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Gold Board Level Module Hardware Manual

June 2016 (Ver. 1.009)

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Chapter 1: Introduction

The Gold Board Level Modules Servo Drive is an advanced high power density servo drive. It provides top servo performance, utmost efficiency, advanced networking and built-in safety, all in super compact packages. The Gold line has a fully featured motion controller and local intelligence.

It can operate as a stand-alone device or as part of a multi-axis system in a distributed configuration on a real-time network, and is easily set up and tuned using the Elmo Application Studio (EASII) software tools.

As part of the Gold product line, it is fully programmable with the Elmo motion control language. For more about software tools, refer to the Elmo Application Studio (EASII) User Guide.

The Gold Board Level Modules Servo Drive is available in a variety of options. There are multiple power rating options, different communications options, a variety of feedback selections and I/O configuration possibilities. The configuration of the drive is determined by the Catalog Number.

This hardware guide describes the hardware features and description of the STO, feedback, IO, communication signals in the Gold Board Level Modules Servo Drive and the steps for its PCB layout, installation and power-up. Following these guidelines ensures optimal performance of the drive and the system to which it is connected.

For the **main and auxiliary power signal** details, refer to the specific Gold Board Level Modules Servo Drive Installation Guide for a detailed description.

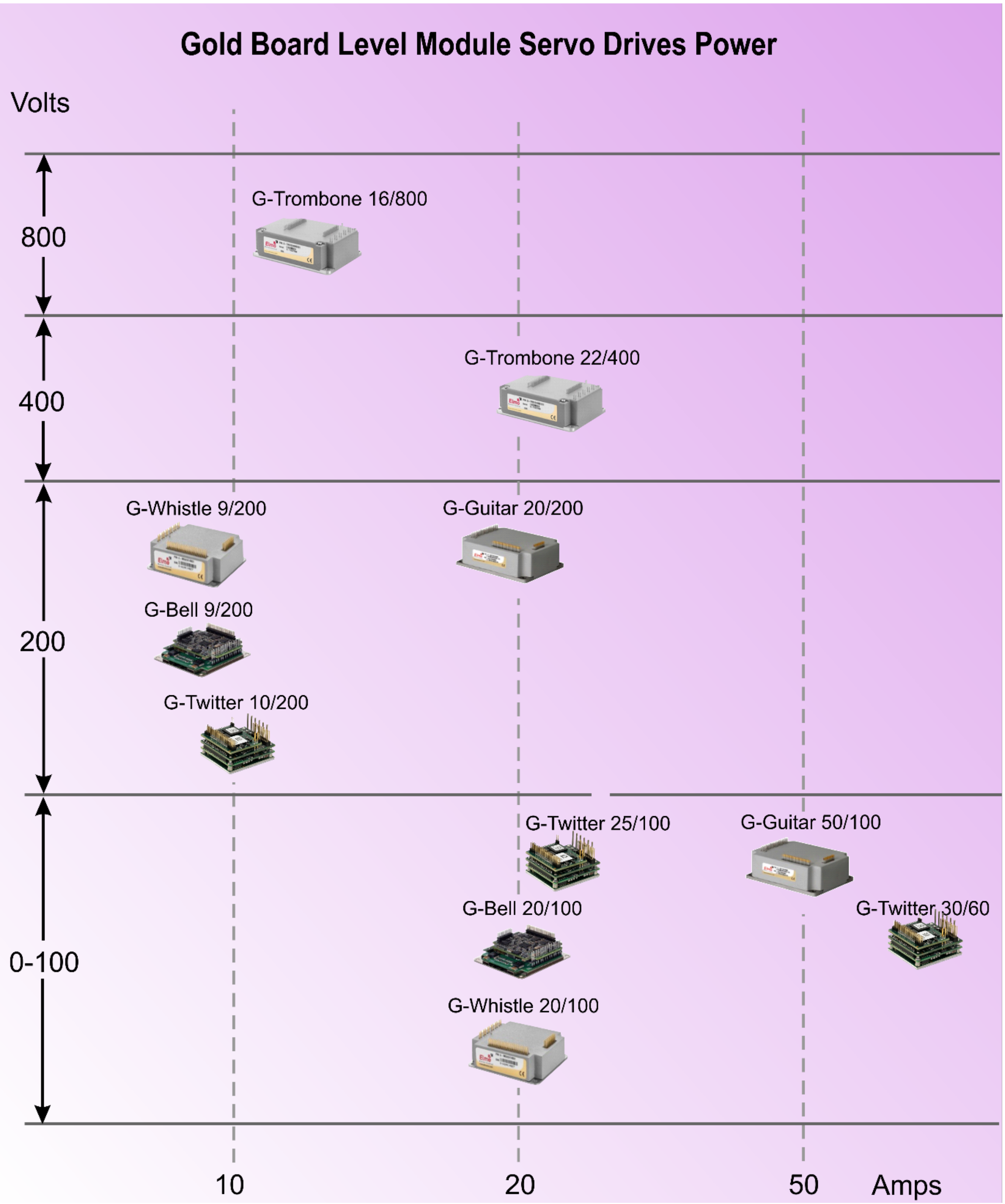
1.1. Other Drive Hardware Manual Available

- **MAN-G- Panel Mounted Drives Hardware Manual**. This manual describes the Gold series of panel mounted hardware drives.

1.2. Gold Board Level Module (BLM) Servo Drives Power

1.2.1. Gold Products

The following describes the range of Gold Board Level Module servo drives which subscribe to the standard Environmental Conditions (refer to section 15.1).



Gold Whistle

Current/Voltage (Amps/VDC	1/100	2.5/100	5/100	10/100	15/100	20/100	3/200	6/200	9/200
Continuous Output Power(W)	**80**	**200**	**400**	**800**	**1200**	**1600**	**480**	**960**	**1450**

STO	TTL	**2**
Digital Input	TTL	**6**
Digital Output	Optical Isolated Open Collector-emitter	**2**
	TTL (Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	**√**
Communication Options	USB	**√**
	EtherCAT (option)	**√**
	CAN (option)	**√**
	RS232 TTL level	**√**

Gold Guitar

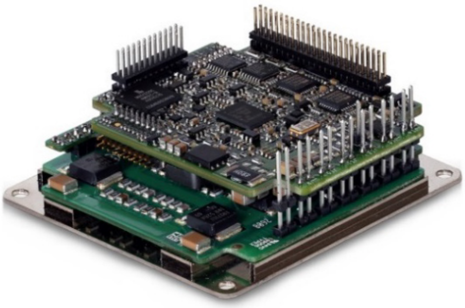
Current/Voltage (Amps/VDC	20/100	35/100	50/100	10/200	17/200	20/200
Continuous Output Power(W)	1600	2800	4000	1650	2800	3240

STO	TTL	**2**
Digital Input	TTL	**6**
Digital Output	Optical Isolated Open Collector-emitter	**2**
	TTL (Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	√
mmunication Options	USB	√
	EtherCAT (option)	√
	CAN (option)	√
	RS232 TTL level	√

Gold Bell

Current/Voltage (Amps/VDC	1/100	2.5/100	5/100	10/200	15/100	20/100	3/200	6/200	9/200
Continuous Output Power(W)	80	200	400	800	1200	1600	480	960	1450

STO	TTL	**2**
Digital Input	TTL	**6**
Digital Output	Optical Isolated Open Collector-emitter	**2**
	TTL (Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	**√**
Communication Options	USB	**√**
	EtherCAT (option)	**√**
	EtherCAT with Switches (option)	**-**
	CAN (option)	**√**
	RS232 TTL level	**√**

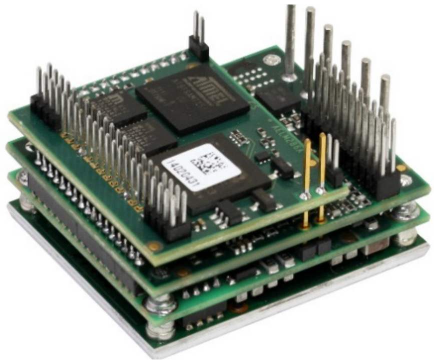


<table>
<tr><th colspan="9">Gold Trombone</th></tr>
<tr><td>Current/Voltage (Amps/VDC</td><td>12/400</td><td>16/400</td><td>R17/400</td><td>R22/400</td><td>8/800</td><td>12/800</td><td>R11/800</td><td>R16/800</td></tr>
<tr><td>Continuous Output Power(W)</td><td colspan="8">Up to 10000 W of continuous qualitative power</td></tr>
<tr><td rowspan="2">STO</td><td colspan="3">TTL, or</td><td>2</td><td colspan="4" rowspan="13">
</td></tr>
<tr><td colspan="3">PLC Source</td><td>2</td></tr>
<tr><td rowspan="2">Digital Input Options</td><td colspan="3">TTL, or</td><td>6</td></tr>
<tr><td colspan="3">PLC Source</td><td>6</td></tr>
<tr><td rowspan="2">Digital Output Options</td><td colspan="3">TTL, or</td><td>4</td></tr>
<tr><td colspan="3">PLC Source</td><td>4</td></tr>
<tr><td rowspan="2">Analog Input</td><td colspan="3">Differential ±10V</td><td>1</td></tr>
<tr><td colspan="3">Single Ended</td><td>1</td></tr>
<tr><td>Feedback</td><td colspan="3">Standard Port A, B, & C</td><td>√</td></tr>
<tr><td rowspan="4">Communication Options</td><td colspan="3">USB</td><td>√</td></tr>
<tr><td colspan="3">EtherCAT (option)</td><td>√</td></tr>
<tr><td colspan="3">CAN (option)</td><td>√</td></tr>
<tr><td colspan="3">RS232 TTL level</td><td>√</td></tr>
</table>

Gold Twitter

Current/Voltage (Amps/VDC	30/60	3/100	6/100	10/100	15/100	25/100	10/200	R50/60	R45/100	R15/200
Continuous Output Power(W)	**1300**	**300**	**1000**	**800**	**1200**	**2000**	**1600**	**2200**	**3600**	**2400**

STO	TTL	**√**
Digital Input	TTL	**6**
Digital Output	5V logic (Non Isolated)	**2**
	3.3V logic(Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	**√**
Communication Options	USB	**√**
	EtherCAT (option)	**√**
	CAN (option)	**√**
	RS232 TTL level	**√**
	Standard RS232	**√**

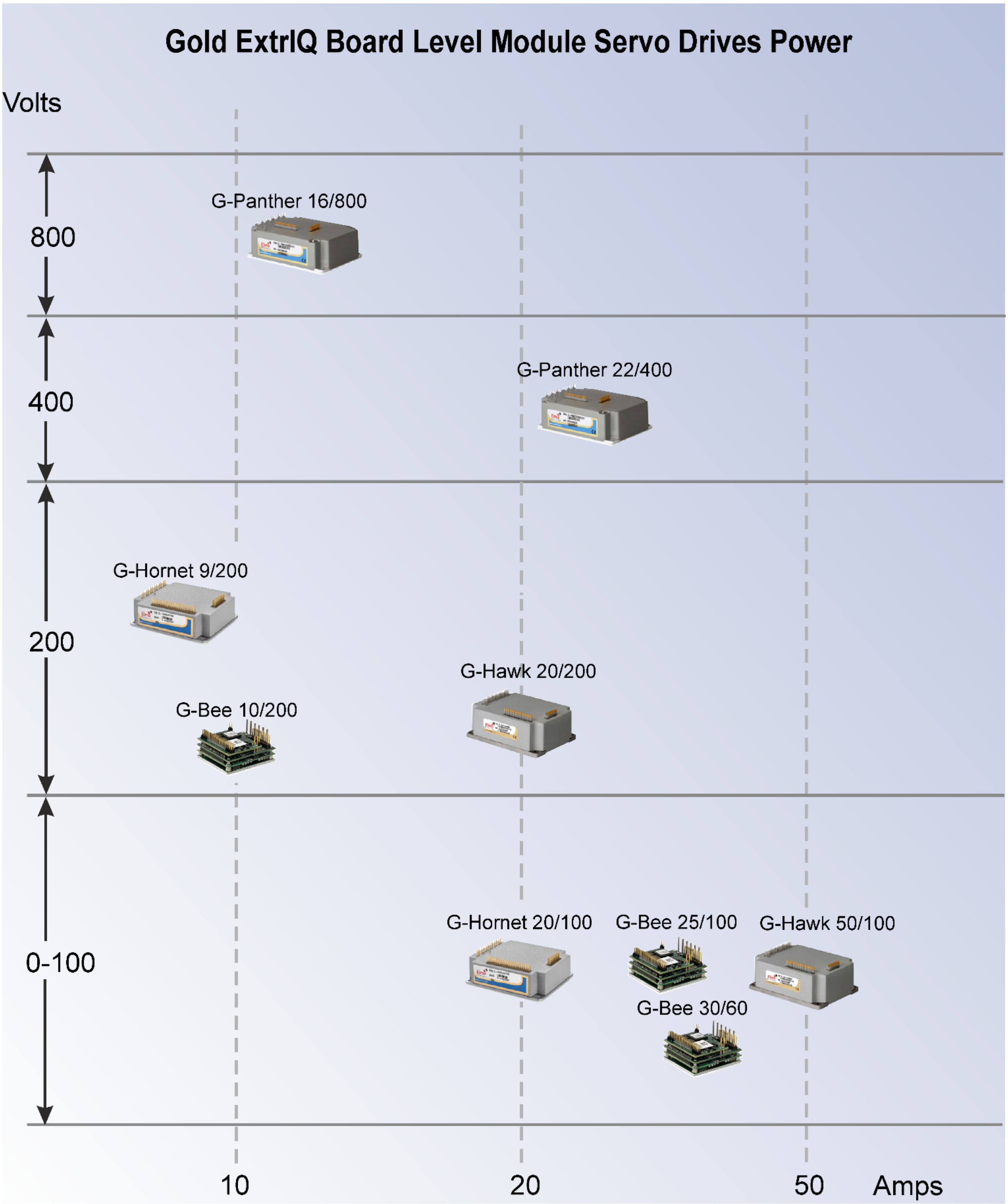


CAN Version

EtherCAT Version

1.2.2. Gold ExtrIQ Products

The following describes the range of Gold ExtrIQ Board Level Module servo drives which subscribe to the ExtrIQ Environmental Conditions (refer to section 15.1).



Gold Hornet

Current/Voltage (Amps/VDC	1/100	2.5/100	5/100	10/100	15/100	20/100	3/200	6/200	9/200
Continuous Output Power(W)	**80**	**200**	**400**	**800**	**1200**	**1600**	**480**	**960**	**1450**

STO	TTL	**2**
Digital Input	TTL	**6**
Digital Output	Optical Isolated Open Collector-emitter	**2**
	TTL (Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	**√**
Communication Options	USB	**√**
	EtherCAT (option)	**√**
	CAN (option)	**√**
	RS232 TTL level	**√**

Gold Hawk						
Current/Voltage (Amps/VDC	**20/100**	**35/100**	**50/100**	**10/200**	**17/200**	**20/200**
Continuous Output Power(W)	**1600**	**2800**	**4000**	**1650**	**2800**	**3240**

STO	TTL	**2**
Digital Input	TTL	**6**
Digital Output	Optical Isolated Open Collector-emitter	**2**
	TTL (Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	**√**
Communication Options	USB	**√**
	EtherCAT (option)	**√**
	CAN (option)	**√**
	RS232 TTL level	**√**

Gold Panther

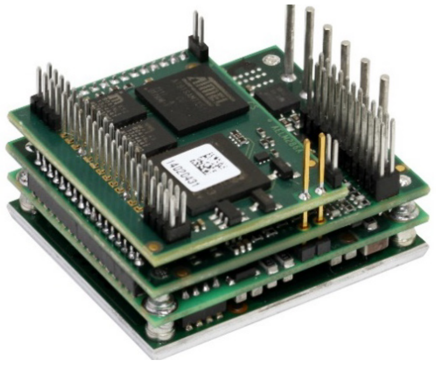
Current/Voltage (Amps/VDC	12/400	16/400	R17/400	R22/400	8/800	12/800	R11/800	R16/800
Continuous Output Power(W)	Up to 10000 W of continuous qualitative power							

STO	TTL	**2**
Digital Input	TTL	**6**
Digital Output	Optical Isolated Open Collector-emitter	**2**
	TTL (Non Isolation)	**2**
Analog Input	Differential ±10V	**1**
	Single Ended	**1**
Feedback	Standard Port A, B, & C	**√**
Communication Options	USB	**√**
	EtherCAT (option)	**√**
	CAN (option)	**√**
	RS232 TTL level	**√**

Gold Bee

Current/Voltage (Amps/VDC	30/60	3/100	6/100	10/100	15/100	25/100	10/200	R50/60	R45/100	R15/200
Continuous Output Power(W)	1300	300	1000	800	1200	2000	1600	2200	3600	2400

STO	TTL	√
Digital Input	TTL	6
Digital Output	5V logic (Non Isolated)	2
	3.3V logic(Non Isolation)	2
Analog Input	Differential ±10V	1
	Single Ended	1
Feedback	Standard Port A, B, & C	√
Communication Options	USB	√
	EtherCAT (option)	√
	CAN (option)	√
	RS232 TTL level	√
	Standard RS232	√



CAN Version

EtherCAT Version

1.3. Elmo Part Number Description

The Hardware configuration of the Drive is determined by the Elmo part/catalog number, consisting of a maximum of eighteen words/digits.

G-[AAANNN] R XXX/YYY E E H Z Z

Enclosure Type G- [AAANNN]RXXX/YYYEEHZZ	
AAA	Determines the type of the Package of the product in the family. None = Only one enclosure type in the family (such as DRUM, Cello, etc.) - No letters in P/N SOL = Integration of the Module and Interface board - three letters in the P/N) DC = Encased product - two letters in the P/N
NNN	Family Name (such as DRU, etc.)

Output Current Profile - G- AAANNN[R]XXX/YYYEEHZZ	
R	Determines the Current Profile: Blank = Standard current profile R = No peak current profile. The R type drive has no peak current capabilities, but only continuous current capabilities. These are higher than the "traditional" IC (by 1.5) and are only thermally limited.

Continuous Current (Amps) - G- AAANNNR[XXX]/YYYEEHZZ
The current may comprise of either one to three digit values. The current is given in amplitude. In all non "R" drives, the peak current is IP = 2xIC.

Maximum Operating Voltage (V) - G- AAANNNRXXX/[YYY]EEHZZ
The voltage may comprise of either two or three digit values.

Network Communications – G- AAANNNRXXX/YYY[E]EHZZ	
S	Standard, available for all Gold products: • CANopen • USB • RS232 (TTL)
E	EtherCAT, available for all Gold products: • EtherCAT or Ethernet. The default configuration of the drive is EtherCAT. However the drive can be configured to the Ethernet mode instead of EtherCAT. • USB • RS232 (TTL)

Feedback - G- AAANNNRXXX/YYYE[E]HZZ	
There are two feedback configurations. All Gold drives support in these configurations.	
E	Port A: Absolute Serial Encoder, Incremental Encoder, Digital Hall Port B: Incremental Encoder, Analog Encoder, Analog Hall
R	Port A: Absolute Serial Encoder, Incremental Encoder, Digital Hall Port B: Resolver

G-TRO: I/O and STO Type Table options - G- AAANNNRXXX/YYYEE[H]ZZ

	IO	**STO**
T	TTL	TTL
S	PLC Source	PLC Source

Chapter 2: Safety Information

In order to achieve the optimum, safe operation of the Gold Board Level Modules 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 Gold Board Level Modules Servo Drive 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 Gold Board Level Modules 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 and all Elmo Motion Control manuals:

Warning:
This information is needed to avoid a safety hazard, which might cause bodily injury or death as a result of incorrect operation.

