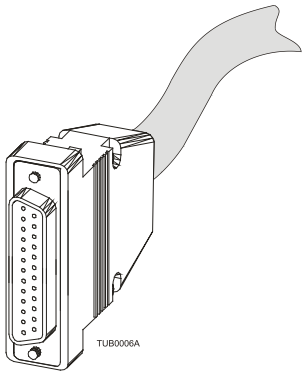


Figure 29: Analog Inputs Connection Diagram

3.4.8.2. Digital Inputs (on the GENERAL I/O Port)

The Tuba servo drive is equipped with a 25-pin D-Sub plug for digital inputs. When assembling an I/O cable for digital input follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies) using a 25-pin D-Sub socket with a metal case. The pins are described below.

Pin	Signal	Function	Pin Positions
1	N.C.	Not Connected	
2	IN10	Programmable input 10	
3	IN9	Programmable input 9	
4	IN8	Programmable input 8	
5	IN7	Programmable input 7	
6	N.C.	Not Connected	
7	IN6	Programmable input 6	
8	N.C.	Not Connected	
9	IN5	Programmable input 5	
10	IN4	Programmable input 4	

Pin	Signal	Function	Pin Positions
11	IN3	Programmable input 3	
12	IN2	Programmable input 2	
13	IN1	Programmable input 1	
14	INRET10	Programmable inputs return 10	
15	INRET9	Programmable inputs return 9	
16	INRET8	Programmable inputs return 8	
17	INRET7	Programmable inputs return 7	
18	N.C.	Not Connected	
19	INRET6	Programmable inputs return 6	
20	N.C.	Not Connected	
21	INRET5	Programmable inputs return 5	
22	INRET4	Programmable inputs return 4	
23	INRET3	Programmable inputs return 3	
24	INRET2	Programmable inputs return2	
25	INRET1	Programmable inputs return 1	

Table 12: Digital Inputs (on the Committed I/O port) Pin Assignments

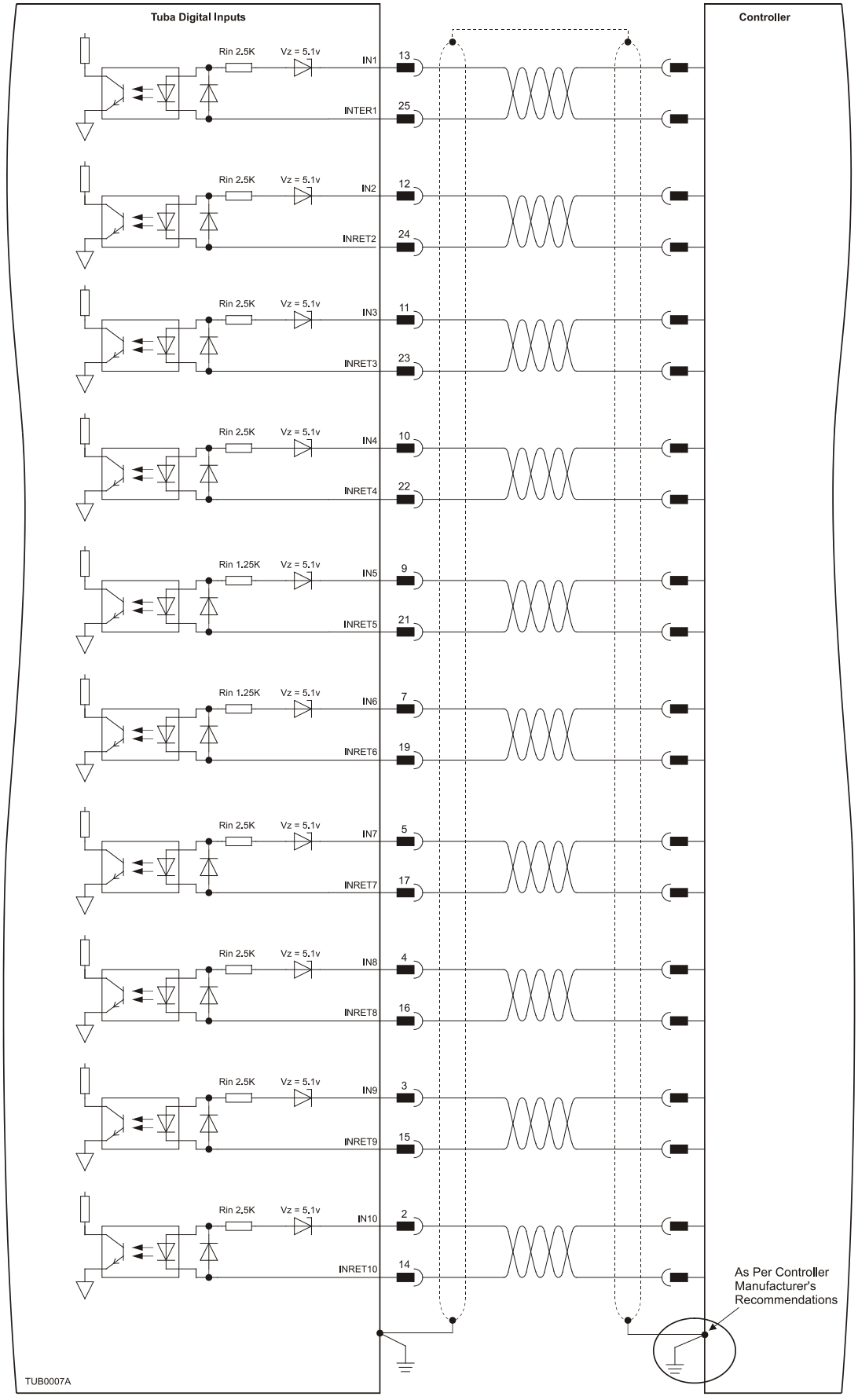


Figure 30: Digital Inputs (on the General I/O port) Connection Diagram

3.4.8.3. Digital Outputs (on the COMMITTED I/O Port)

The Tuba servo drive is equipped with a 15-pin, high-density, D-Sub socket for digital outputs. When assembling an I/O cable for digital outputs follow the instructions in Section 3.4.4 (Feedback and Control Cable Assemblies) using a 15-pin high density D-Sub plug with a metal case. The pins are described below.