Caution:
This information is necessary to prevent bodily injury, damage to the product or to other equipment.

Important:
Identifies information that is critical for successful application and understanding of the product.

2.1. Safety Referenced in this Document

The following table lists the references to specific sections on Functional Safety and the safety function STO:

Type	Reference
Safety function STO	Chapter 9: STO (Safe Torque Off)
Functional Safety Standards	17.1 Functional Safety

2.2. 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 Gold Board Level Modules Servo Drive from all voltage sources before servicing.
- The high voltage products within the Gold Line range contain 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.

2.3. Cautions

- The maximum DC power supply connected to the instrument must comply with the parameters outlined in this guide.
- When connecting the Gold Board Level Modules Servo Drive to an approved isolated 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 Gold Board Level Modules Servo Drive, verify that all safety precautions have been observed and that the installation procedures in this manual have been followed.
- Make sure that the Safe Torque Off is operational

2.4. CE Marking Conformance

The Gold Board Level Modules 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 2006/42/EC as amended, and with those of the most recent versions of standards EN 60204-1 and EN ISO 12100 at the least, and in accordance with 2006/95/EC.

Concerning electrical equipment designed for use within certain voltage limits, the Gold Board Level Modules Servo Drive meets the provisions outlined in 2006/95/EC. The party responsible for ensuring that the equipment meets the limits required by EMC regulations is the manufacturer of the end product.

2.5. 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 time of installation, or 18 months from time of shipment, whichever comes first. No other warranties, expressed or implied — and including a warranty of merchantability and fitness for a particular purpose — extend beyond this warranty.

Chapter 3: Product Features

3.1. System Architecture

The GOLD line supports a variety of voltage levels. The following figure describes the system architecture of low voltage products (up to 200V, e.g. G-WHI, G-HOR, G-GUT, G-BEL).

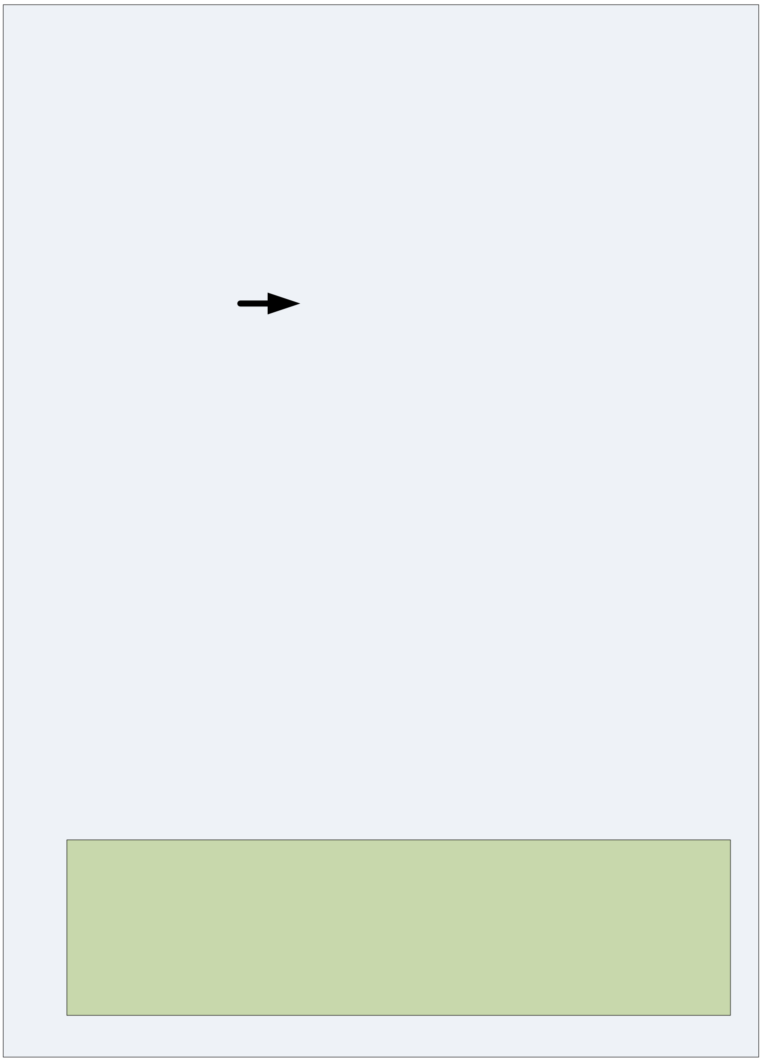


Figure 1: Gold Servo Drive System Block Diagram for Common Power Return products

For high voltage products (G-TRO), the following figure describes the architecture, where the Power stage is fully isolated from the control unit.

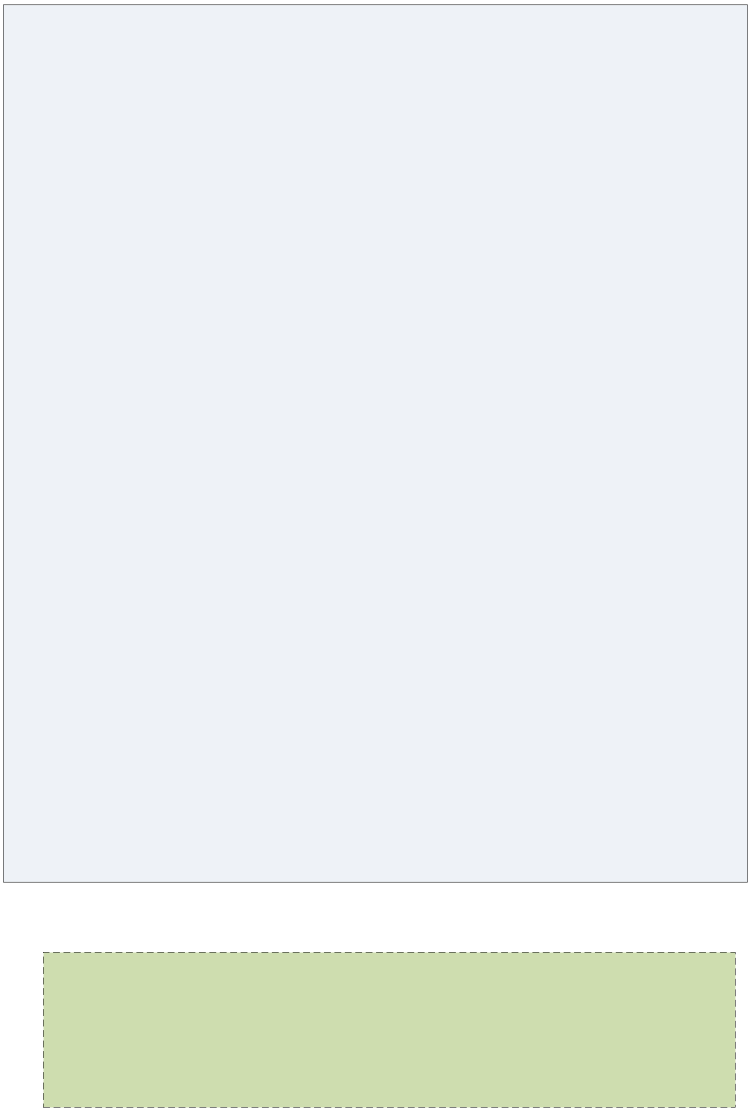


Figure 2: Gold Servo Drive System Block Diagram for Control Isolated from the power stage products

3.2. Power Supply Architecture

Single DC power supply

Refer to the Main DC power supply topology defined in the individual installation guide.

Optional Backup (Auxiliary) Supply

Refer to the Main DC power supply topology defined in the individual installation guide.

3.3. Servo Control

- Advanced and extremely fast vector control algorithm (current loop bandwidth: 4 kHz)
- Current/Torque sampling rate: up to 25 kHz (40 µs)
- Velocity sampling rate: up to 12.5 kHz (80 µs)
- Position sampling rate: up to 12.5 kHz (80 µs)
- Electrical commutation frequency: up to 4 kHz
- Current closed loop bandwidth exceeds 4 kHz
- Position/Velocity/Acceleration command range – full 32 bit
- Position over velocity, with full dual loop support
- S-curve Profile Smoothing
- Cogging, BEMF and ωxL compensation
- Dual Loop Operation supported by Auto Tuning
- Fast, easy and efficient advanced Auto Tuning
- Motion profiler numeric range:
  - Position up to ±2 x 109 counts
  - Velocity up to 2 x 10^9 counts/sec
  - Acceleration up to 2 x 10^9 counts/sec^2

3.4. Advanced Filters and Gain Scheduling

- “On-the-Fly” gain scheduling of current and velocity
- Velocity and position with “1-2-2” PIP controllers
- Automatic commutation alignment
- Automatic motor phase sequencing
- Current gain scheduling to compensate for the motor’s non-linear characteristics
- Advanced filtering: Low pass, Notch, General Biquad
- Current loop gain scheduling to compensate for bus voltage variations
- Velocity gain scheduling for ultimate velocity loop performance
- Gains and filter scheduling vs. position for mechanical coupling optimization, speed and position tracking errors

- High order filters gain scheduling vs. speed and position

3.5. Motion Control

- Motion control programming environment
- Motion modes: PTP, PT, ECAM, Follower, Dual Loop, Current Follower, Fast event capturing inputs
- Full DS-402 motion mode support, in both the CAN and CAN over EtherCAT (CoE) protocols, including Cyclic Position/Velocity modes. Fast (Hardware) event capturing inputs, supporting < 1 µs latch latency
- Fast (hardware) Output Compare, with < 1 µs latency
- Output compare repetition rate:
  - Fixed Gap: Unlimited
  - Table based: 4 kHz
- Motion Commands: Analog current and velocity, pulse-width modulation (PWM) current and velocity, digital (SW) and Pulse and Direction
- Distributed Motion Control
- EASII (Elmo Application Studio) software: an efficient and user friendly auto tuner

3.6. Fully Programmable

- Third generation programming structure
- Event capturing interrupts
- Event triggered programming

3.7. Feedback Ports Options

- There are Port A and Port B feedback input ports that are flexible and configurable. Each port can be programmed to serve as:
  - Commutation feedback and/or
  - Velocity feedback and/or
  - Position feedback
- Port A supports the following sensors, depending on the specific model:
  - Incremental encoder
  - Incremental encoder and digital Hall
  - Absolute serial encoder
  - Absolute serial encoder and digital Hall (for dual loop)
- Port B supports the following sensors, depending on the specific model:
  - Incremental encoder

    - Analog encoder
    - Analog Hall
    - Resolver
- Port C is a flexible and configurable feedback output port. It supports the Encoder emulation outputs of Port A or Port B or internal variables
- Analog input (±10 V ptp) support:
    - Velocity feedback (tachometer)
    - Position feedback (potentiometer)

3.8. Feedback Sensor Specifications

- Incremental Quadrature Encoder (with or without commutation halls) up to 75 Megacounts per second (18 MHz PPS (Pulses Per Second))
- Incremental encoder and digital Halls
- Digital Hall
    - Up to 4 kHz commutation frequency
    - 5 V logic
    - Input voltage up to 15 VDC
- Interpolated Analog (Sine/Cosine) Encoder :
    - Supports 1 V PTP Sine/Cosine
    - Sin-Cos Frequency: up to 500 kHz
    - Internal Interpolation: up to ×8192
    - Automatic Correction of amplitude mismatch, phase mismatch, signal offset
    - Emulated encoder output of the Analog encoder
- Analog Halls (commutation & position)
    - One feedback electrical cycle = one motor's electrical cycle
    - Supports 1 V PTP Sin/Cos
    - Sin/Cos Frequency: up to 500 kHz
    - Internal Interpolation: up to ×8192
    - Automatic correction of amplitude mismatch, phase mismatch, signal offset
- Absolute serial encoders:
    - NRZ (Panasonic, Tamagawa, Mitutoyo, etc.)
    - EnDAT 2.2
    - BiSS
    - SSI

  - Sanyo Denki
  - Stegmann Hiperface
- Resolver
  - 14 bit resolution
  - Up to 512 revolutions per second (RPS)
  - Emulated encoder outputs of the Resolver
- Auxiliary Encoder inputs (ECAM, follower, etc.) single-ended, unbuffered
- The Gold Board Level Modules Servo Drive provides 5 V supply voltage for the encoders, Resolver or Hall supplies

3.9. Communications

The Gold Line offers variety of communication protocols (refer to the communication options of the specific drive):

- EtherCAT networking
- EtherCAT Slave:
  - CoE (CAN over EtherCAT)
  - EoE (Ethernet over EtherCAT)
  - FoE (File over EtherCAT) for firmware download
  - Supports Distributed Clock
  - EtherCAT cyclic modes supported down to a cycle time of 250 µs
- CAN Networking
- Ethernet TCP/IP
  - UDP
- USB 2.0
- RS232 (TTL Level)
- Standard RS232 in G-TWI

3.10. Safe Torque Off (STO)

Two STO (Safe Torque Off) inputs TTL level, or can be configured to PLC level in the G-TRO.

3.11. Digital Outputs

The Digital Outputs support the following optional functions:

- Fast event capture (for two inputs only)
- Inhibit/Enable motion
- Stop motion under control (hard stop)

- Motion reverse and forward limit switches
- Begin on input
- Abort motion
- Homing
- General purpose

The Gold WHI, BELL, and GUT support four Digital Outputs:

  - Two optically isolated open collector and open emitter
  - Two TTL 3.3 V non-isolated outputs.

The **Gold Trombone** supports four digital outputs that can be configured to:

  - TTL voltage level, *or*
  - Source mode High current PLC voltage level

The **Gold Twitter** supports four TTL digital outputs

3.12. Differential Outputs

- Three differential outputs:
  - Port C EIA-422 differential output line transmitters
  - Response time < 1 µs
  - Output current: ± 15 mA

3.13. Digital Inputs

The Gold WHI, BELL, and GUT support six isolated TTL digital inputs

The Gold Trombone supports six isolated digital inputs which can be configured to TTL Level or PLC Source voltage level

The Gold TWI supports six 5V logic level digital inputs

The Digital inputs support the following optional functions:

- Fast event capture (for two inputs only)
- Inhibit/Enable motion
- Stop motion under control (hard stop)
- Motion reverse and forward limit switches
- Begin on input
- Abort motion
- Homing
- General purpose

3.14. Differential Inputs

- Six very fast differential event capture inputs 5 V logic
  - Via Port A or B (three on each port, depending on model)
  - EIA-422 Differential input line receiver
  - Response time < 1 µs

3.15. Analog Input

- One differential **Analog Input** –12-bit resolution (Input: ±10 V)
- One Single ended Analog input

3.16. Built-In Protection

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

3.17. Status Indication

- Output for a bi-color LED

3.18. 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

Chapter 4: Installation

The Gold Board Level Modules Servo Drive must be installed in a suitable environment and properly connected to its voltage supplies and the motor.

4.1. How to Use this Guide

In order to install and operate your Elmo Gold servo drive, you will require both this manual and the drive specific installation guide.

1. Use this manual in conjunction with the specific installation guide, which includes mechanical structure of the product, pinouts, power connectivity, and thermal data. After carefully reading the safety instructions in the first chapter, the following chapters provide you with installation instructions as follows:
    - This chapter provides step-by-step instructions for unpacking the Gold Board Level Modules Servo Drive.
    - The various chapters in this manual provide the general wiring background and instructions necessary for all Gold line products.
    - The Specific relevant installation guide provides instructions for mounting, connecting and powering up the Gold Board Level Modules Servo Drive.
2. Perform the STO installation and startup instructions located in Chapter 9:
3. Perform the instructions in these guides, to successfully mount and install your Gold Board Level Modules Servo Drive. 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 Gold Product Line Software Manual, which describes the comprehensive software used with the Gold Board Level Modules Servo Drive
    - The Gold Product Line Command Reference Manual, which describes, in detail, each software command used to manipulate the Gold Board Level Modules Servo Drive motion controller
    - The Elmo Application Studio (EASII) User Manual, which includes explanations of all the software tools that are part of the Elmo Application Studio software environment

4.2. Unpacking the Drive Components

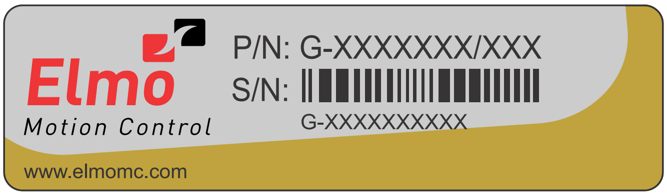
Before you begin working with the Gold Board Level Modules Servo Drive, verify that you have all of its components, as follows:

- The Gold Board Level Modules Servo Drive servo drive
- The Elmo Application Studio software and software manual

The Gold Board Level Modules Servo Drive is shipped in a cardboard box with Styrofoam protection.

To unpack the Gold Board Level Modules Servo Drive:

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 Gold Board Level Modules Servo Drive you have unpacked is the appropriate type for your requirements, locate the part number sticker on the side of the Gold Board Level Modules Servo Drive. It looks like this (example):



GGENERIC001B

4. Verify that the Gold Board Level Modules Servo Drive type is the one that you ordered, and ensure that the voltage meets your specific requirements.
   The catalog number at the top gives the type designation as described in the specific installation guide.

Chapter 5: Integrated Module of PCB

The Gold Board Level Modules Servo Drive are designed to be mounted on a PCB by soldering its pins directly to the PCB. The following rules should be applied.

5.1. Logic Power

Supply Voltage	Purpose
3.3V	Power Supply 3.3V for EtherCAT/Ethernet transformer EtherCAT LEDs, Drive status indicator The maximum current consumption is 50mA
+5V	Encoder +5V supply. Refer to the specific manual for current consumption.

5.2. Returns/ "Grounding" Topology

When wiring traces of the following return signals on the Integration Board, the **Returns** of each function must be **wired separately** to its designated terminal on the drive. **Do not use a common ground plane**. Shorting the commons on the Integration Board may cause performance degradation (ground loops, voltage drops, noises, etc.).

5.3. Power Conductor and Power Returns

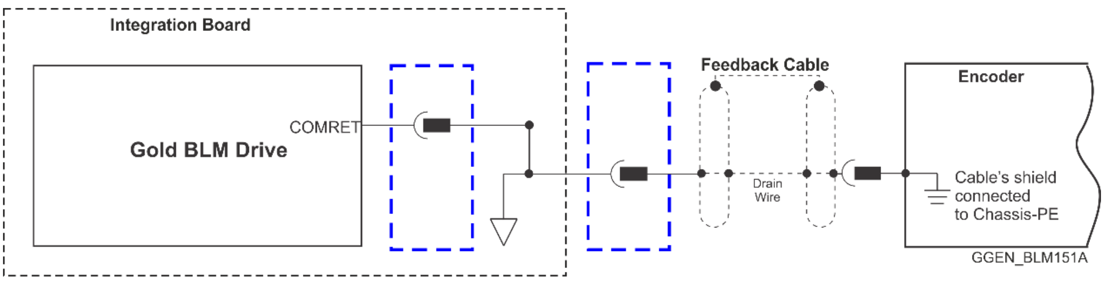
For details of the Power conductor, Power return and PE, refer to the specific installation guide.