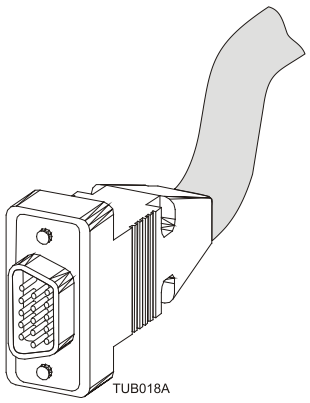
Pin	Signal	Function	Pin Positions
1	OUT1	Programmable output 1	
2	OUT2	Programmable output 2	
3	OUT3	Programmable output 3	
4	OUT4	Programmable output 4	
5	OUT5	Programmable output 5	
6	OUTRET1	Programmable output return 1	
7	OUTRET2	Programmable output return 2	
8	OUTRET3	Programmable output return 3	
9	OUTRET4	Programmable output return 4	
10	OUTRET5	Programmable output return 5	
11	OUT6	Programmable output 6	
12	OUTRET6	Programmable output return 6	
13, 14, 15	N/A	-	

Table 13: Digital Outputs (on the Committed I/O port) Cable - Pin Assignments

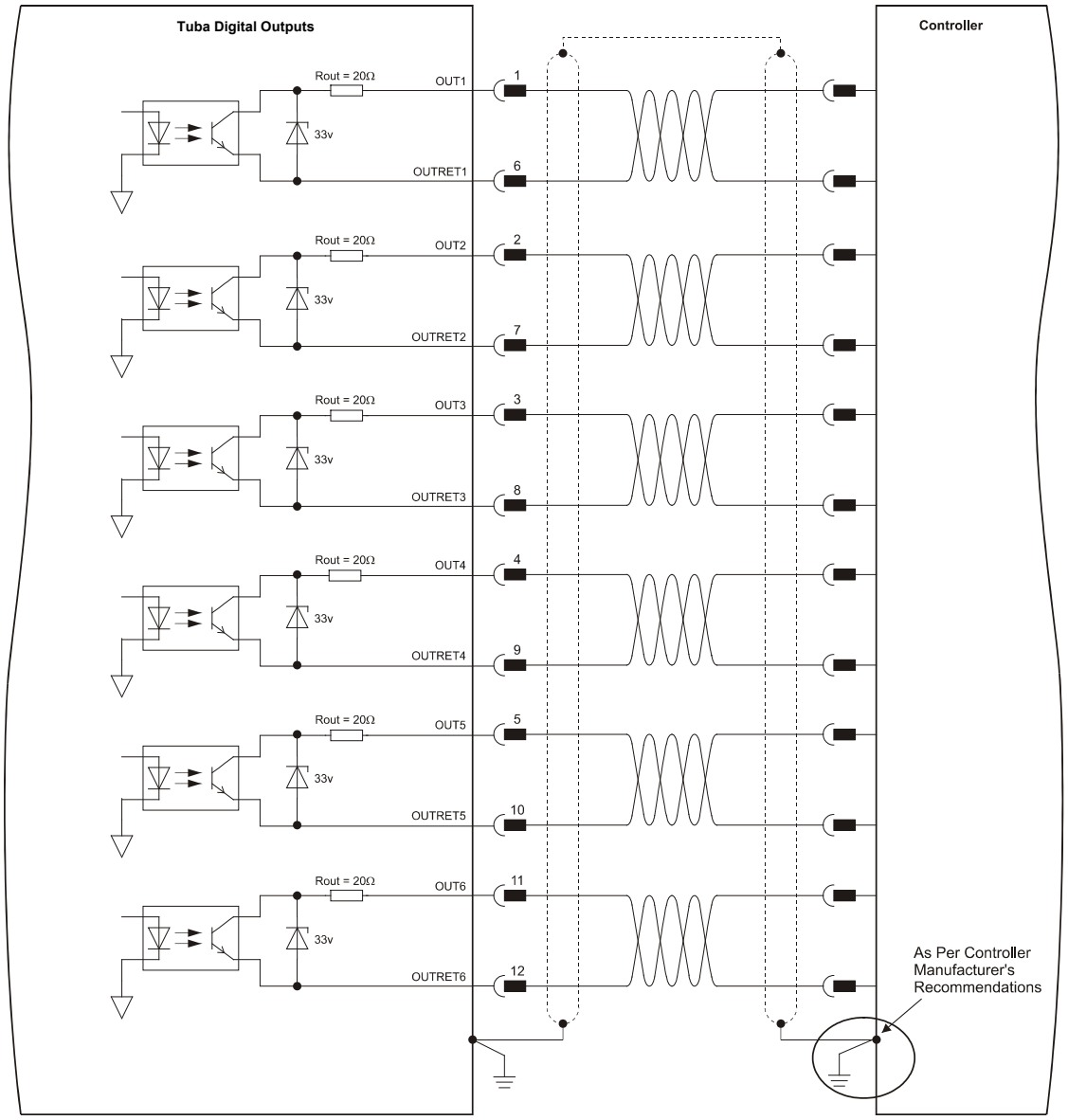


Figure 31: Digital Outputs (on the COMMITTED I/O port) Connection Diagram

3.4.9. Communication Cables

The communication cables use an 8-pin RJ-45 plug that connect to the RS-232 and CAN ports on the front of the Tuba.