5.4. COMRET

All the digital signals (control and communication) share the same common (COMRET). Improper plane design may cause "problems" such as ground loops, too high impedance drops, interferences etc. How is "proper" plane design achieved?

By using the following:

- A large plane. This can be achieved only when sufficient layers are available.
- Viases should be used to connect other "points" to the common. This ensures short and direct connection with minimum impedances and ground loops.
- COMRET plane should not be mixed with the Power conductors
- Power conductors should not be mixed with various low level Control Signals (feedbacks, communication, analog input, digital IOs).
- Connect the COMRET of the feedback cable to the shield. It is recommended to connect the shield of the cable to the Chassis-PE of the Encoder. Refer to the figure below.



5.5. The Printed Circuit Board (PCB)

The recommended PCB is composed of standard common glass epoxy (FR4) with board thickness recommended for ruggedness of >= 1.6 mm.

5.5.1. Number of Layers

It is possible to layout the Integration Board on a double sided PCB. However, it will be considerably tougher and the result will not be as good as using a multi-layer PCB. Using multilayer PCB has the following benefits:

- Simpler and easier layout
- Better performance.
  Much easier to create proper grounding topology, easy to get separation between power and control signals, minimizing cross talks, better high frequency performance, higher noise immunity, less heat dissipated on the conductors of the PCB.
- Higher density - smaller solution.
  It is easier to implement an Integration Board with higher density and smaller size.
- Heat Dissipation
  Multi-layer PCBs improve the heat dissipation of the Power conductors and reduce the temperature of the board.
- Communication
  It is highly recommended to use at least four layers on the PCB, for the routing of the EtherCAT signals.

5.5.2. Board Zones

Divide the PCB virtually into two zones; Power Zone, and Control & Communication Zone.

- **Power Zone**
  This area is dedicated to Power conductors only: VP+, PR, PE, VL+, VL-, VN- and motor leads.
- **Control and Communication Zone**
  This area of the PCB is dedicated to Control low level signals: Communication, Feedbacks, analog input, I/Os.
  To ensure the performance and simple implementation, do not "invade" from one "territory" to the other. This is recommended for all layers of the PCB.

The following diagram describe the Power and Control Zones:

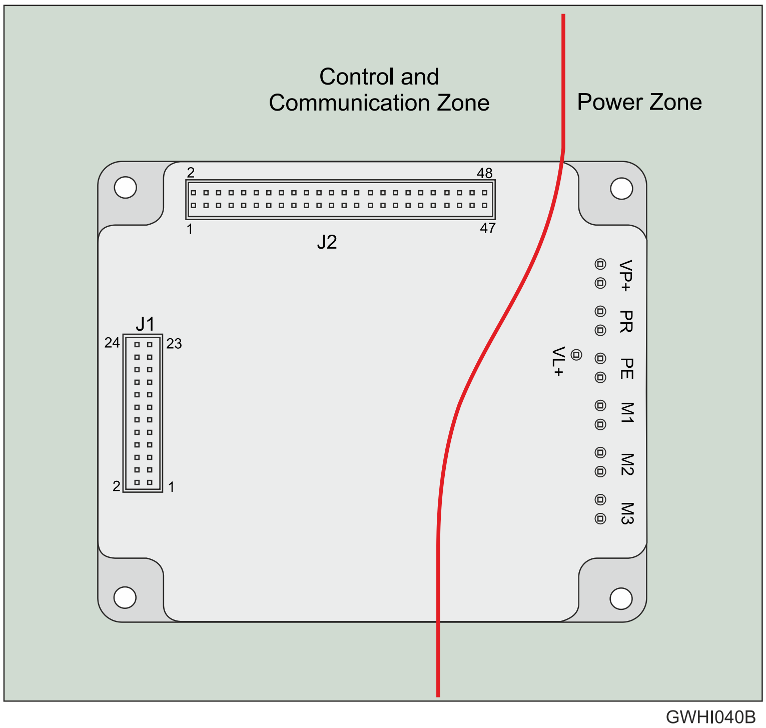


Figure 3: Power and Control Zones

Refer to section 3.1 System Architecture for the diagram of all products.

5.5.3. Layout of connector with 1.27mm Pitch Layout

Some of the BLM connectors are high density connectors with pitch of 1.27mm. It is necessary to remove the pads of the connector pins in the internal layers in order to route the trace between two pins as shown in Figure 4 below.

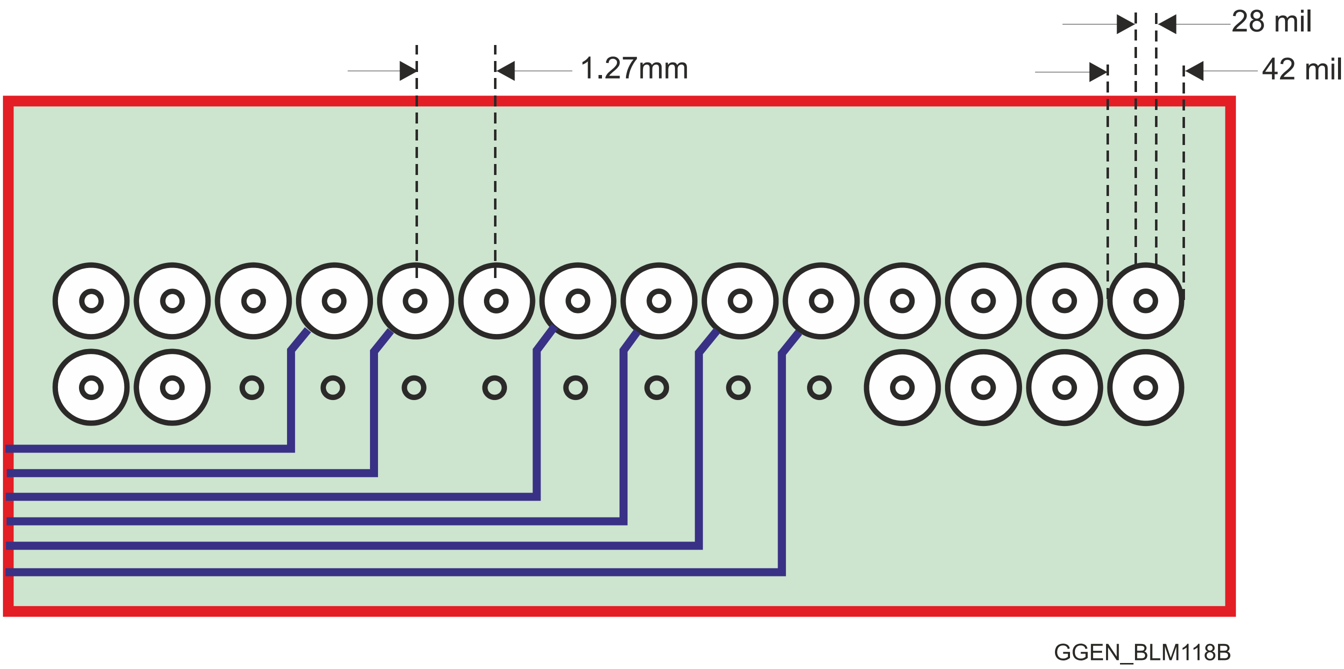


Figure 4: Routing the Trace between Pins

5.6. Power and Power Motor Conductors

The power conductors must be kept as far away as possible from the feedback, control and communication conductors. The **size of the conductors** 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 application is the current used for sizing the motor conductors (M1, M2, M3 and PE) and power conductors (VP+, PR, VN- in Gold Trombone, and PE).

5.6.1. Power Conductors Design Rules

5.6.1.1. Thickness

For conductor thickness, it is highly recommended to use:

- **External layers** of basic copper: 0.5 to 1 Oz (1 Oz = 35 µm), or Clad copper: 30 to 35 µm. The clad thickness is also the thickness of the copper in the through holes (vias). It must be >25 µm, to ensure the current carrying capabilities also via the through holes.
  This will result total thickness of the external layers of 1.5 to 2 oz.
- **Internal Layers** of 1 to 2 oz. It is preferred 2 oz but layout constrains such as thin conductors in the same layer might not allow the 2 oz. In most of the cases 1 oz is sufficient.
- Sizing the power conductors should be calculated according to IPC-2152. The power conductors should be sized according to the IPC-2152 standard calculation. Refer to the section 5.6.1.4 and 5.6.1.6 below.

5.6.1.2. Length

The conductors should be as short as possible to minimize EMI and to minimize the heat generated by the conductors.

5.6.1.3. Spacing

The Gold BLM products conforms to the following industry safety standard:

- **Recognized UL61800-5-1** - Adjustable Speed Electrical Power Drive Systems
- **Recognized UL 508C** – Power conversion equipment.
- **Approved EN61800-5-1** – Adjustable speed electrical power drive system.
- **UL 840** – Insulation coordination including clearance and creepage distance for electrical equipment.
- **CSA c22.2 no. 274-13 -** Adjustable speed drives

The above safety standards have become a mandatory demand in most of the servo applications. In order to maintain overall integrated compliance with the safety standards, the following spacing must be defined between each of the high voltage conductors (VP+, PR or VN- for Gold Trombone, M1, M2, M3, VL+, VL-) and between the high voltage and logic (low voltage) sections.

Table 1: Spacing for Power Conductors in the Component/Print Side Layer of the Board

	Gold BLM Products up-to-200V	G-TRO 400V Model	G-TRO 800V Model
Clearance	0.5 mm	3 mm	5.5 mm
Creepage	0.63 mm	2 mm	4 mm
Using UL 746C certified Acrylic Coating* maintains the following spacing:			
Clearance	0.5 mm	3 mm	5.5 mm
Creepage	0.4 mm	1 mm	2.4 mm

Note: ***All Elmo PCBs are coated, on both their sides, by the UL certified acrylic coating 1B73 manufactured by Humiseal.**

Table 2: Spacing for Power Conductors in the Internal Layer of the Board

Gold BLM Products up-to-200V	G-TRO 400V Model	G-TRO 800V Model
0.4 mm	1 mm	2 mm

5.6.1.4. Width of Conductor Calculation

This section describes how to determine the width of the power conductor. The calculation is performed according to the IPC-2152 standard to determine the current carrying capacity in Printed Board design (August 2009). This standard replaces the standard IPC-2221A.

The free calculator is to be found on the web:

http://www.ipc.org/ContentPage.aspx?Pageid=PCB-Tools-and-Calculators

The following table describes the current carrying rating of PCB conductors. These ratings comply with the IPC-2152. The table prerequisites for a conductor in the external and internal layers for continuous current are:

- FR4 PCB material
- Boards with a thickness of 1.6 mm (63 mil)

Thickness (oz)	Current (A)	Width Conductor (mil)	
Copper Thickness	Continuous Current in the conductor	Conductor Temperature rise of 30°C	Conductor Temperature rise of 45°C
1	5	131	115
1	10	362	308
1	15	See Note 1.	538
1	20	See Note 1.	See Note 1.
2	5	65	58
2	10	181	154
2	15	See Note 1.	269
2	20	See Note 1.	See Note 1.
2	30	See Note 1.	See Note 1.
2	50	See Note 1.	See Note 1.

Note 1: **Using a single layer conductor is impractical, as the width value of the conductor necessary, will be too high. Paralleling conductors is therefore required.**

With regards to the table above, the following should be noted:

- The current ratings in the table are in RMS values. The Current excitation of Elmo's Servo Drives is Sinusoidal and the current rating is given in Amplitude. Elmo's current rating must be divided by 1.41 to provide the RMS value.
  For example, WHI-20/100 is rated for 20 A amplitude.
  The PCB conductor has to carry 20 A/1.41 = 14 A.
- A high-current-carrying conductor should have a large cross section and, if possible, a cross section larger than the value in the table above. This will reduce the resistance of the high-current conductors and thus decrease the heat dissipation. It will also eliminate common mode interferences (voltage drops along the lines).

- Higher currents than those in the table are achieved by paralleling conductors that are placed in multiple layers.
- To create a uniform current distribution, the parallel conductors must be “almost” identical, and it is preferably that they are positioned in parallel, one beneath the other.
- When paralleling, make sure to have a sufficient number of VIAs and an adequate diameter for each VIA.
- It is more efficient to achieve the required cross section by paralleling conductors than by using a single conductor. For example, 10 A conduction requires a single 308 mil conductor or two 115 mil conductors (115*2 < 308).
- The glass transition temperature (TG) of the PCB should be ≥150°C. UL limits the operating temperature of PCBs to <TG - 15°C.
- When the TG of the PCB is 180°C, a temperature rise of 45°C is admissible with wide margins.
- The table above applies to internal and external conductors.

A 30 A RMS design example:
In this example, the application has a continuous current equal to 30 A RMS, the PCB temperature rise can be up to 45°C, and the copper thickness is 2 oz.

The conductor for 30 A can be split between three 2 oz layers. The current in each layer will be 10 A RMS; therefore, the conductor width in each layer will be 154 mil. The conductors should be routed in parallel.

5.6.1.5. PCB Power Vias ("Through Holes")

When paralleling high current carrying conductors located in different layers, the actual paralleling is achieved by shorting the conductors by means of VIAs (VIAs are plated through holes). These through holes carry the entire current between the parallel conductors. Therefore, they must be properly designed to carry the required current. In principle, the cross section of the VIAs must be equal to the cross section of the ∑Cross_Section of the parallel conductors.

A good approximation of the VIA cross-section is given by the following formula:

$$S_{VIA\_Cross\_Section} = \pi * D_{VIA\_Diameter} * P_{VIA\_Plating\_Thickness}$$

VIA	Single VIA		2 VIAs		3 VIAs		4 VIAs		5 VIAs	
Diameter	Δ=45°	Δ=30°	Δ=45°	Δ=30°	Δ=45°	Δ=30°	Δ=45°	Δ=30°	Δ=45°	Δ=30°
mm	Current		Current		Current		Current		Current	
0.30	1.5	1.3	2.7	2.3	3.6	3.1	4.2	3.6	5.3	4.6
0.51	2.7	2.4	4.9	4.3	6.5	5.8	7.56	6.7	9.5	8.4
0.76	3.5	3.1	6.3	5.6	8.4	7.4	9.8	8.7	12.3	10.9
1.02	4.8	4.2	8.6	7.6	11.5	10.1	13.44	11.8	16.8	14.7
1.27	6	5	10.8	9.0	14.4	12.0	16.8	14.0	21.0	17.5
1.52	6.5	5.5	11.7	9.9	15.6	13.2	18.2	15.4	22.8	19.3
1.78	7	6.1	12.6	11.0	16.8	14.6	19.6	17.1	24.5	21.4
2.03	7.6	6.7	13.7	12.1	18.2	16.1	21.28	18.8	26.6	23.5
2.29	8	7	14.4	12.6	19.2	16.8	22.4	19.6	28.0	24.5
2.54	8.1	7.7	14.6	13.9	19.4	18.5	22.68	21.6	28.4	27.0
2.79	10	8	18.0	14.4	24.0	19.2	28	22.4	35.0	28.0
3.05	11	9	19.8	16.2	26.4	21.6	30.8	25.2	38.5	31.5

Note: **The table includes de-rating**

To use this table, do the following:

1. Determine the RMS value of the current in the conductors of the application.
2. Select the diameter of the VIAs and the number of VIAs that are rated for the RMS current of the conductors.
3. In most cases, more than one combination will be possible. Select the appropriate combination for the PCB layout.

With regards to the table above, the following should be noted:

- The current ratings in the table are the RMS values. The current excitation of Elmo's servo drives is sinusoidal, and the current rating given is the amplitude. Elmo's current rating must be divided by 1.41 to obtain the RMS value.

For example, WHI-20/100 is rated for an amplitude of 20 A.
The PCB VIAs are required to carry 20 A/1.41 = 14 A.

- It is recommended to set the minimum diameter of high-current-carrying VIAs as follows:
  - For I ≥ 10 A the VIA diameter should be >0.6 mm.
  - For I < 10 A the VIA diameter should be ≥0.4mm (and never lower than D = 0.3 for current-carrying VIAs).
- A group of paralleled VIAs must have the same diameter and same shape.

5.6.1.6. Planes structure

The **Planes structure** should be wide and thick. Using Planes for the power supply minimizes both the impedance of the tracks and the conduction losses. It also reduces interference. For the minimum dimensions, refer to the Sections 5.6.1.4 and 5.6.1.6 above.
The VP+ and PR should be laid in parallel planes. Parallel adjacent planes in a PCB create a parasitic capacitor. Its capacitance can vary from a small number of picofarad to several hundred picofarad. This is a high-frequency capacitor with very low impedance and is therefore a “good” capacitor that contributes to the filtering and noise reduction on the power supply bus.

5.6.2. The Motor’s Conductors

The **Motor’s conductors** are a major contributor to the created EMI. A “proper” treatment such as described below, will reduce this contribution to negligible levels.

Non-paralleling
Unlike the supply conductor, the motor’s three conductors must not be parallel. Any parasite between the motor conductors is a source of interferences. A parasitic capacitor between the motor conductors results in a “short” short circuit every PWM switching, and also adds to the enormous noise, causing in extreme cases, activation of the short circuit protection.

Non-crossing
Crossing between the motor conductors must be avoided or at least minimized.

Short length
The motor’s conductor must be as short as possible.

Wide width
The width of the power conductor is determined by the continuous current. The calculation of the width is to be found via the details in Sections 5.6.1.4 and 5.6.1.6 above.

5.6.3. Power and Power Motor Conductors – PCB Layers

5.6.3.1. Double side PCB

The following design will work, but is not recommended.

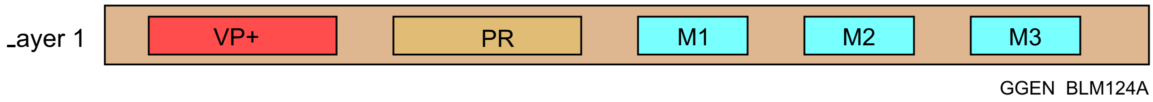


Figure 5: Typical Implementation with a Double-Sided PCB

5.6.3.2. Multilayer PCB

The following Multilayer PCB is recommended. The VP+ and PR are parallel planes. Motor conductors do not intersects or cross (in other layers) each other or any other conductor on board.

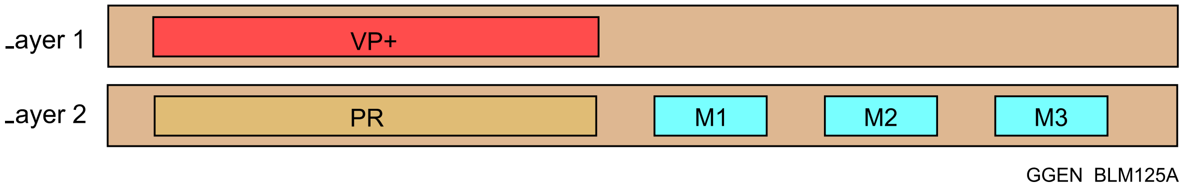


Figure 6: Recommended Implementation with a Multilayer PCB

If the planned continuous current is high, the power conductor can be split between several planes (refer to the above Sections 5.6.1.4 and 5.6.1.6 above). The conductor will then be routed in parallel in several planes as shown in Figure 7.