The communication interface may differ according to the user's hardware. The Tuba 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 Tuba 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. The interface is electrically isolated by optocouplers.

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

3.4.9.1. RS-232 Communication (on the COMM.1 Port)

Notes for connecting the RS-232 communication cable:

- Use a 26 or 28 AWG twisted pair shielded cable. The shield should have aluminum foil covered by copper braid with a drain wire.
- 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 male RJ plug must have a shield cover.
- Ensure that the shield of the cable is connected to the shield of the RJ plug. The drain wire can be used to facilitate the connection.

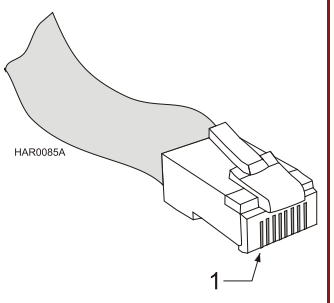
RS-232 (L) Pin	RS-232 (R) Pin	Signal	Function	Pin Locations
1, 2	1, 2	N/A	—	
3 ———	——— 3	Tx	RS-232 transmit	
4	4	N/A	—	
5 ———	——— 5	COMRET	Communication return	
6 ———	——— 6	Rx	RS-232 receive	
7, 8	7,8	N/A	—	

Table 14: RS-232 Cable - Pin Assignments

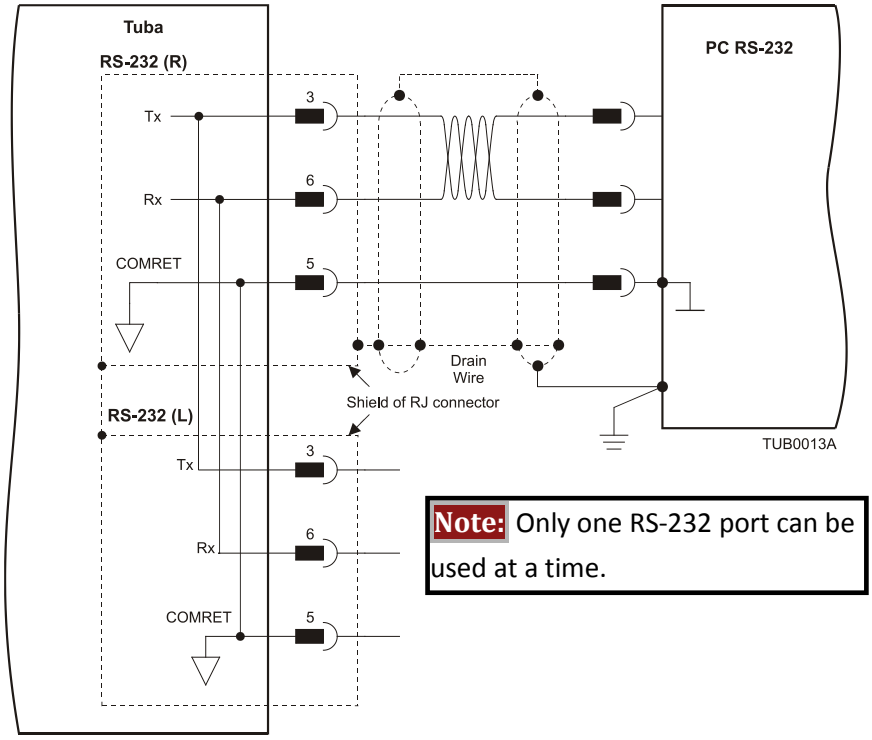


Figure 32: RS-232 Connection Diagram

3.4.9.2. CAN Communication (on the COMM.2 Ports)

Notes for connecting the CAN communication cable:

- Use 26 or 28 AWG twisted pair shielded cables. For best results, the shield should have aluminum foil and covered by copper braid with a drain wire.
- 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 male RJ plug must have a shield cover.
- Ensure that the shield of the cable is connected to the shield of the RJ plug. The drain wire can be used to facilitate the connection.
- Connect a termination 120-Ω resistor at each of the two ends of the network cable.

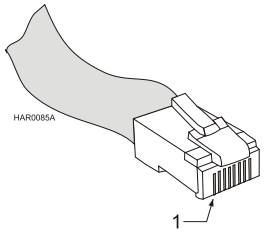
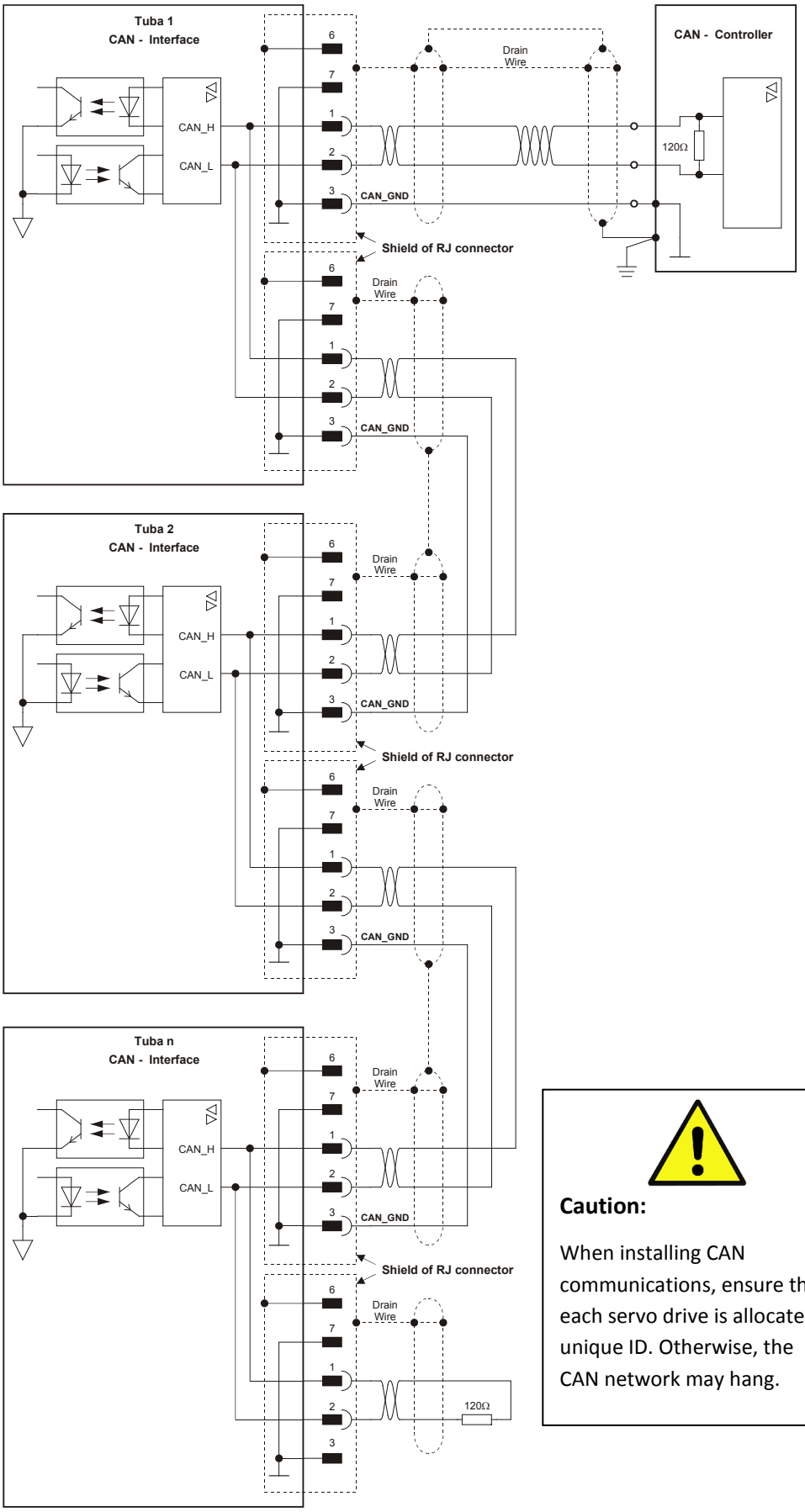
Pin	Signal	Function	Pin Positions
1	CAN_H	CAN_H busline (dominant high)	
2	CAN_L	CAN_L busline (dominant low)	
3	CAN_GND	CAN ground	
4, 5, 8	N/A	—	
6	CAN_SHLD	Shield, connected to the RJ plug cover	
7	CAN_GND	CAN Ground	

Table 15: CAN Cable - Pin Assignments



Caution:

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

Figure 33: CAN Connection Diagram

3.5. Powering Up

After the Tuba has been mounted, check that the cables are intact. The Tuba servo drive is then ready to be powered up.



Caution:
Before applying power, ensure that the AC supply is within the range specified for your specific type of Tuba.

3.6. Initializing the System

After the Tuba 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*.

Chapter 4: Technical Specifications

This chapter provides detailed technical information regarding the Tuba. 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 Tuba'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 Motion Control Modes

- PTP, PT, PVT, ECAM, Follower, Pulse and Direction, Dual Loop
- Fast event capturing inputs
- Fast output compare (OC)

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
- 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
- Absolute 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
  - Encoder outputs, buffered, differential.
- Resolver
  - Programmable 10 to 15 bit resolution
  - Up to 512 revolutions per second (RPS)
  - Encoder outputs, buffered, differential
- Tachometer (inputs for ±20 V max. voltage and for ±20 V max. voltage)
- Potentiometer (0 to 5 V input voltage provided by the Tuba)
- Elmo drives provide supply voltage for all the feedback options

4.1.6. Input/Output

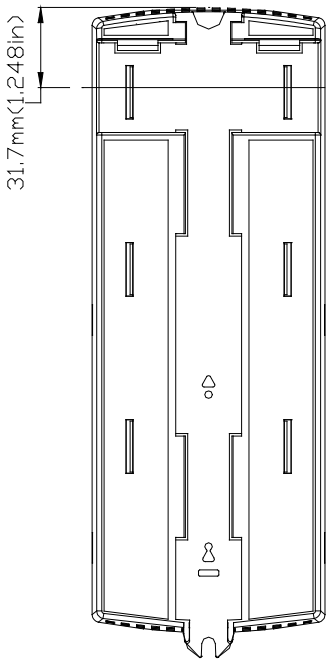
- Analog Inputs – up to 14-bit resolution
- Programmable digital inputs, optically isolated
  - Inhibit / Enable motion
  - Software and analog reference stop
  - Motion limit switches
  - Begin on input
  - Abort motion
  - General-purpose
  - Homing
- Fast event capture inputs, optically isolated
- Programmable digital outputs
  - Brake Control
  - Amplifier fault indication
  - General-purpose
  - Servo enable indication
- Buffered and differential outputs of the main encoder with up to 5 MHz pulses
- Buffered and differential outputs of the auxiliary encoder