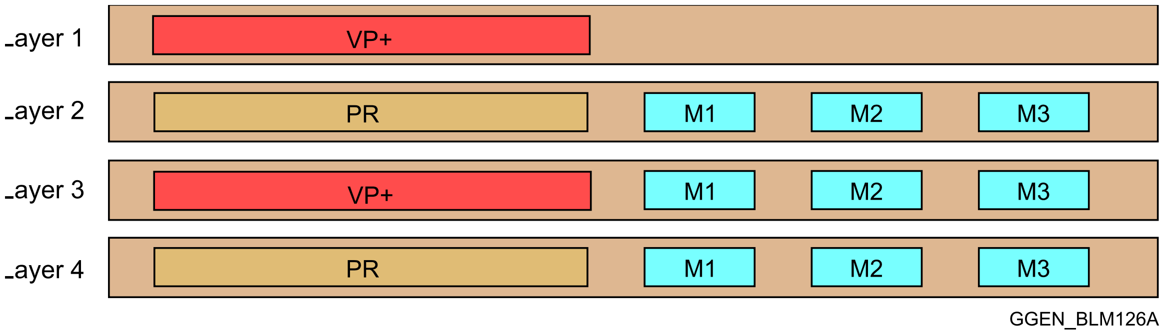


Figure 7: Power conductor split between several planes

5.6.3.3. DC Bus Capacitance

To ensure proper and reliable operation of the servo system, make sure that the capacitance on the DC bus conforms to the following goals:

- Low impedance path, free from parasitic inductances for the switching devices
- Filtering of the PWM high frequency current ripples
- Reduction of voltage fluctuations on the DC bus
- Filtering of external voltage interferences

The internal capacitance of the Gold Whistle serves all of these goals. However, the DC bus capacitance cannot serve as an energy reservoir. The power is delivered entirely from the power supply and not from the capacitance. Refer to the link http://www.elmomc.com/applications/Power-Supply-for-Servo-Applications.htm for details.

The DC bus is sensitive to the quality of the power supply and the impedance of the DC bus, which is influenced by the following: long wires, thin wires, parasitic inductances, high ripple voltage, voltage drops, etc.

In most cases, when the power supply is nearby, is properly wired, and is traced, it is not necessary to add a DC bus capacitance. Nevertheless, it is recommended to add a DC bus capacitance. It should be inserted by paralleling “general purpose” electrolytic capacitors with ceramic capacitors. In general, as a rule of thumb, the capacitors have the following ranges:

- Electrolytic: ≈10 µF/1 A
- Ceramic: ≈0.5 µF/1 A

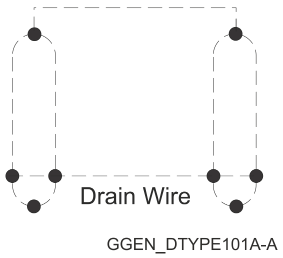
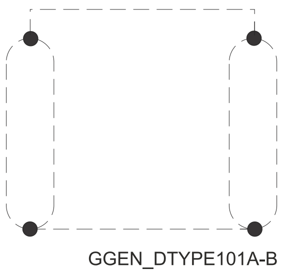
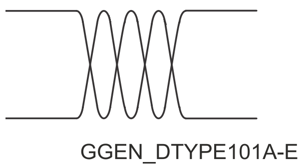
For example, in Elmo’s Duo, which is two G-WHI20/100 units integrated on one PCB, the total electrolytic capacitance is ≈400 µF (∑40 A).

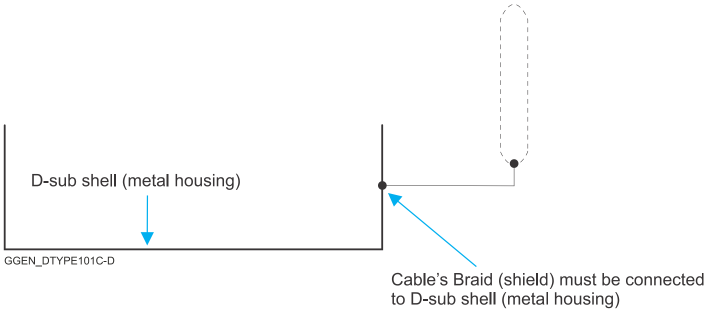
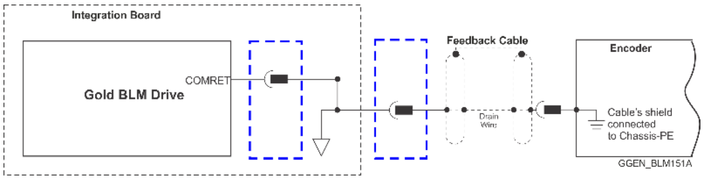
The total ceramic capacitance is ≈15 µF (∑40 A).

Chapter 6: Wiring Legend

The wiring diagrams shown in this manual are examples and only show the signal name. They do not include pin numbers. For specific details, please refer to the specific servo drive installation guide.

The following table legend describes the wiring symbols detailed in all installation guides. All the wiring diagrams show wiring for D-TYPE connectors.

Wiring Symbol	Description
	Earth connection (PE)
	Protective Earth Connection
	Common at the Controller
	Shielded cable with drain wire. The drain wire is a non-insulated wire that is in direct contact with the braid (shielding). Shielded cable with drain wire significantly simplifies the wiring and earthing.
	Shielded cable braid only, without drain wire.
	Twisted-pair wires

Wiring Symbol	Description
	In D-type Connector: The cable`s braid (Shield) must be connected to the D-sub shell (metal housing)
	Encoder Earthing. The cable`s shield is connected to the chassis (PE) in the connector. Earthing the Encoder and connecting the Earth (PE) to the drive COMRET is mandatory to insure reliable operation, high noise immunity and rejection of voltage common mode interferences.

Chapter 7: Drive Status Indicator

This red/green dual LED is used for immediate indication of the following states:

- **Initiation state:** In this state the LED indicates whether the drive is in the boot state (blinking red) or in the operational state (steady red).
- **Working state:** In this state the LED indicates whether the drive is in an amplifier failure state (red) or is ready to enable the motor (green).

The Drive provides signals for Drive status indicator.

The following table describes the LED signals:

Signal	Function
LED2	Bi-color indication output 2 (Cathode)
LED1	Bi-color indication output 1 (Cathode)

The following figure describes how to connect the LEDs:

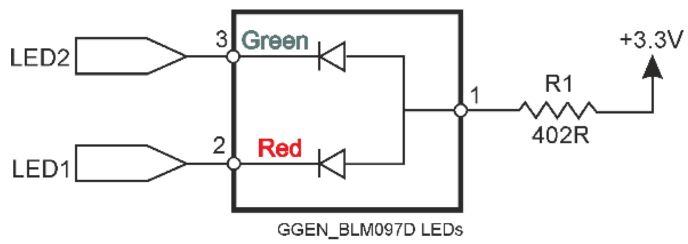


Figure 8: Connecting the Drive Status LEDs

The above is an example of bi-directional LEDs.

Manufacture	P/N	Descriptions
Kingbright	KPBA-3010SURKCGKC	bi-directional LEDs

Chapter 8: Motor Power

The following table describes the motor power cable connections.

Pin	Function	Cable		
		Brushless Motor	**Brushed DC Motor**	**Stepper Motor Only for Bell products**
PE	Protective Earth	Motor	Motor	Motor
M1	Motor phase	Motor	No Connection	Motor
M2	Motor phase	Motor	Motor	Motor
M3	Motor phase	Motor	Motor	Motor
M4	Motor phase	No Connection	No Connection	Motor

Table 3: Power Motor

To power the drive, connect the M1, M2, M3, M4 (in the Bell products) and PE pins on the Gold Board Level Modules Servo Drive. hree for the phases and an additional wire to Earth. Safety requires that the Earthing wire will have the same current carrying capability as the other three phases motor's wires. This to be able to short motor's current to the PE in case a failure.

- 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 servo drive.
- Ensure that the motor chassis is properly grounded.

The phase connection is arbitrary as Elmo Application Studio (EASII) 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.

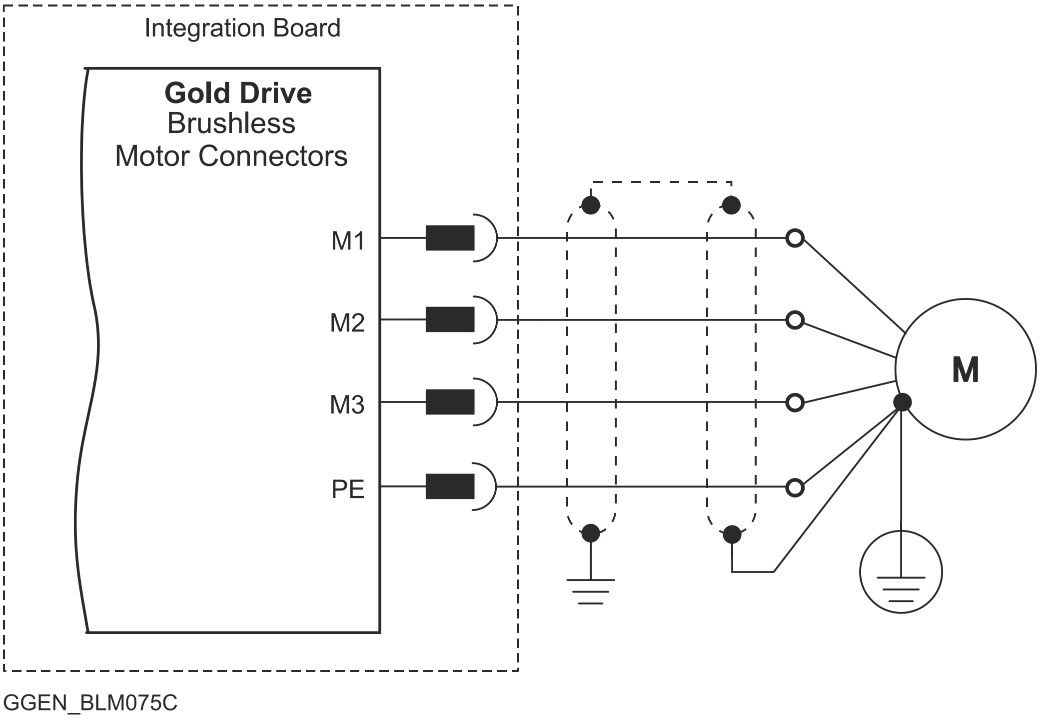


Figure 9: Brushless Motor Power Connection Diagram

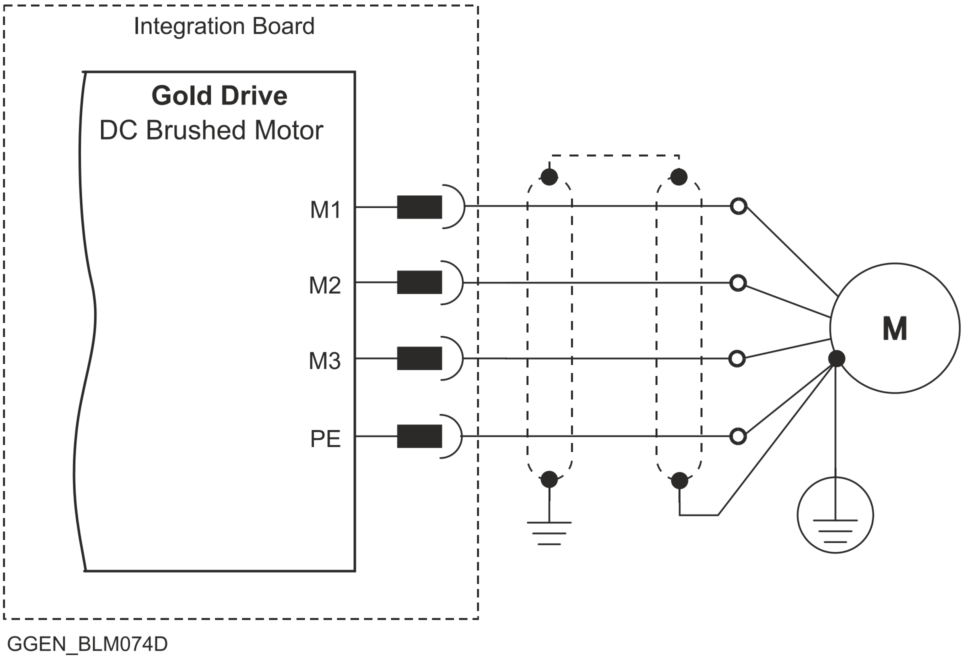


Figure 10: DC Brushed Motor Power Connection Diagram

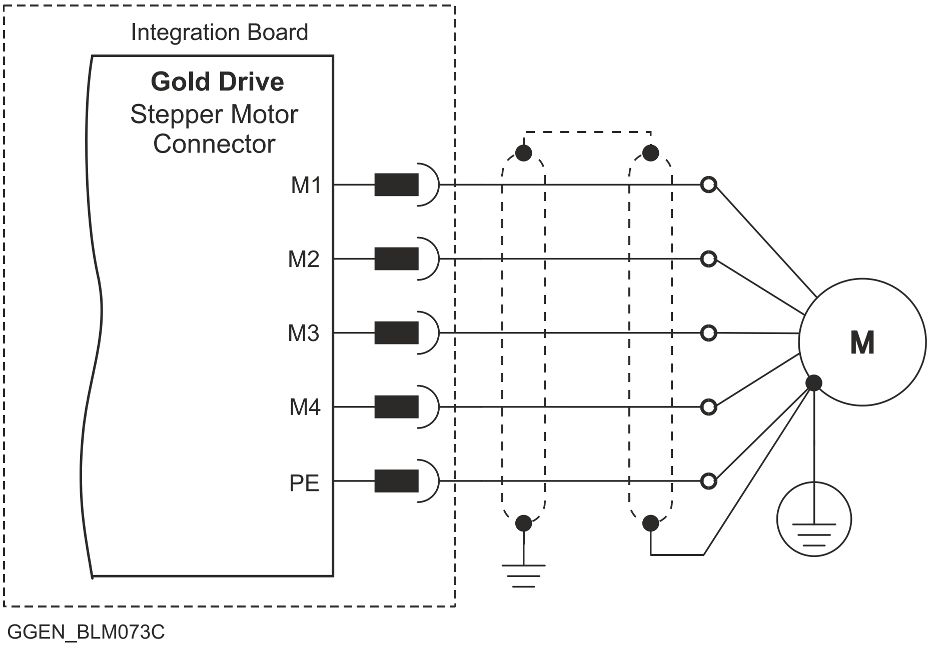


Figure 11: Stepper Motor Power Connection Diagram

Chapter 9: STO (Safe Torque Off)

This chapter describes and specifies the safety requirements in the system level of the Safe Torque Off (STO) for the Gold line. The Gold line drives support Safe Torque Off (STO) according to the following industry safety standards:

- IEC 61800-5-2:2007 SIL 3
- EN 61508-1:2010 SIL 3
- EN 61508-2:2010 SIL 3
- EN 61508-3:2010 SIL 3
- EN ISO 13849-1:2008 Cat 3, PL e

9.1. STO Signals

Signal	Function
STO1	STO 1 input
STO2	STO 2 input
STO_RET	STO signal return The two digital STO inputs are optically isolated from the other parts of the Gold Board Level Modules Servo Drive, and share one return line.

Table 4: STO Input Pin Assignments

Refer to the specific product installation guide pin assignments.

9.2. STO Functionality Description

Activation of the Safe Torque Off (STO) function causes the drive to stop providing power, which controls the motor movement. The STO may be used to prevent unexpected motor rotation while the drive remains connected to a power supply.

The motor can only be electrically activated, when both STO inputs are active, i.e., current flows through the diode of the Optically Isolated STO inputs (see following figure). Whenever one of the inputs is no longer active, power that can generate motion is no longer provided to the motor by the drive. The motor in this case will be "free running" and will come to a rest under its own inertia and frictional forces.

According to Stop Category 0 of IEC 60204-1, the IEC 61800-5-2, and ISO 13849-1 category 3 requirements, it is required that the STO function is governed by two, fully redundant inputs. Thus, the ELMO STO consists of two STO inputs, namely STO1_IN and STO2_IN.

The STO1_IN stops (inhibits) the PWM signals to the High Side Gate Drivers, and the STO2_IN stops (inhibits) the PWM signals to the Low Side Gate Drivers.

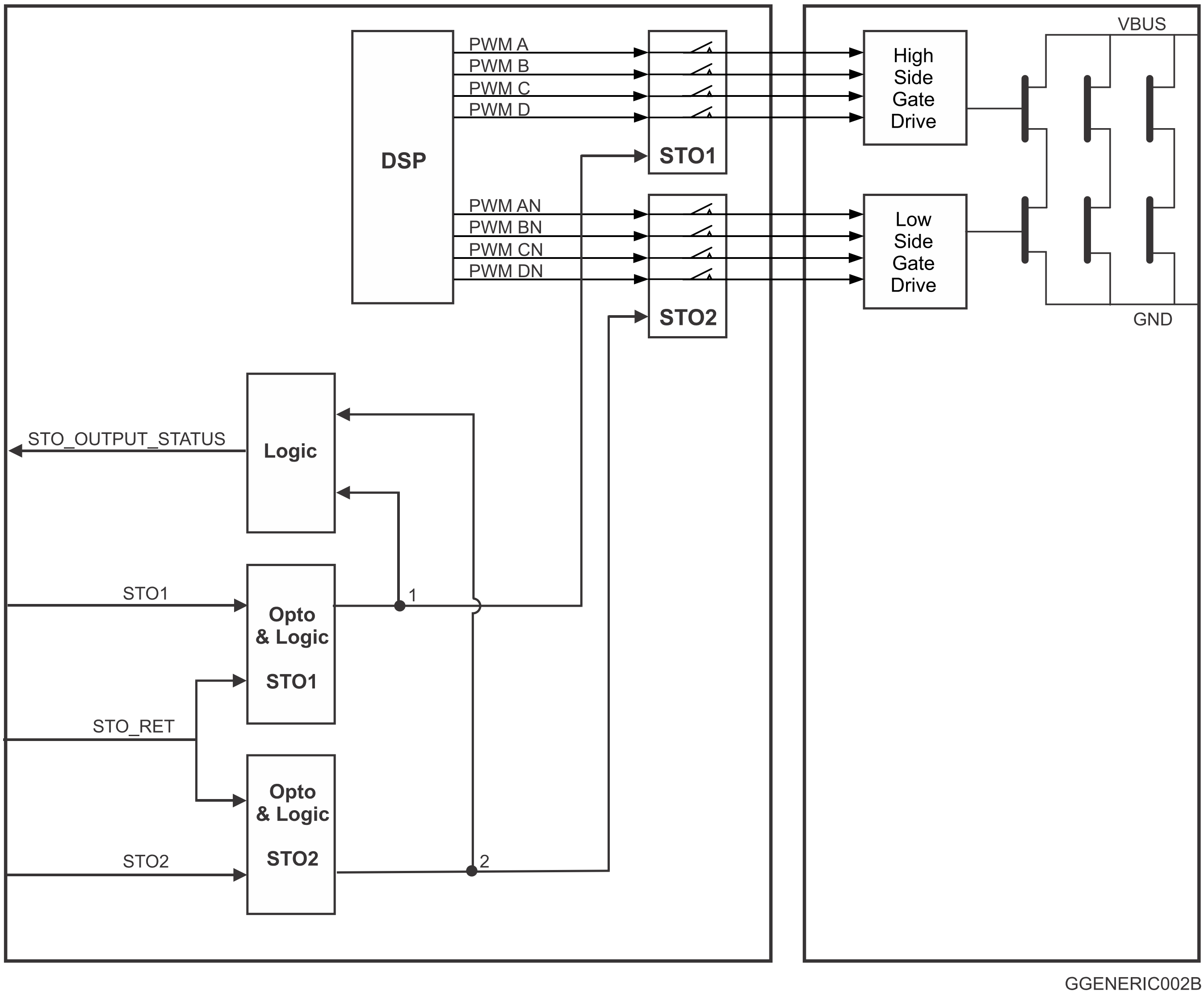


Figure 12: System block Diagram

Note: PWMD is required for a Stepper Motor in products like the G-Bell.

Table 5 defines the behavior of the motor as a function of the state of the STO inputs:

STO1_IN	STO2_IN	Motor Function
Non-Active	Non-Active	Disabled
Non-Active	Active	Disabled
Active	Non-Active	Disabled
Active	Active	Can be enabled

Table 5: State of STO

In addition to the main inhibitive function of the two STO inputs, their status is also reported back to the DSP for user indication, and for latching the software from enabling the motor automatically when the STO inputs are reactivated (i.e. STO function Not Active). Therefore, once the STO function is **active** (i.e. disabling motor operation), re-initializing the servo loop requires, in addition to the STO function being deactivated (by activating Both STO inputs), the software must also initiate a **motor enable** command.

The STOx_IN signals are isolated using opto-couplers. The output signal of the opto-coupler enters the filter to avert a false command.

9.3. Safety Controller Short Pulses

The Safety controller can transmit short pulses on the STO_IN for user diagnostics purposes. Elmo does not use these short pulses and they are not required for the Gold Drive diagnostics. These short pulses will not disturb the STO function and motor operation, if the pulse width is less than specified in STO Timing section (Figure 13).

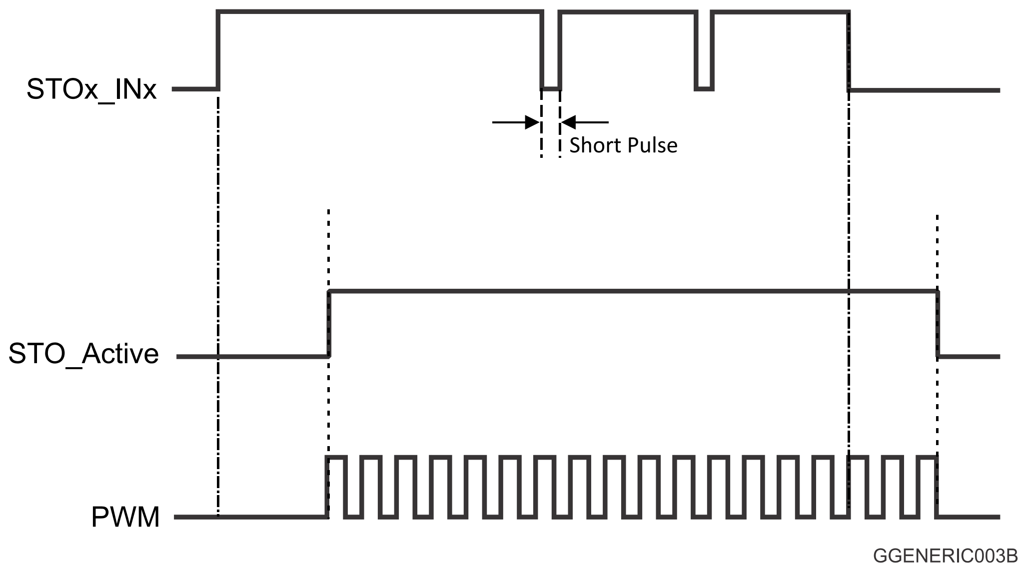


Figure 13: Timing Diagram of short pulses

9.4. STO Input Interface

The STO input supports TTL input level and the PLC source option.

9.4.1. STO Input Interfaces - TTL Mode

Feature	Details
Type of input	Optically isolated
Input current for all inputs	I_{in} = 3.8 mA @ Vin = 5 V
High-level input voltage	2.4 V < Vin < 15 V, 5 V typical
Low-level input voltage	0 V < Vin < 0.8 V

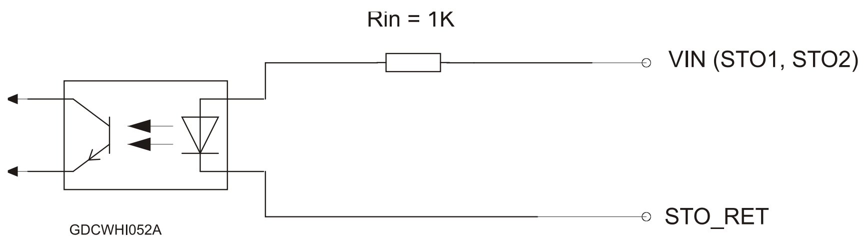


Figure 14: STO TTL Input Schematic

Refer to the diagram below for the TTL option connection.

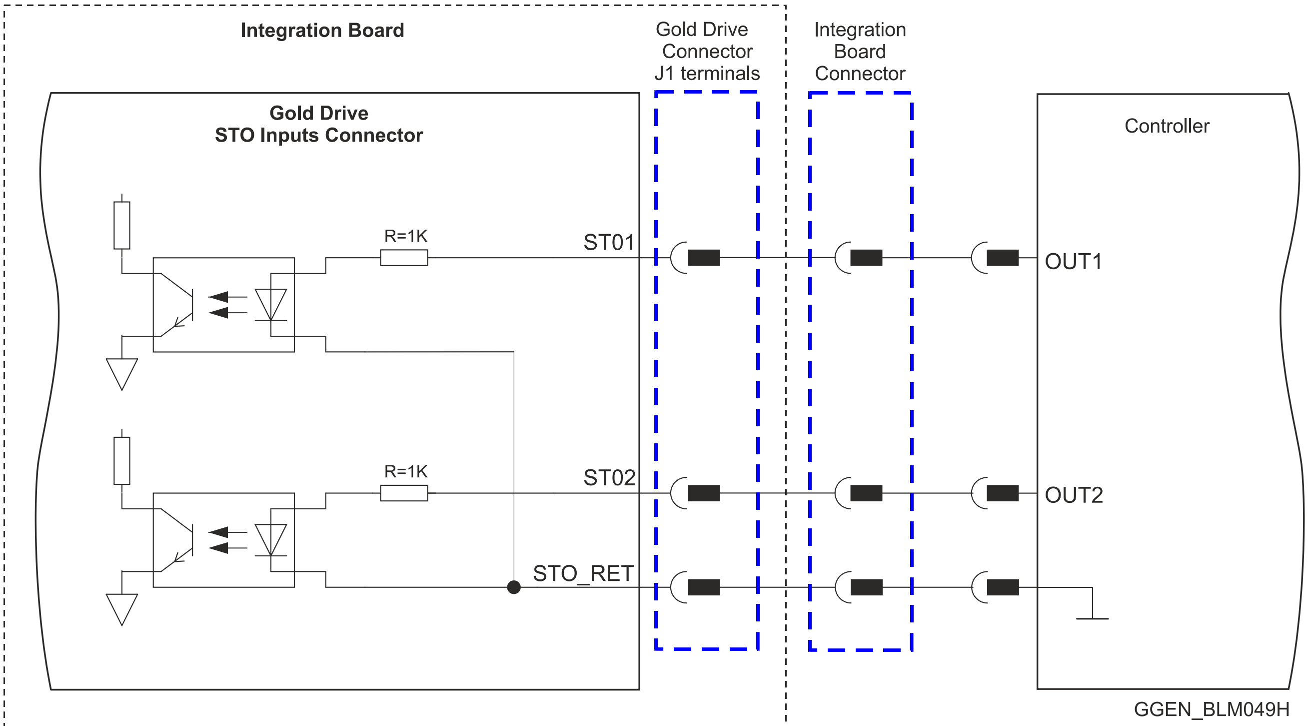


Figure 15: STO Input Connection – TTL Option

9.4.2. PLC Source option connection

Feature	Details
Type of input	Optically isolated
Input current for all inputs	I_{in} = 2 mA @ Vin = 12 V
High-level input voltage	12 V < Vin < 30 V
Low-level input voltage	0 V < Vin < 7 V

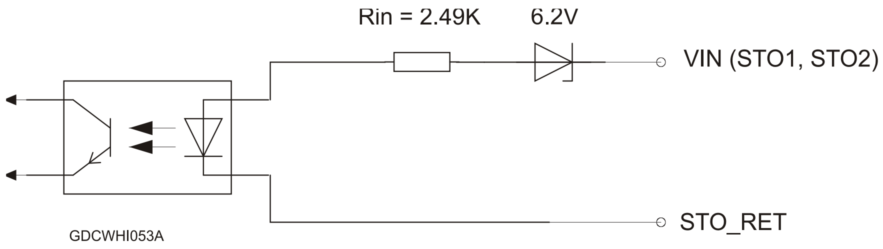


Figure 16: STO PLC Input Schematic

Refer to the following figures for the PLC option connection.

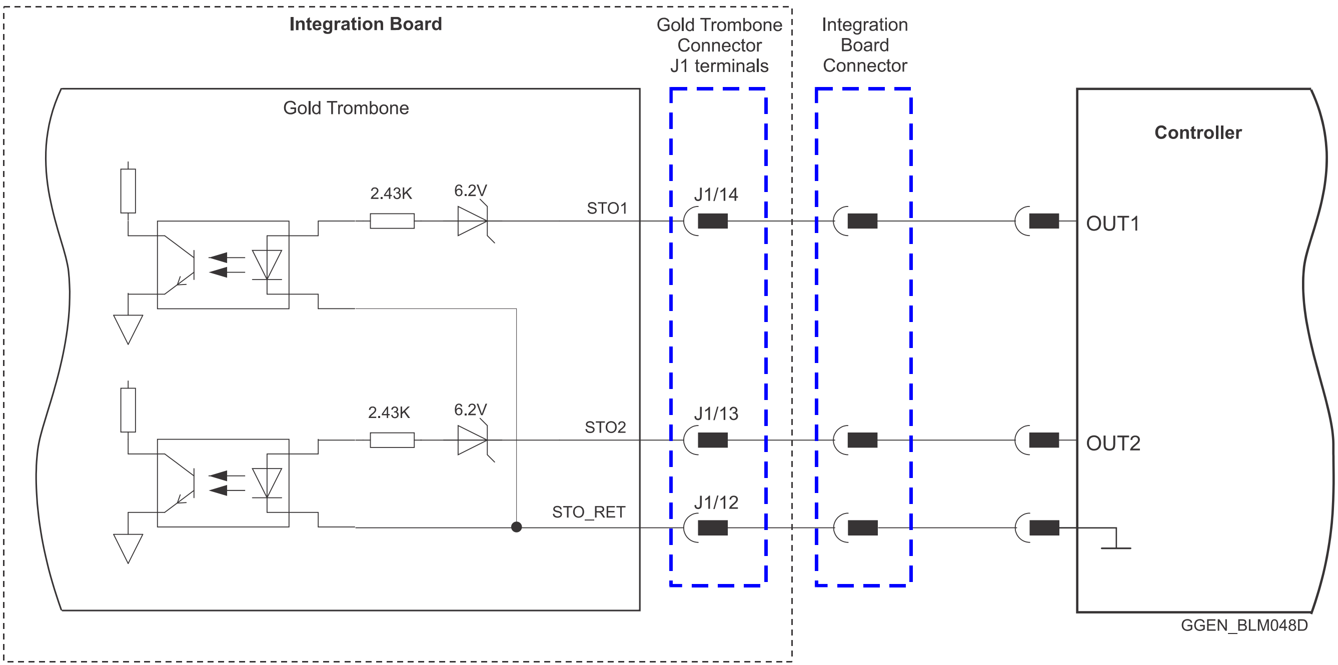


Figure 17: STO Input Connection – PLC Source Option for the G-TRO

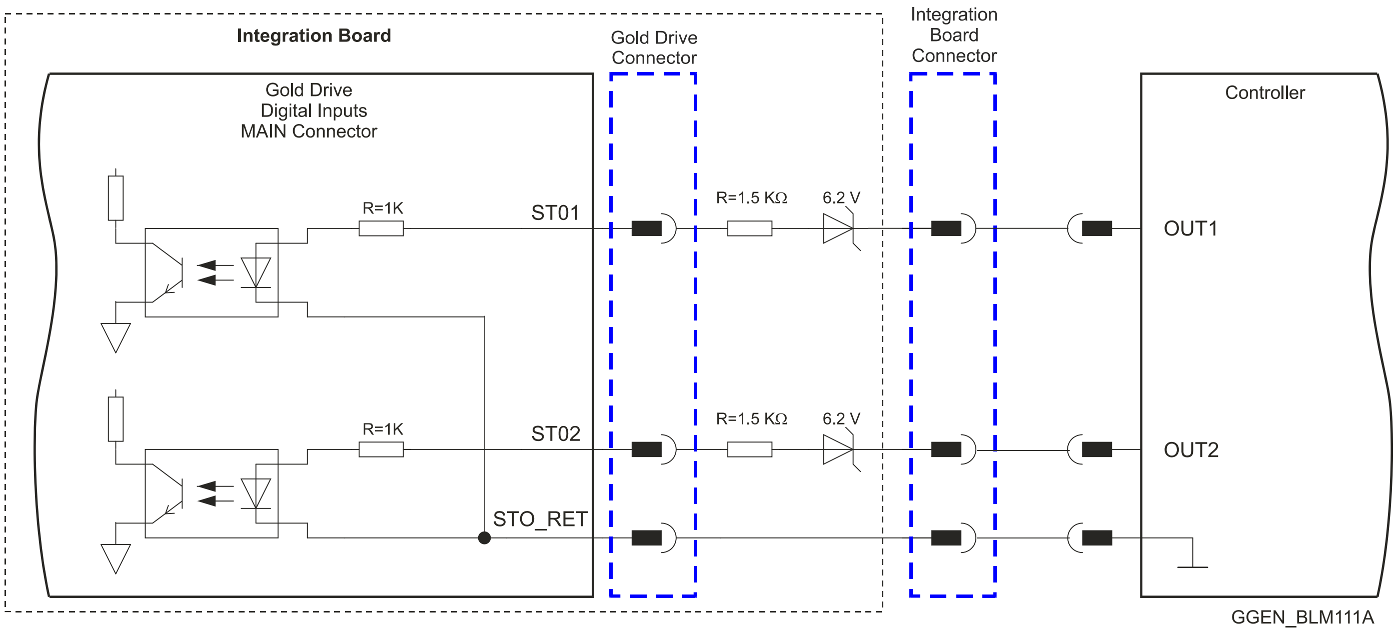


Figure 18: STO Input Connection – PLC Source Option for the G-WHI, G-BEL, G-GUT, and G-TWI

9.4.3. STO Connection of Several Drives

The following figure describes how to connect the STO input to several drives.

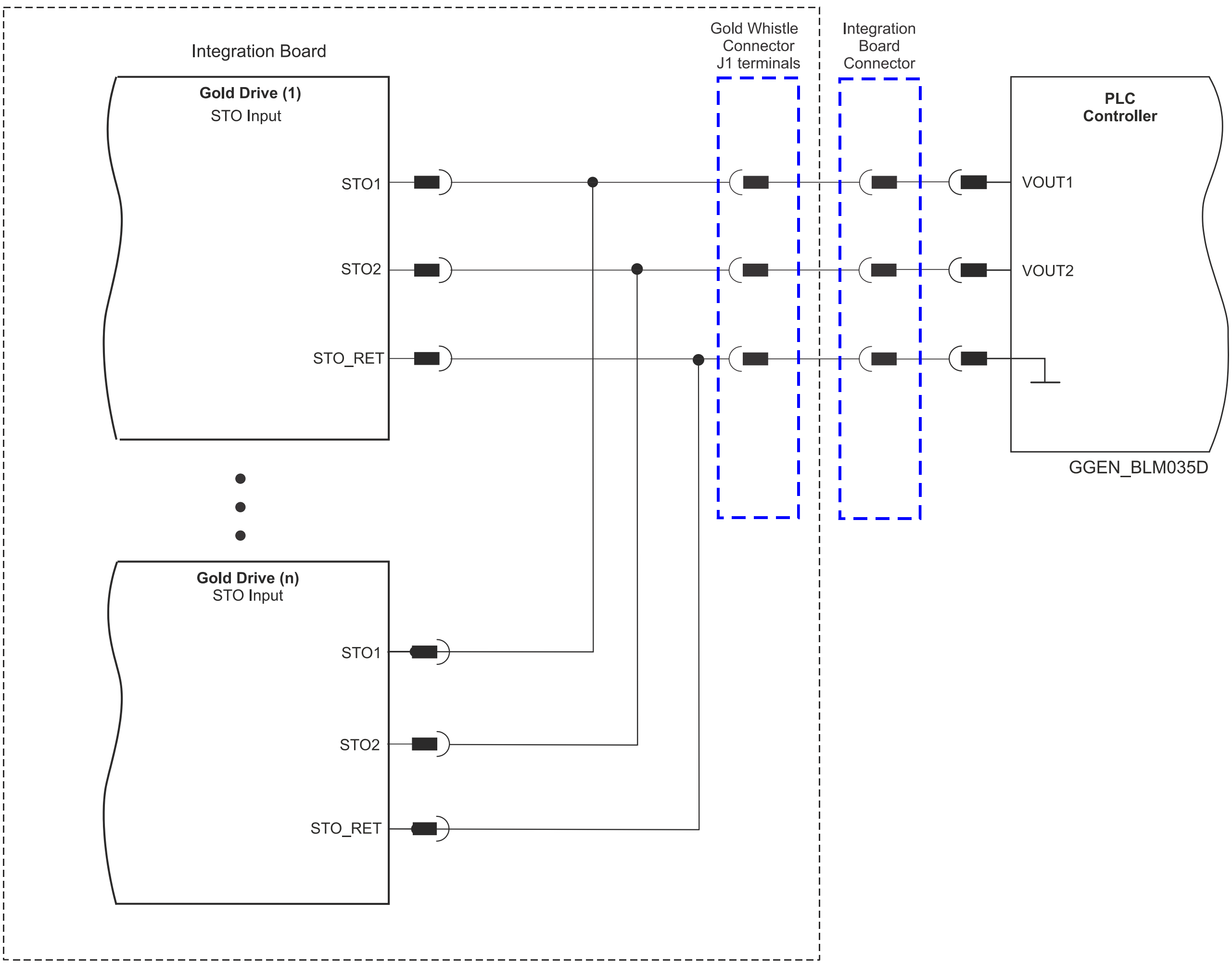


Figure 19: STO Input Status

9.4.4. STO Layout Design

The two digital STO inputs are optically isolated from the other parts of the Gold Board Level Modules Servo Drive, and share one return line, STO_RET. To retain isolation, the Input Return pin and all other conductors on the input circuit must be laid out separately. The STO1, STO2, and STO Return signals must maintain clearance as required by the STO standard EN 60664-1 Table F.2. According to EN 60664-1 Table F.2 the following clearance should be maintained:

Pollution degree	Description	Minimum Clearance in air up to 2000 m above sea level
1	"No pollution or only dry, non-conductive pollution occurs. The pollution has no influence".	0.04mm
2	"Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected".	0.2mm
3	"Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected".	0.8mm

The following figure describes the layout of the interface of J1 connector.