- Emulated output of the resolver, interpolated analog encoder, Tachometer or Potentiometer
- Fast output compare (OC), optically isolated

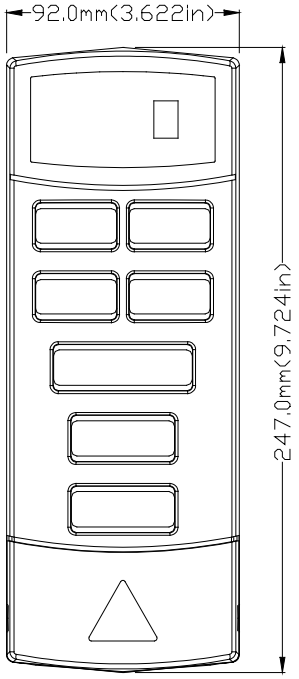
4.1.7. Built-In Protection

- Software error handling
- Abort (hard stops and soft stops)
- Status reporting
- Protection against
  - Shorts between motor power outputs
  - Shorts between motor power output and power input/return
  - Failure of internal power supplies
  - Overheating
  - Over/Under voltage
  - Loss of feedback
  - Following error
  - Current limits
- Protection against regenerated over-voltage (when using external DC Link)
- DC-Linkage extends the limits of the built-in shunt and provides over voltage protection.

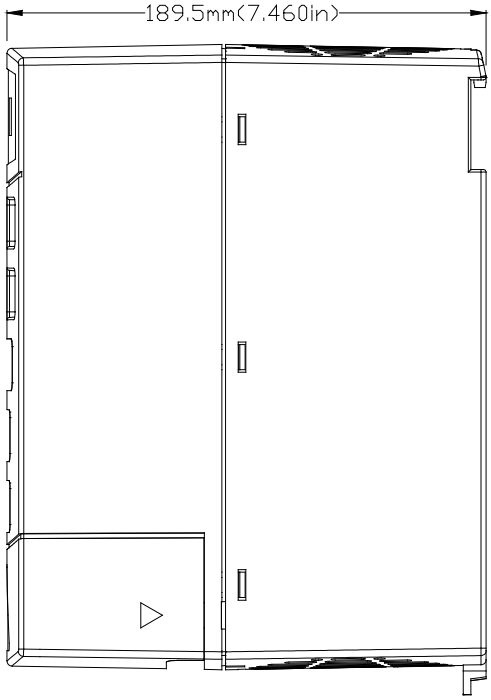
4.2. Tuba Dimensions



Rear View

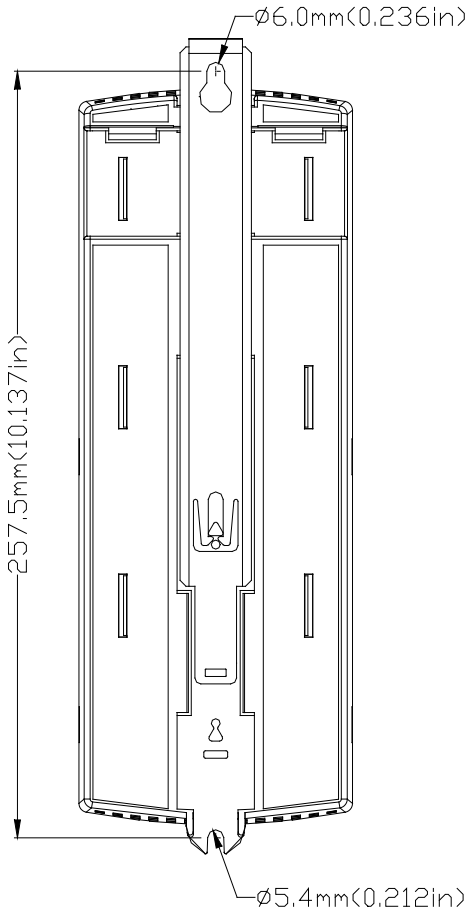


Front View



Side View

4.3. Mounting Dimensions



Rear View

4.4. Mechanical Specifications

Feature	Details
Mounting Method	• Wall Mount (Bookshelf) • DIN Rail
Overall Dimensions	247 x 190 x 92 mm (9.7" x 7.5" x 3.6")
Weight	2.7 kg (5.9 lbs)

4.5. Power Ratings

Feature	Units	12/230	15/230	20/230	12/460	15/460	20/460
Minimum supply voltage	VAC	60			140		
Nominal supply voltage	VAC	1 x 115, 1 x 230, 3 x 230			3 x 400, 3 x 460		
Maximum supply voltage	VAC	1 x 270 or 3 x 270			3 x 505		
Maximum continuous power output	W	3600	4500	6000	6800	8500	11300
Efficiency at rated power (at nominal conditions)	%	> 93					
Auxiliary supply voltage `	VDC	24 ± 15%					
Auxiliary power supply	VA	20					
Amplitude sinusoidal/DC continuous current	A	12	15	20	12	15	20
Sinusoidal continuous RMS current limit (Ic)	A	8.5	10.6	14.1	8.5	10.6	14.1
Peak current limit	A	2 x Ic					
Built-in shunt (peak power)	kW	6			11		
Weight	kg (lbs)	2.7 kg (5.9 lbs)					
Dimensions	mm (in)	247 x 190 x 92 (9.7" x 7.5" x 3.6")					
Digital in/Digital out/Analog in		10/6/2					
Mounting method		Wall mount (“Bookshelf”) or DIN rail					