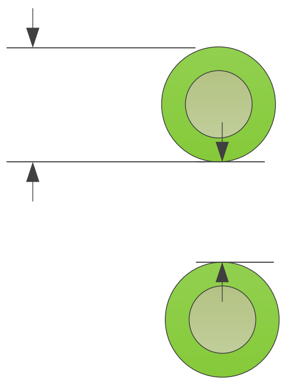


Figure 20: J1 Connector Interface Layout

In Figure 20, the clearances between the pads is 8mil (0.2mm). This means that only Pollution Degree 1 and 2 with a minimum clearance of 0.2mm will be acceptable. If the environmental situation is Pollution Degree 3, the interface board should be coated with Acrylic Conformal Coating, in order to achieve a better Pollution degree.

9.5. STO Output Status (upon customer request)

The STO Output Status can reveal the status of the STO for user diagnostic proposes.

Table 6 describes the STO Output Status:

STO1_IN	STO2_IN	STO_Output Status
0	0	1
0	1	1
1	0	1
1	1	0

Table 6: STO Output Status

Warning: **The STO Output status is not a safety function.**

Figure 21 describes the timing diagram for the STO Output Status.

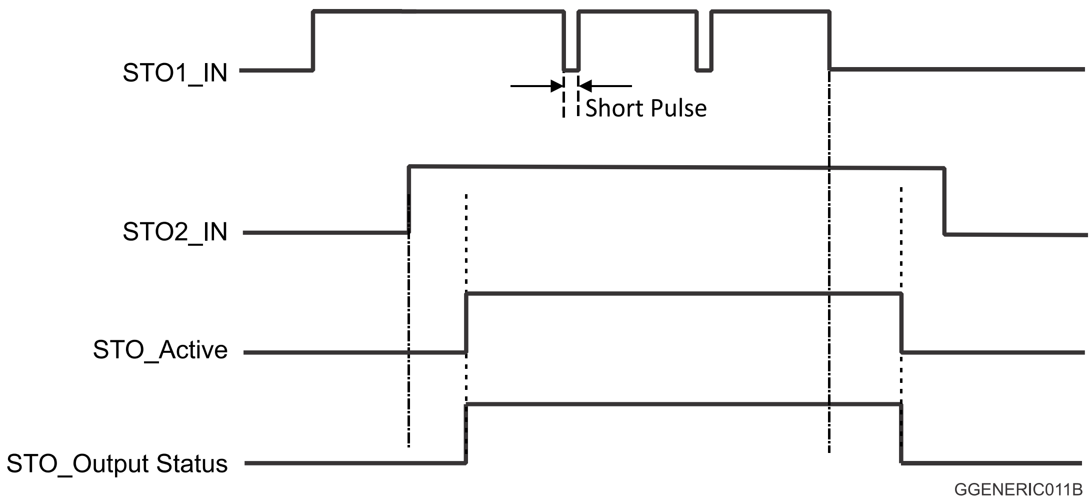


Figure 21: STO Output Status Timing Diagram

Note: **The Polarity of STO Output Status is determined by the OL Command**

The STO output Status can be configured as a regular digital output. The OUT1 or OUT2 can be configured as the STO Output status, which can be connected on the integration board as describe in the following figure:

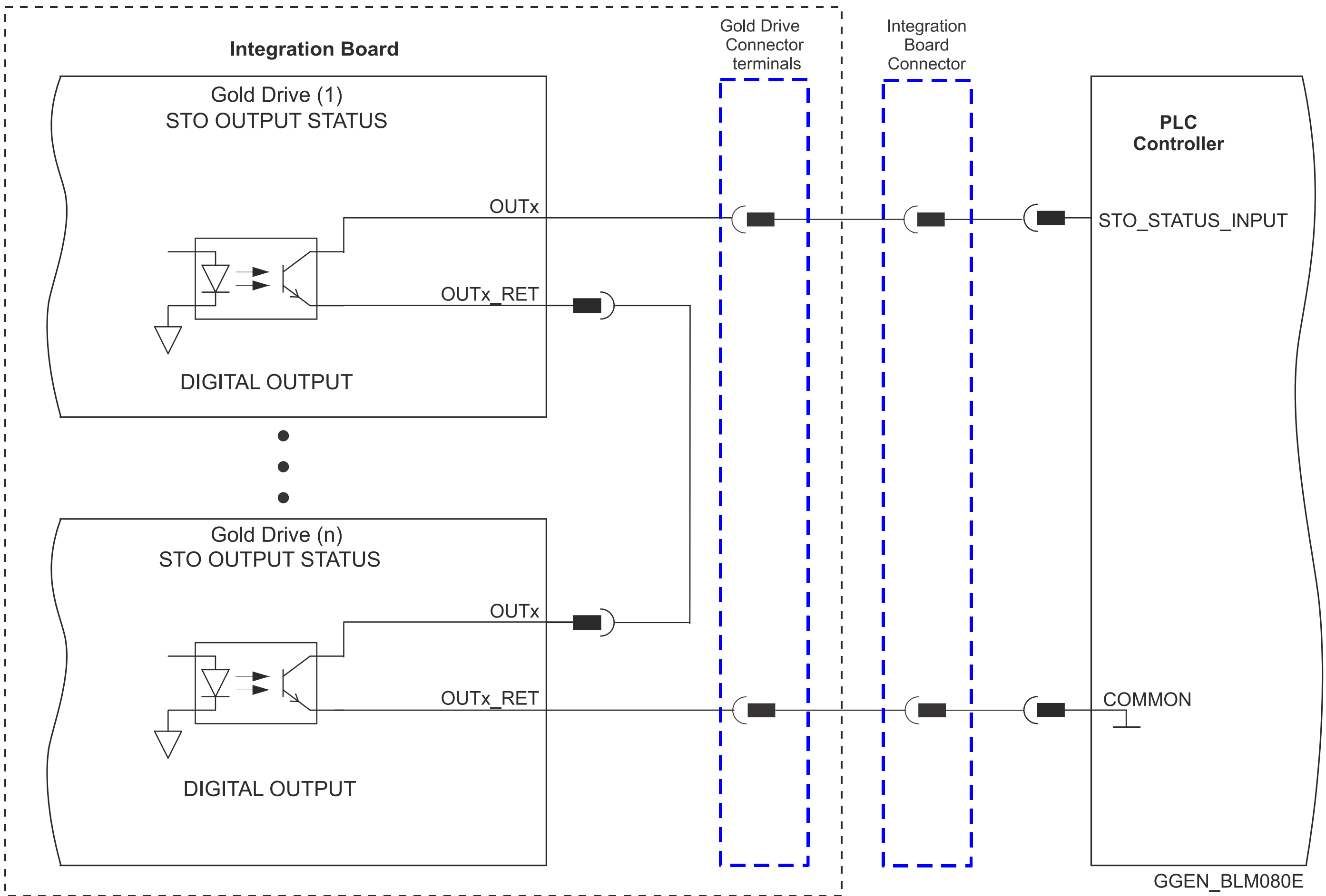


Figure 22: STO Dedicated Output Status

The above connection cannot be implemented in the Gold Trombone. The STO Output Status can only be configured in the Gold Trombone, to the following two options:

- Source mode – TTL level

  Or

- Source mode – High Current PLC level

9.6. Diagnostics

The STO diagnostic consists of:

- On demand Diagnostic, and
- Periodic diagnosis

9.6.1. On Demand Diagnostics

This diagnostic is run after start-up and also initiated whenever a change in one of the STO inputs (STO1 or STO2) is detected.

9.6.2. Periodical Diagnostics

The STO diagnostic is also run periodically every 240 msec when the STO is active.

The Voltage monitor checks the power supply continuously. When the voltage monitor detects that the voltage of the power supply is more than 4V and less than 2.6V, it will hold the power supply in the shut-down and after a while turns it on again.

The following objects and Elmo commands support the STO diagnostic status and error reports:

- STO Status Register – available through the communication channels e.g. CAN, EtherCAT or USB. It is also displayed using the Elmo Application Studio software.
- ELMO Status Register
- Drive Status Indication
- STO output status

9.6.3. STO Status Register

The STO status register includes the state machine data at the time the STO error is detected. This register is reported via SDO only in the 0x2086 object. In Elmo, it is reported in the **OV[62]** command. The register includes the following formats:

Bits	Description
0-4	For Elmo's internal use only
5-6	0 – STO full diagnostics is in progress. 1 – STO full diagnostics passed, and STO periodic diagnostics is in progress. 2 - Error is detected.
7	Unused
8-12	Error Code range: 0 to 16 For error codes = 2, 3, 6, 8, 9, 12, 13: Please check if the rise time (Time 9 in Figure 25: STO Rise and Fall Time) and the fall time (Time 10 in Figure 25: STO Rise and Fall Time) of the STO_IN signals are accordance with the requirements of section 9.9 STO Timing. This problem can occur if a high capacitance is connected to the STO inputs

Bits	Description
	(e.g. the STO inputs are connected to the main power) causing a violation of the STO timing. Elmo recommends to separate the STO logic power from the system main power. For other error codes = 0, 1, 4, 5, 7, 10, 11, 14, 15, 16: If the error code occurs repeatedly after power up, return the product to the factory.
13-15	Unused
16-20	For Elmo's internal use only
21-31	Unused

Table 7: Object 0x2086 (OV[62]) STO Status Register

9.6.4. ELMO Status Register

The Elmo Status Register, or **SR** command, is a 32bit register which includes the statuses reported from the drive. The Elmo Status Register can be monitored using the DS402 protocol object 0x1002. The Object 0x1002 is mapable. The following are the STO status bits:

Bits	Description
14	STO1_Diag2 current status.
15	STO2_Diag2 current status.
31	STO error. The status can be read in object 0x2086, and further detailed state machine values can be read in **OV[62]** command.

Table 8: Object 0x1002 STO Related bits

Refer to the Gold Command Reference for further details.

9.6.5. Drive Status Indicator

This red/green dual LED is used for immediate indication of the following states:

- **Initiation state**
  In this state, the LED indicates whether the drive is in the boot state (blinking red) or in the operational state (steady red).
- **Working state**
  In this state, the LED indicates whether the drive is in an amplifier failure state (red) or is ready to enable the motor (green).

If the STO function is active (i.e. disabling motor operation) or if STO diagnostic error is detected, the LED is red. Motor cannot be enabled in this state.

9.6.6. STO Output Status – GO[1 to 4]

The GO command routes the STO status to a specific output. The **GO[x]** index indicates the output number varying between 1 to 16, and the value indicates the output source. The STO output status can be routed to one of the outputs ranging from 1 to 4, by setting the **GO[1 to 4]** value to 7.

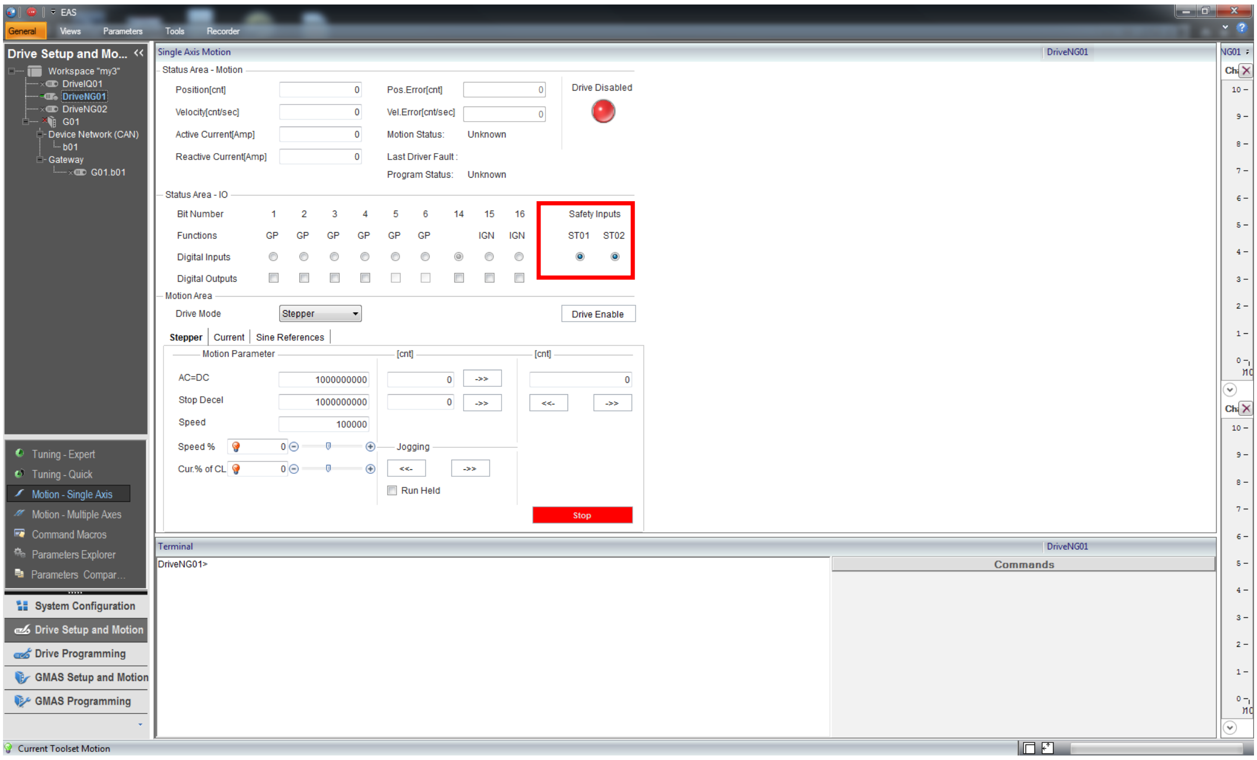
For example by setting **GO[1]**=7, output '1' will behave as "STO output status" signal.

Refer to the Gold Command Reference for further details.

9.7. STO Start-Up

After installing, make sure that the cables are connected correctly and the STO safety mechanism functions as required according to the following procedure:

1. Open the EAS and its System Configuration window.
   Connect the drive via the USB, Ethernet, or other communication channel.
2. Power on the main power supply to the drive(s).
3. Configure the drive(s) in the EAS.
4. Click Drive Setup and Motion and select Motion.
   Locate and view the *Safety Inputs* green LEDs. If necessary, click Refresh to refresh the LED display.



5. Turn OFF /ON the STOx_IN. Check the EAS LED display to see whether the STO status behaves according to the following table:

Step #	STO1_IN	STO2_IN	STO Operation
1	Non-Active	Non-Active	Disable
2	Active	Non-Active	Disable
3	Non-Active	Active	Disable
4	Active	Active	Enable

Table 9: State of STO

If an error is detected during the diagnostics, the error led in the EAS screen is lit.

9.8. Maintenance

To maintain the safety level, the customer shall run the diagnostic of the STO periodically.
To run the STO diagnostic, the STO input lines should be changed from active level (HIGH) to de-active level (LOW) for more than 10msec.

- For SIL 2 the STO diagnostic must be executed periodically within one year.
- For SIL 3 the STO diagnostic must be executed periodically every 24 hours.

9.9. STO Timing

This section describes the STO timing (Figure 23). When the Software enables the STO function, STO_EN is high.

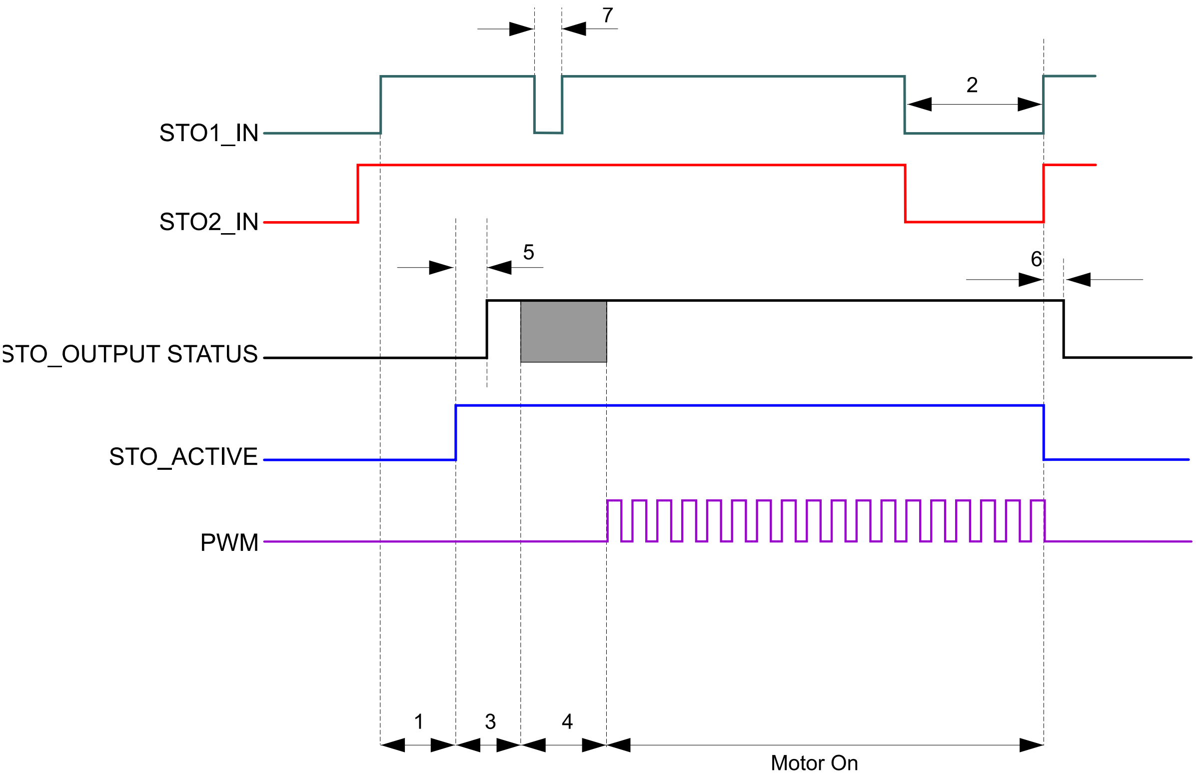


Figure 23: STO Timing Diagram

The following table summarizes the timing parameter of the STO described in Figure 23:

Time	Description	Time
1	The minimum STOx_IN width required for STO activation	5 msec
2	The minimum STOx_IN width that requires for STO deactivation (the Motor is disabled)	9 msec
3	The time from the STO activation until the STO diagnostic can start. The STO signals must be active continuously, for the diagnostic to start.	12 msec
4	Diagnostic time, after which the motor can be enabled **Note: The STO_Output_Status changes during the diagnostic time.**	34 msec
5	The maximum time for STO Output Status on	1 msec

Time	Description	Time
6	The maximum time for STO Output Status off	1 msec
7	The maximum width of the short pulse	1 msec

The Process Safety time described for Time 8 in the table below, is the STO periodic diagnostic which is executed every “Process safety time”. The Diagnostic does not influence the Motor operation.

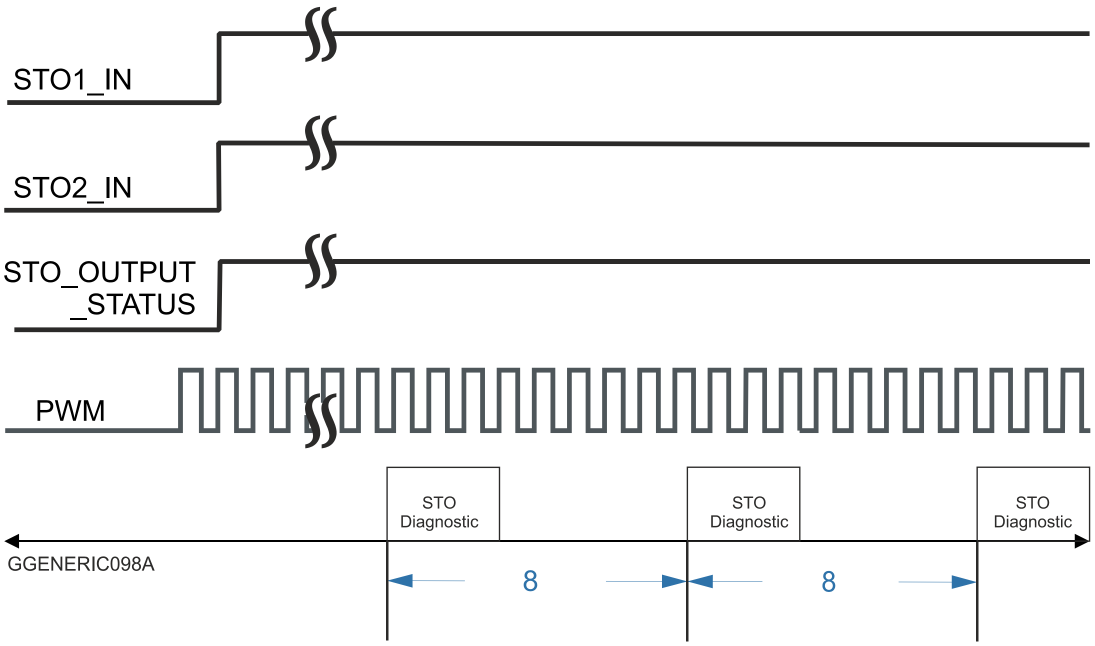


Figure 24: Process Safety Time

Time	Description	Time
8	Process Safety time The STO periodic diagnostic is executed every “Process safety time”. The Diagnostic does not influence the Motor operation	240 msec

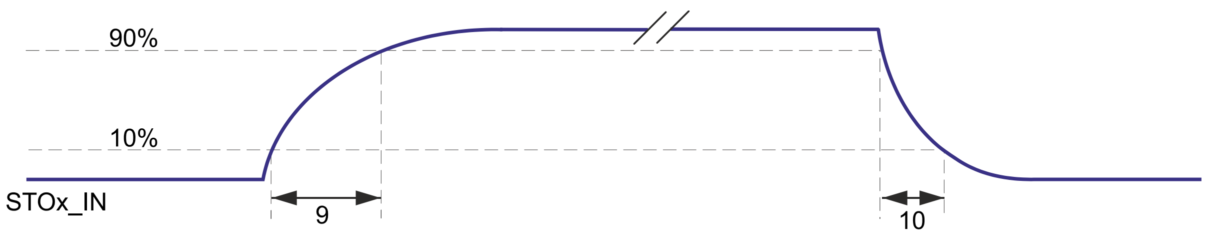


Figure 25: STO Rise and Fall Time

Time	Description	Time
9	Maximum STO rise time	1.5 msec
10	Maximum STO fall time	1.5 msec

Table 10: STO Timing

9.10. STO Standards Data

The following table summarizes the STO standards data.

Data	Value
EN ISO 13849-1:2008	
PL	e
Category	3
MTTFd	Higher than 100years
DC	97%
IEC 61508	
SIL	3
PFH	2.71 E-9
SFF	>90% per channel
Lifetime	20 years

Table 8: STO standards data

Note:

In order to maintain the safety level, the customer shall run the diagnostic of the STO periodically. Therefore to run the STO diagnostic the STO input lines should be changed from active level (HIGH) to de-active Level (LOW) for more than 10msec.

For SIL 2 the STO diagnostic must be executed periodically within one year.

For SIL 3 the STO diagnostic must be executed periodically every 24 hours.

Chapter 10: Feedbacks

10.1. Introduction

The Gold Board Level Modules Servo Drive has two configurable motion sensor input ports and one output port: Port A and port B are input ports, port C is the feedback output port. Motion sensors from the controlled motor and from other sources can be connected to any of the available inputs on either port A or B. Software configuration designates each input a role, e.g., the incremental encoder on port B is the controlled motor position feedback, the Hall sensors on port A are commutation feedback, and the incremental encoder on port A is follower input.

The following table describes Gold Servo Drives support of Dual Loop Configurations and Dual Encoders operation.

Port B \ Port A	Incremental Encoder with Commutation Digital Halls	Incremental Encoder without Commutation Digital Halls	Commutation Digital Halls	Absolute Serial Encoder	Absolute Serial Encoder (Absolute) & Digital Halls
Incremental Encoder	√	√	√	√	√
Analog Encoder	√	√	√	√	√
Analog Halls	√	√	√	√	√
Resolver	√	√	√	√	√

For more information about sensors and their use refer to the Gold Line Administrative Manual.

10.2. Feedback Supply Voltage

The Gold Board Level Modules Servo Drive has two feedback ports (Main and Auxiliary). The Gold Board Level Modules Servo Drive supplies voltage only to the main feedback device and to the auxiliary feedback device if needed.

Feature	Details
Encoder supply voltage	5 V ±5%
Maximum Encoder supply current	2 x 200 mA Refer to the specific installation guide

10.3. Feedback Port A

Port A supports the following sensor inputs:

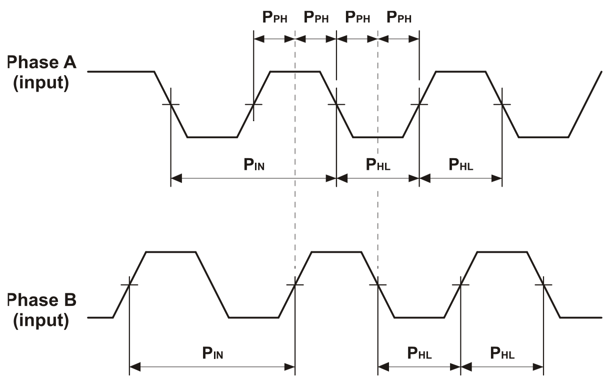
- Digital Hall sensors
- Incremental encoder or absolute serial encoder
- Differential pulse-width modulation (PWM) signal input can be connected to port A. The PWM signal (only pulses) can be connected to one of the pins in port A (A/B or index) depending on other feedbacks.
- Differential Pulse & Direction signal inputs can be connected to port A. The signals can be connected to the applicable pair of matching + and – encoder channels and are configurable by software.

The port A includes the following signals:

Incremental Encoder		Absolute Serial Encoder	
Signal	**Function**	**Signal**	**Function**
PortA_ENC_A+	Channel A +	ABS_CLK+	Absolute encoder clock+
PortA_ENC_A-	Channel A -	ABS_CLK-	Absolute encoder clock-
PortA_ENC_B+	Channel B+	ABS_DATA+	Absolute encoder data+
PortA_ENC_B-	Channel B -	ABS_DATA-	Absolute encoder data -
PortA_ENC_INDEX+	Index+	Reserved	Reserved
PortA_ENC_INDEX-	Index -	Reserved	Reserved
HA	Hall sensor A	HA	Hall sensor A
HB	Hall sensor B	HB	Hall sensor B
HC	Hall sensor C	HC	Hall sensor C

Table 11: Port A Pin Assignments

10.3.1. Incremental Encoder

Feature	Details
Encoder format	• A, B and Index • Differential • Quadrature
Interface	RS-422
Input resistance	Differential: 120 Ω
Maximum incremental encoder frequency	Maximum absolute: 75 Megacounts per second (18 MHz PPS (Pulses Per Second))
Minimum quadrature input period (PIN)	53 nsec
Minimum quadrature input high/low period (PHL)	26 nsec
Minimum quadrature phase period (PPH)	13 nsec
Maximum encoder input voltage range	Common mode: ±7 V Differential mode: ±7 V
 **Figure 26: Main Feedback - Encoder Phase Diagram**	
Capture with differential input Port A	T > 0.1 µsec if the differential input functionality is set to touch probe/capture (index/strobe).

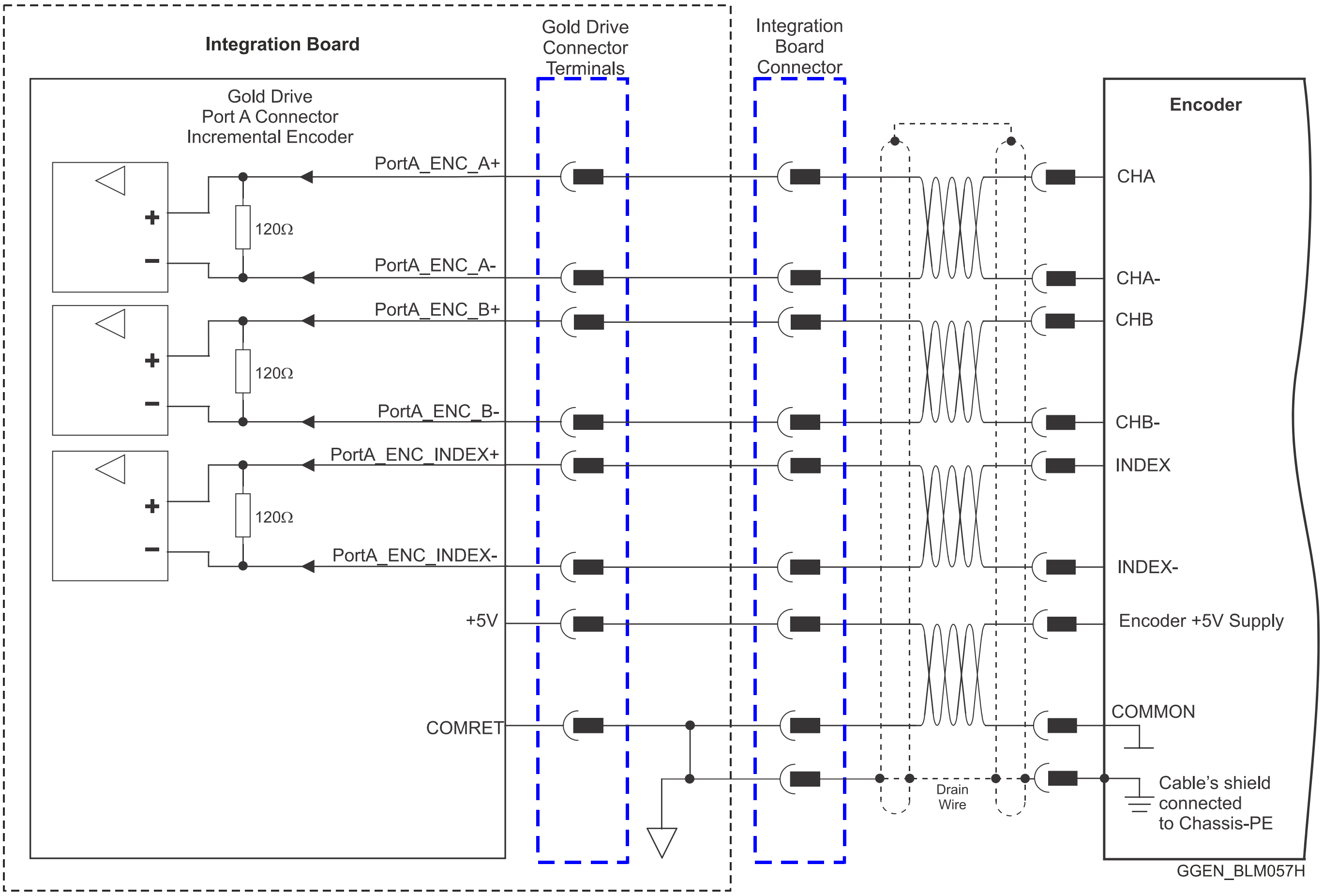


Figure 27: Port A Incremental Encoder Input – Recommended Connection Diagram

10.3.2. Hall Sensors

Feature	Details
Halls inputs	• HA, HB, HC. • 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} : 3 kHz

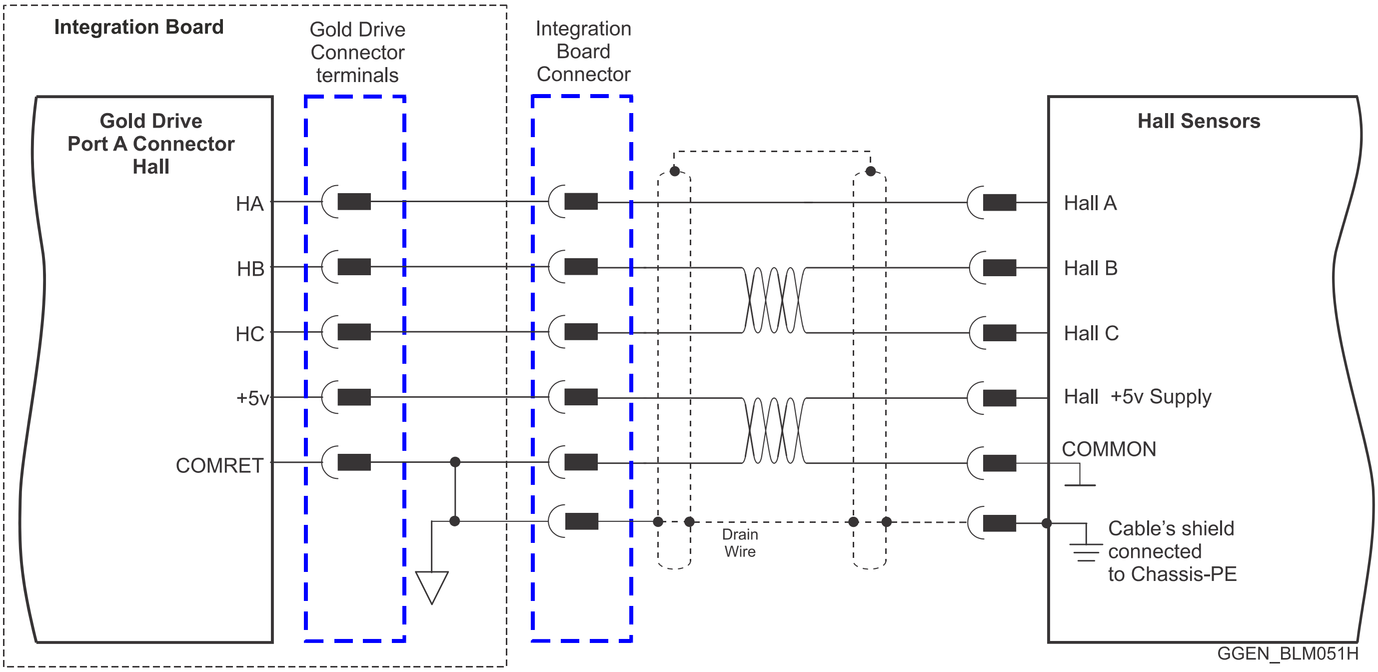


Figure 28: Hall Sensors Connection Diagram

10.3.3. Absolute Serial Encoder

The following Absolute Encoder are supported:

- EnDat 2.2
- Biss C and Biss B
- Pansonic
- Tamagawa
- SSI
- Sanyo
- Nikon
- Hiperface

Gold Drives support various types of True Absolute Serial Interfaces Encoders. The position data is acquired by a communication transmission cycle, generated by the drive on every 2nd TS (TS - on the position and velocity loops routines), and is subsequently used for the servo current, velocity and position loops. Some absolute sensor protocols have up to 96 bits of data (composed of commands / position information / status / errors / CRC codes / etc.), that have to be retrieved on every transmission cycle.

Sensors also require different recovery time, that is the minimal time between each two consecutive transmission cycles, in some cases, can be as high as 40 µsec. As the sample rate of the Gold drives can be as low as 50 µsec, the serial absolute position data should be read at rates of at least 10 kHz (each 2×TS or 100 µsec). For this reason, the Gold drive serial interfaces operate at fast clock rates, of either 2.5 MHz or 1.25 MHz. For some slow (low resolutions) SSI interface encoders, Elmo has also implemented serial interfaces at frequency of 625 KHz.

It is important to note that using higher transmission rates (> 2.5 MHz) has no advantage whatsoever, as the data is already read on every velocity loop cycle. Using higher data rates will limit the signal glitch filtering ability, and eventually reduce the transmission immunity to noises.

The communication transmission cycle clock sequence is initiated by the Gold Drive, and is synchronized to the drive servo control loops ISR and PWM pulses within a few nanoseconds. This is important since all absolute sensors also latch (lock) the encoder position value at that point (usually at the falling edge of the first clock of any new transmission cycle). Any jitter at this synchronization would have resulted in significant velocity jitters and would have impaired the drive servo loop performances.

The following is the diagram connection of the **Endat, Biss**, and **SSI**:

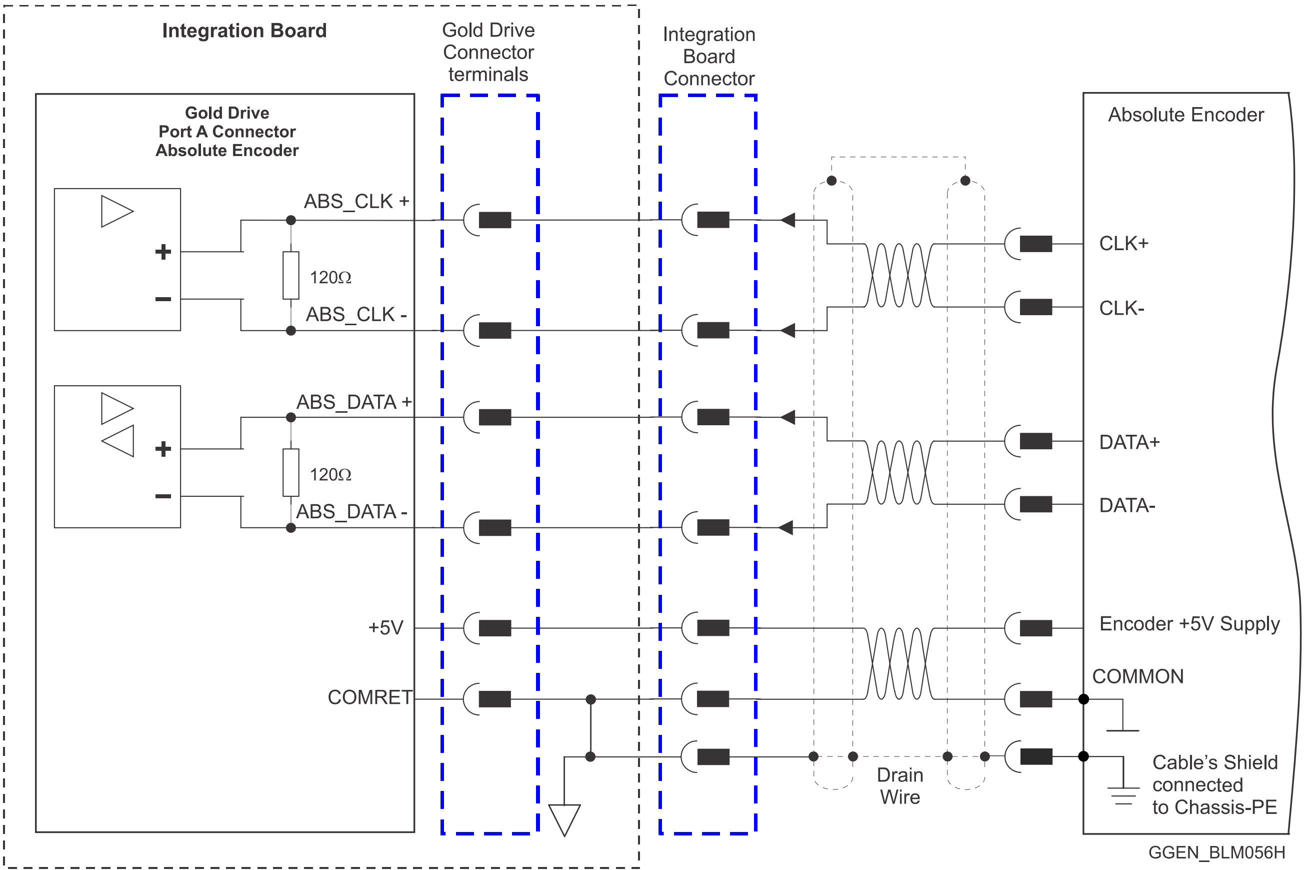


Figure 29: Absolute Serial Encoder – Recommended Connection Diagram for Endat, Biss, SSI