4.6. Environmental Conditions

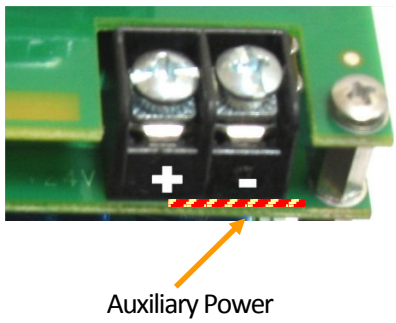
Feature	Details
Operating ambient temperature according to IEC60068-2-2	0 °C to 40 °C (32 °F to 104 °F)
Storage temperature	-20 °C to +85 °C (-4 °F to +185 °F)
Maximum non-condensing humidity according to IEC60068-2-78	95%
Maximum Operating Altitude	2,000 m (6562 feet)
Mechanical Shock according to IEC60068-2-27	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

4.7. Tuba Connections

The following connectors are used for wiring the Tuba.

Pins	Type	Maker & Part No.	Port
5	Motor	10 pole 8 mm pitch Molex terminal block	M1, M2, M3
2	Ground		PE, PE
3	Power		AC1, AC2, AC3
2	DC Link		B1, B2
2	Auxiliary Power	2 pole 0.325" (8 mm) pitch Molex terminal strip	+, - (24v)

Connector Location



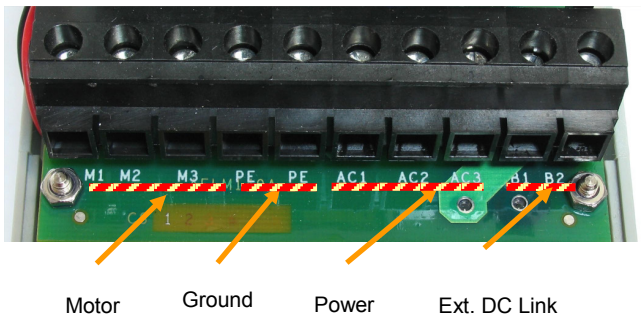


Table 16: Connectors on the Bottom of the Tuba

Pins	Type	Port	Connector Location
8	RJ-45 x 2	COMM. 1	
9	D-Sub Socket	ANALOG INPUTS	
8	RJ-45 x 2	COMM. 2	
15	D-Sub Socket High Density	COMMITTED I/O	
25	D-Sub Plug	GENERAL I/O	
15	D-Sub Socket	FEEDBACK A	
15	D-Sub Plug	FEEDBACK B	

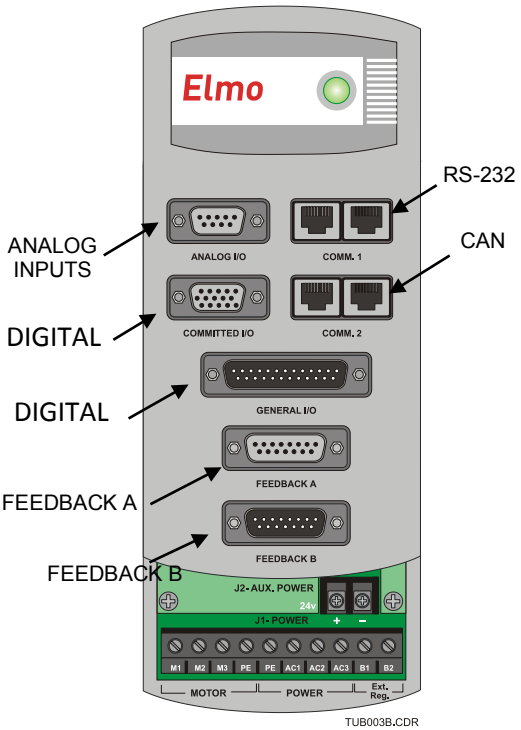


Table 17: Connectors on the Tuba

4.7.1. Auxiliary Supply

Feature	Details
Auxiliary power supply	*DC source only*
Auxiliary supply input voltage	24 V ±15%
Auxiliary supply input power	20 W

Notes:

- The Tuba CANNOT operate without a 24 Volt Auxiliary Power Supply
- Be sure to maintain power within the 24 V ±15% range as higher voltages will damage the fan.

4.8. Control Specifications

4.8.1. Current Loop

Feature	Details
Controller type	Vector, digital
Compensation for bus voltage variations	"On-the-fly" gain scheduling
Motor types	• AC brushless (sinusoidal) • DC brushless (trapezoidal) • DC brush • Linear motors • Moving 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

4.8.2. 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 - 200 µsec (x2 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.

4.8.3. Position Loop

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

4.9. Feedbacks

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

4.9.1. Feedback Supply Voltage

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

4.9.2. 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: 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

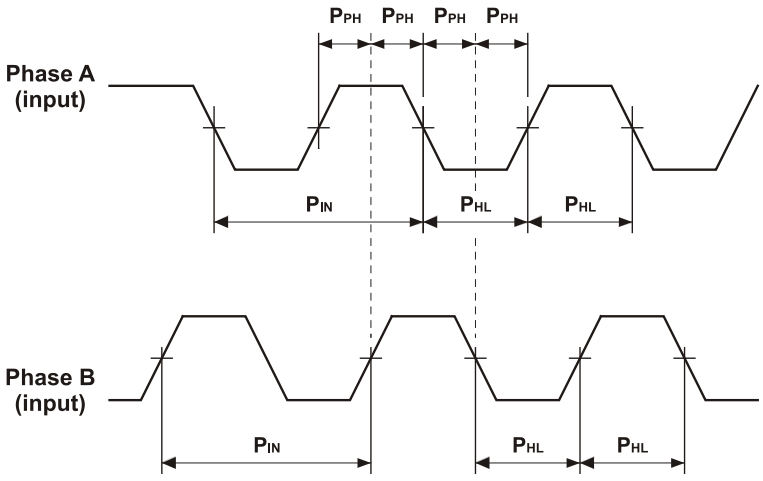


Figure 34: Encoder Phase Diagram

4.9.3. Digital Halls

Feature	Details
Halls inputs	• H_A, H_B, H_C • Single ended inputs • Built in hysteresis 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): 3 mA Source current: 1.5 mA (designed to also support open collector Halls)
Maximum frequency	f_{MAX} : 2 kHz