The following is the diagram connection of the Pansonic, Tamgawai, Sanyo, and Nikon:

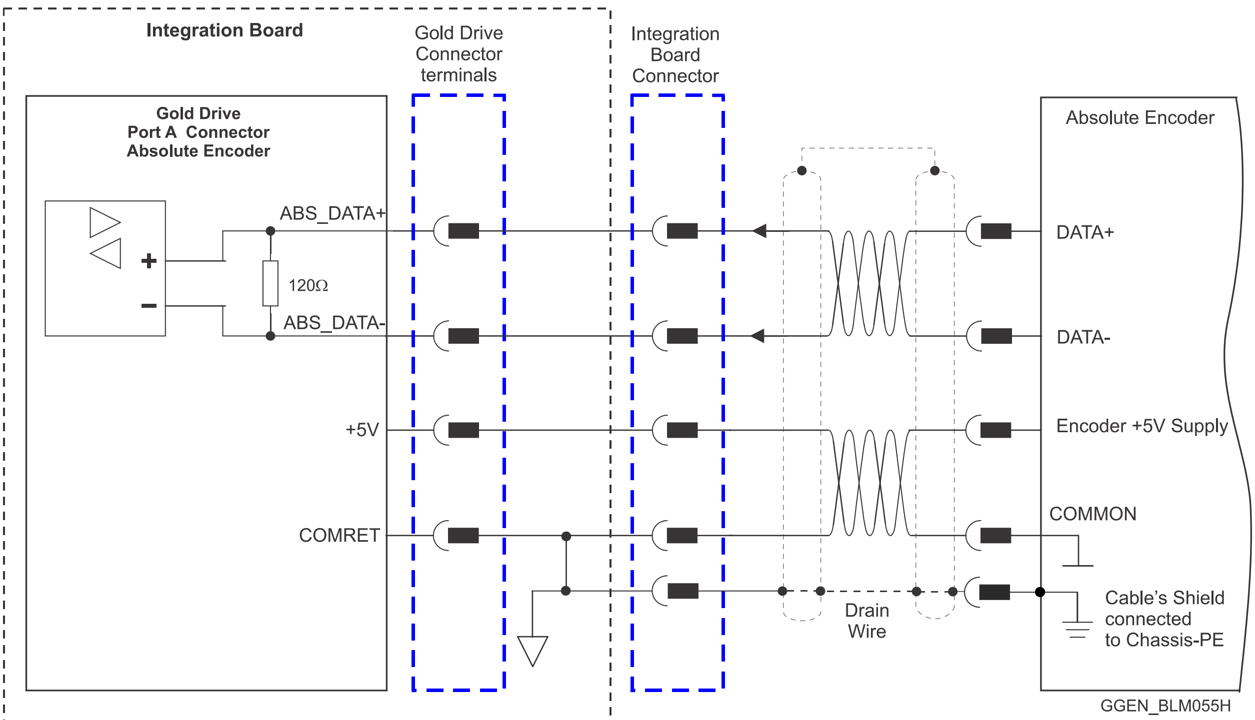


Figure 30: Absolute Serial Encoder – Recommended Connection Diagram for Pansonic, Tamgawai, Sanyo / Nikon

10.3.3.1. EnDat 2.2

Feature	Details
Interface	• RS-485 • Clock – Differential output line (clock+, Clock-) • Data – Differential bidirectional line (Data+, Data-,)
Protocol	Serial Protocol
Input Resistance	Differential 120 Ω
Transmission Rate	2.5 MHz, 1.25Mhz
Cable length	Up to 100 meters cable operation was tested successfully.
Resolution	Elmo supports all known resolutions, both linear (LIC 4000 series) and rotary (ECN series) single and multi-turn devices.
Glitch filter	Advanced (programmable) glitch filtering for better signal noise immunity.
automatic propagation delay compensation	Supported

10.3.3.2. BISS-C and B

The BiSS protocol was developed by IC-Haus. It is a full-duplex (differential Rx/Tx RS-422) serial protocol.

- The BiSS Protocol defines both the BiSS B (that support both register and sensor modes) and BiSS C (sensor mode only).
- Gold drives support BiSS B (sensor mode only) and BiSS C, in single device (slave) point-to-point configuration.

Feature	Details
Interface	• RS-485 • Clock – Differential output line (clock+, Clock-) • Data – Differential bidirectional line (Data+, Data-,)
Protocol	Serial Protocol
Input Resistance	Differential 120 Ω
Transmission Rate	2.5 MHz, 1.25Mhz
Cable length	Up to 100 meters cable operation was tested successfully.
Glitch filter	Advanced (programmable) glitch filtering for better signal noise immunity.
Automatic propagation delay compensation	Supported

10.3.3.3. Panasonic

Feature	Details
Interface	• RS-485 • Data – Differential bidirectional line (Data+, Data-,)
Protocol	• Half -duplex serial protocol (NRZ)
Input Resistance	Differential 120 Ω
Transmission Rate	Only 2.5 MHz,
Cable length	Up to 100 meters cable operation was tested successfully.
Glitch filter	Advanced (programmable) glitch filtering for better signal noise immunity.
Automatic propagation delay compensation	Supported

10.3.3.4. Tamagawa

Feature	Details
Interface	• RS-485 • Data – Differential bidirectional line (Data+, Data-,)
Protocol	• Half -duplex serial protocol (NRZ)
Input Resistance	Differential 120 Ω
Transmission Rate	Only 2.5 MHz
Cable length	Up to 100 meters cable operation was tested successfully.
Glitch filter	Advanced (programmable) glitch filtering for better signal noise immunity
Automatic propagation delay compensation	Supported

10.3.3.5. Sanyo / Nikon

Feature	Details
Interface	• RS-485 • Data – Differential bidirectional line (Data+, Data-,)
Protocol	• Half -duplex serial protocol (NRZ)
Input Resistance	Differential 120 Ω
Transmission Rate	Only 2.5 MHz,
Cable length	Up to 100 meters cable operation was tested successfully.
Glitch filter	advanced (programmable) glitch filtering for better signal noise immunity.
Automatic propagation delay compensation	Supported

10.3.3.6. SSI

Feature	Details
Interface	RS-485 Clock – Differential output line (clock+, Clock-) Data – Differential bidirectional line (Data+, Data-,)
Protocol	Serial Protocol. The protocol is left open for vendor specific implementation. It does not define any signal integrity fields, error detection bits, "CRC", or Error Bits, etc.
Input Resistance	Differential 120 Ω
Transmission Rate	2.5 MHz, 1.25Mhz, 625Khz (For some slow (low resolutions) SSI sensors)
Cable length	<20M @ 1.25Mhz <35M @ 625Khz
Glitch filter	Advanced (programmable) glitch filtering for better signal noise immunity.
Automatic propagation delay compensation	Because SSI protocol does not define transmission start and stop bits, automatic propagation delay compensation **cannot** be implemented in SSI

10.3.3.7. Hiperface

Stegmann (now SICK) developed the Hiperface interfaces, based on a mixed serial digital interface and analog (SIN/COS) interfaces. The serial digital interface is a UART communication protocol transferred over an RS-485 physical link, connected to the GOLD Servo Drive Port A ABS_Data+ and ABS_Data-. The Analog (Sin/Cos) interfaces is connected to GOLD Servo Drive Port B SIN+/SIN- and COS+/COS-. The Hiperface requires 7-12 VDC for operation (not provided by the Gold servo drive) provided by the user.

The following figure describes the connection diagram.

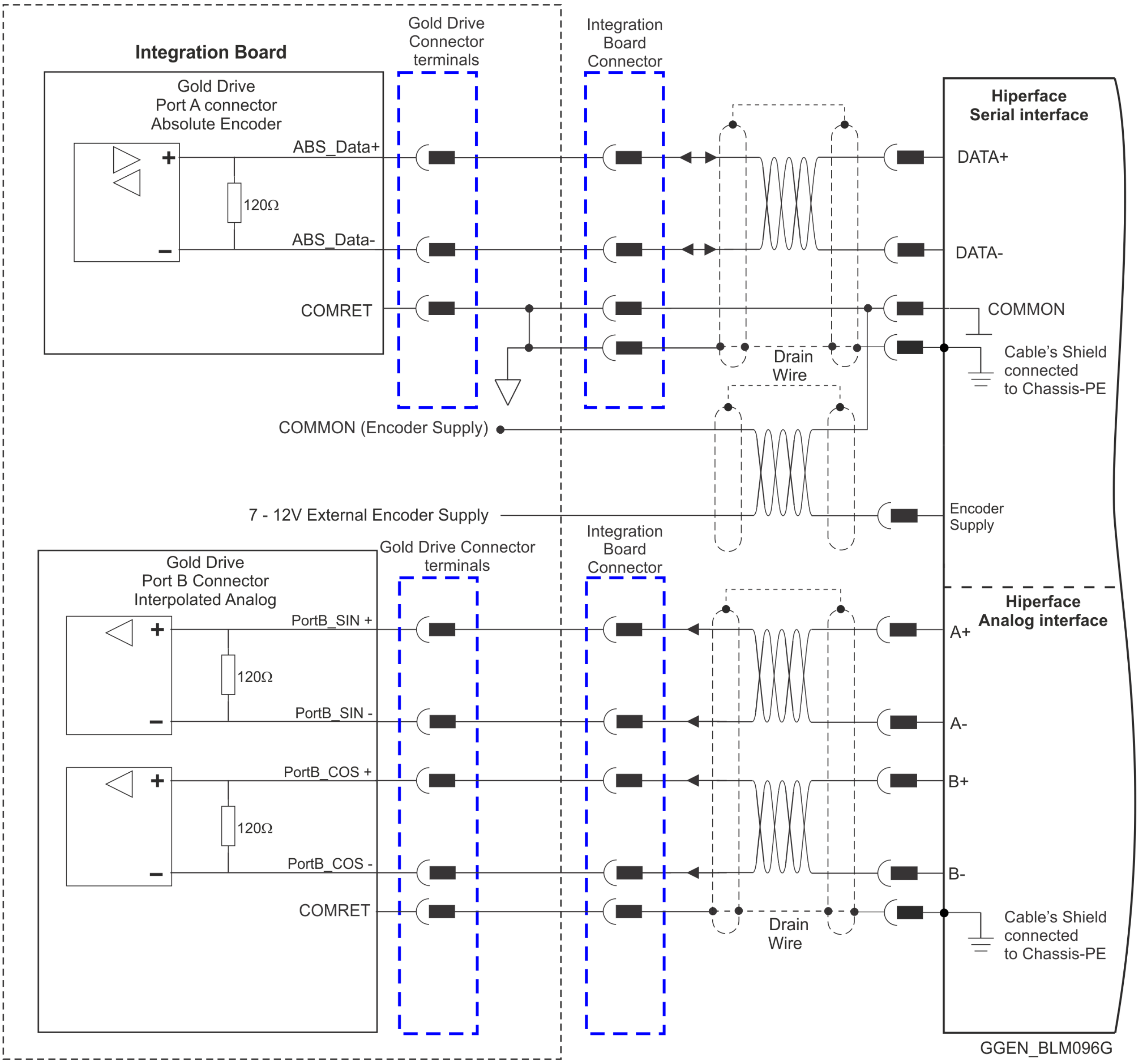


Figure 31: Absolute Serial Encoder – Recommended Connection Diagram for Stegmann Hiperface

Note: When the Hiperface protocol is used the RS232 in not available

10.4. Feedback Port B

Port B supports any of the following sensors:

- Incremental encoder, interpolated analog encoder or analog Hall sensors

Or

- Resolver (separate hardware option)

Differential PWM signal input can be connected to port B in the models that support input from an incremental encoder. The PWM signal can be connected to the applicable pair of matching + and – encoder channels and is configurable by software.

Differential Pulse & Direction signal inputs can be connected to port B in the models that support input from an incremental encoder. The signals can be connected to the applicable pair of matching + and – encoder channels and are configurable by software.

Table 12 describes the signals of Port B.

	Incremental Encoder		Interpolated Analog Encoder		Resolver	
	Signal	**Function**	**Signal**	**Function**	**Signal**	**Function**
J2-13	PortB_ENC_A+	Channel A+	PortB_ SIN+	Sine+	PortB_ SIN+	Sine+
J2-15	PortB_ENC_A-	Channel A -	PortB_ SIN-	Sine-	PortB_ SIN-	Sine-
J2-17	PortB_ENC_B+	Channel B+	PortB_ COS+	Cosine+	PortB_ COS+	Cosine+
J2-19	PortB_ENC_B-	Channel B-	PortB_ COS-	Cosine-	PortB_ COS-	Cosine-
J2-21	PortB_ENC_INDEX+	Channel_Index+	PortB_ANA_Index+	Analog_Index+	PortB_ANA_Index+	RESOLVER_OUT+ Vref f=1/TS, 50 mA Max.
J2-23	PortB_ENC_INDEX-	Channel_Index-	PortB_ANA_Index-	Analog_Index-	PortB_ANA_Index-	RESOLVER_OUT- Vref complement f= 1/TS, 50 mA Maximum

Table 12: Port B Pin Assignments

10.4.1. Incremental Encoder

Feature	Details
Encoder format	• A, B and Index • Differential • Quadrature
Interface	RS-422
Input resistance	Differential: 120 Ω
Maximum incremental encoder frequency	Maximum absolute: 75 Megacounts per second (18 MHz PPS (Pulses Per Second))
Minimum quadrature input period (PIN)	53 nsec
Minimum quadrature input high/low period (PHL)	26 nsec
Minimum quadrature phase period (PPH)	13 nsec
Maximum encoder input voltage range	Common mode: ±7 V Differential mode: ±7 V

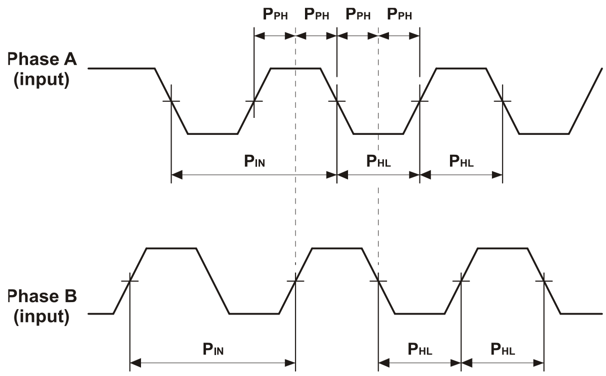


Figure 32: Main Feedback - Encoder Phase Diagram

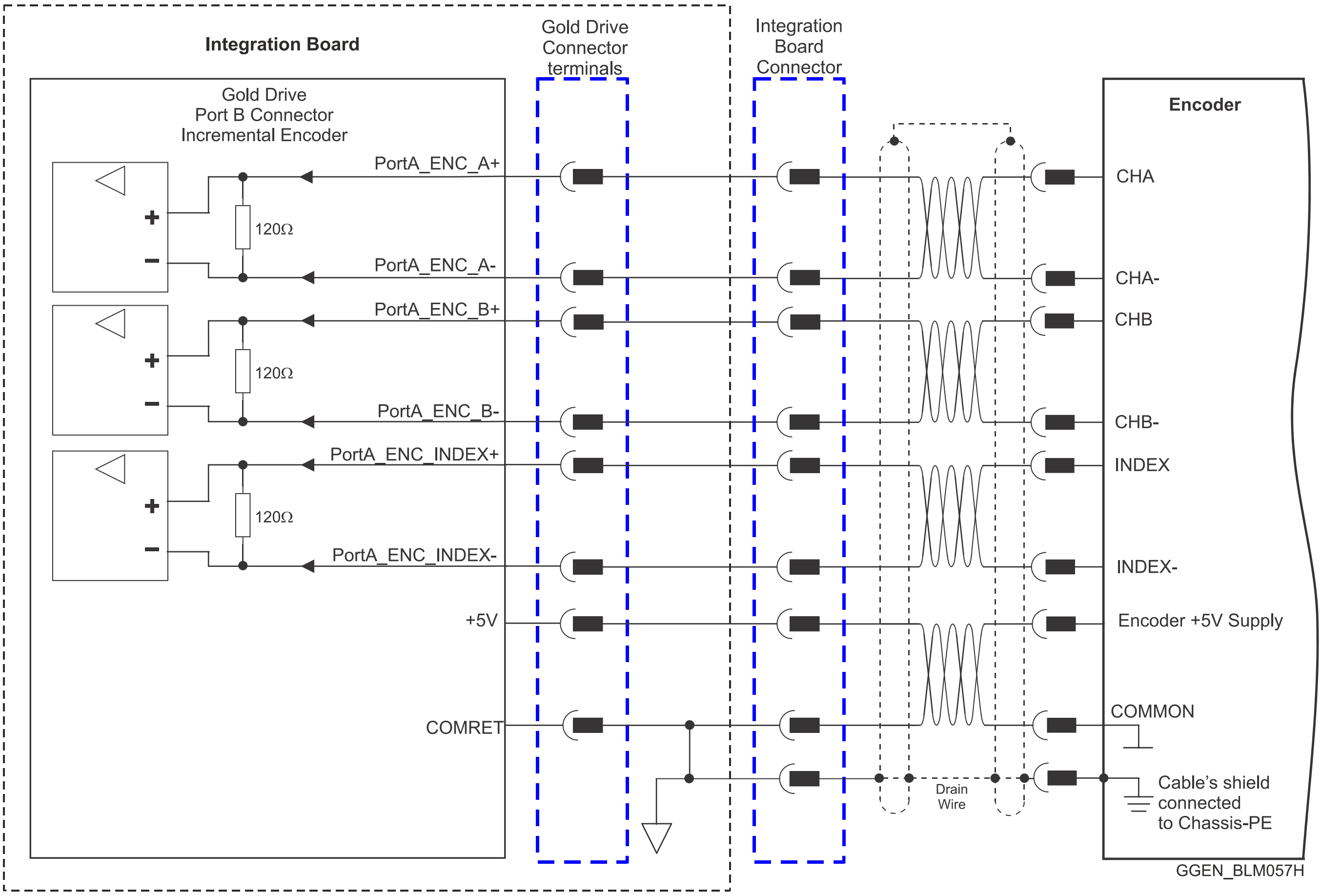


Figure 33: Port B Incremental Encoder Input – Recommended Connection Diagram

10.4.2. 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} : 500 kHz
Interpolation multipliers	Programmable: x4 to x16384 (2 to 13 bits)
Maximum "counts" frequency	2 x 10^9 counts/sec
Automatic errors correction	Signal amplitudes mismatch Signal phase shift Signal offsets
Encoder outputs	See Port C Encoder Outputs specifications, Section 10.5.3.