4.9.4. 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

4.9.5. 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 Tuba
Reference current	Up to ±50 mA

4.9.6. 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 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.

4.9.7. Potentiometer

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

4.9.8. Encoder Outputs

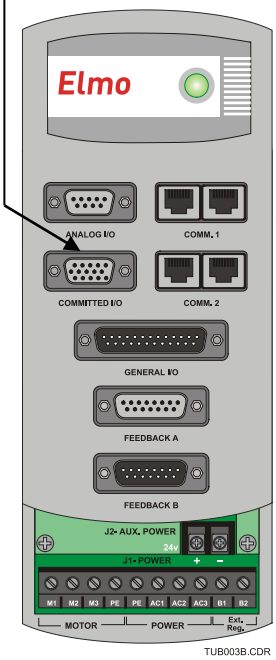
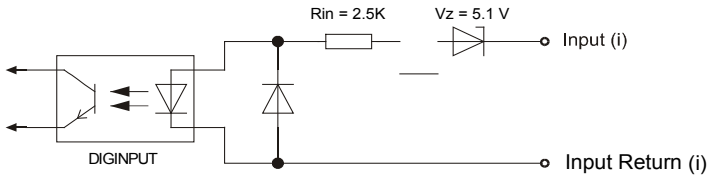
Feature	Details
Encoder output format	• A, B, Index • Differential outputs • Quadrature
Interface	RS-422
Port B1 output current capability	• Driving differential loads of 200 Ω on INDEX/INDEX-, CHB/CHB- and CHA/CHA- pairs
Port B2 output current capability	• INDEXO/INDEXO-, CHBO/CHBO- and CHAO/CHAO- pairs are not loaded
Available as options	• Two simultaneous buffered outputs of main- incremental encoder input • Two simultaneous emulated encoder outputs of the analog encoder input • Two simultaneous emulated encoder outputs of the resolver input • Two simultaneous emulated encoder outputs of the Tachometer Input • Two simultaneous emulated encoder outputs of the Potentiometer Input • Buffered output of auxiliary input
Maximum frequency	f_{MAX} : 5 MHz pulses/output
Index (marker)	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

4.10. I/Os

The Tuba has:

- 10 Digital Inputs
- 6 Digital Outputs
- 2 Analog Inputs

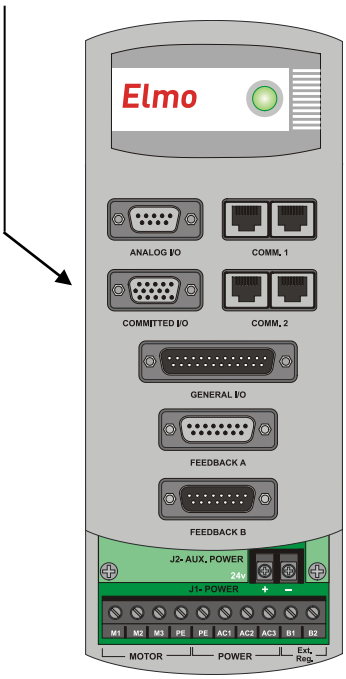
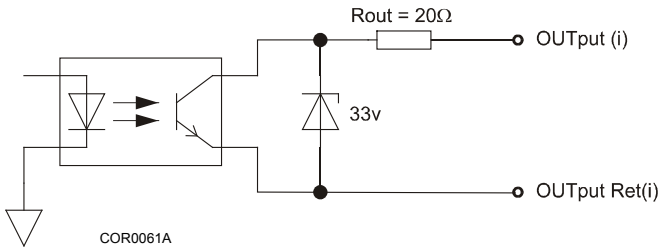
4.10.1. Digital Input Interfaces (on the GENERAL I/O port)

<table>
<tr><th>Feature</th><th>Details</th><th>Connector Location</th></tr>
<tr><td>Type of input</td><td>• Optically isolated
• Single ended
• PLC level</td><td rowspan="6">DIGITAL INPUTS

</td></tr>
<tr><td>Input current</td><td>$Iin = \frac{Vin - 6.5V}{2500\Omega}$
* Iin = 2.2 mA @ Vin = 12 V</td></tr>
<tr><td>Input current for high speed inputs 5 & 6</td><td>$Iin = \frac{Vin - 6.5V}{1250\Omega}$
* Iin = 4.4 mA @ Vin = 12 V</td></tr>
<tr><td>High-level input voltage</td><td>12 V < Vin < 30 V, 24 V typical</td></tr>
<tr><td>Low-level input voltage</td><td>0 V < Vin < 6.5 V</td></tr>
<tr><td>Minimum pulse width</td><td>> 4 x TS, where TS is sampling time</td></tr>
<tr><td rowspan="2">Execution time (all inputs): the time from application of voltage on input until execution is complete</td><td colspan="2">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.</td></tr>
<tr><td colspan="2">

Digital Input Schematic</td></tr>
</table>

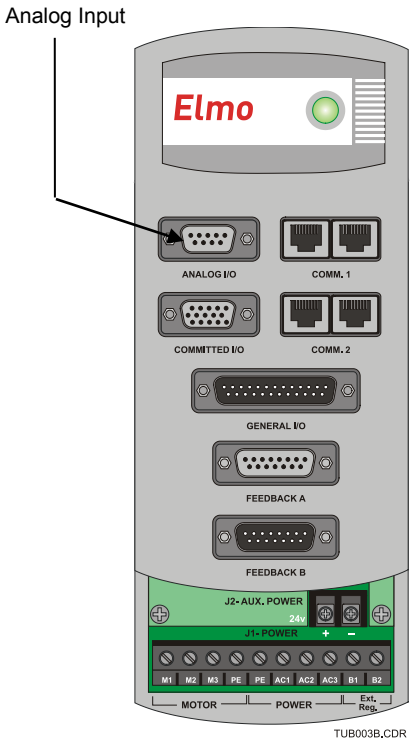
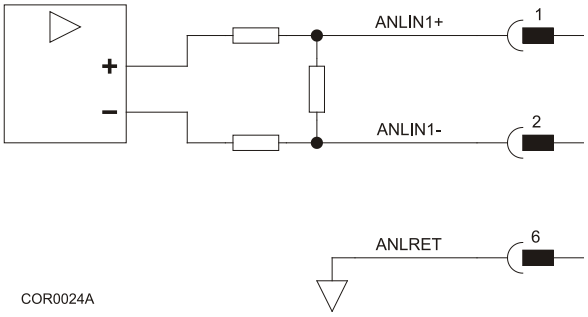
Feature	Details	Connector Location
High-speed inputs 5 & 6 - minimum pulse width, in high-speed mode	T < 5 µsec **Notes:** • Home mode is high-speed mode and can be used for fast capture and precise homing. • High speed input has a digital filter set to same value as digital filter (EF) of main encoder. • Highest speed is achieved when turning on optocouplers.	

4.10.2. Digital Output Interface (on the COMMITTED I/O port)

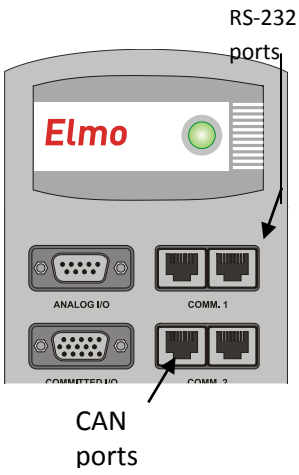
<table>
<tr><th>Feature</th><th>Details</th><th>Connector Location</th></tr>
<tr><td>Type of output</td><td>• Optically isolated
• Open collector and open emitter</td><td rowspan="4">DIGITAL OUTPUTS

</td></tr>
<tr><td>Maximum supply output (Vcc)</td><td>30 V</td></tr>
<tr><td>Max. output current Iout (max) (Vout = Low)</td><td>Iout (max) ≤ 15 mA</td></tr>
<tr><td>VOL at maximum output voltage (low level)</td><td>Vout (on) ≤ 0.3 V + 0.02 * Iout (mA)</td></tr>
<tr><td>RL</td><td>External resistor RL must be selected to limit output current to no more than 15 mA.
$R_L = \frac{Vcc - VOL}{Io(\max)}$</td></tr>
<tr><td>Executable time</td><td colspan="2">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.</td></tr>
<tr><td></td><td colspan="2">

Digital Output Schematic</td></tr>
</table>

4.10.3. Analog Input

Feature	Details	
Maximum operating differential voltage	± 10 V	
Maximum absolute differential input voltage	± 16 V	
Differential input resistance	3 kΩ	
Analog input command resolution	14-bit	

4.11. Communications

Specification	Details	Connector Location
RS-232 (Only one RS-232 Port can be used at a time)	**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 **Device Profile** (drive and motion control)**:** • DS 402	

4.12. Pulse-Width Modulation (PWM)

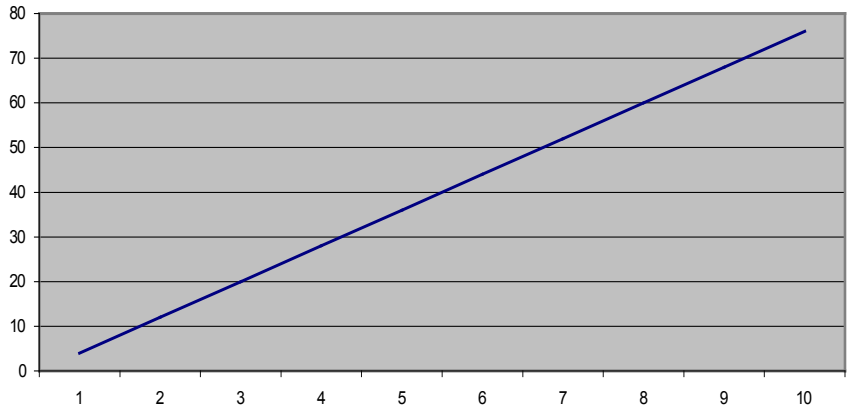
Feature	Details
PWM resolution	12-bit
PWM switching frequency on the load	2/Ts (factory default 22 kHz on the motor)

4.13. Single-Phase Operation

When operating with a single-phase supply (TUB-x/230 only), the voltage drop must be considered. Voltage drop can be calculated using the following equation:

Vout (Max Phase to phase) = 0.85*[Vsupply (AC) - Vdrop]

Vdrop AC RMS



4.14. 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)

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP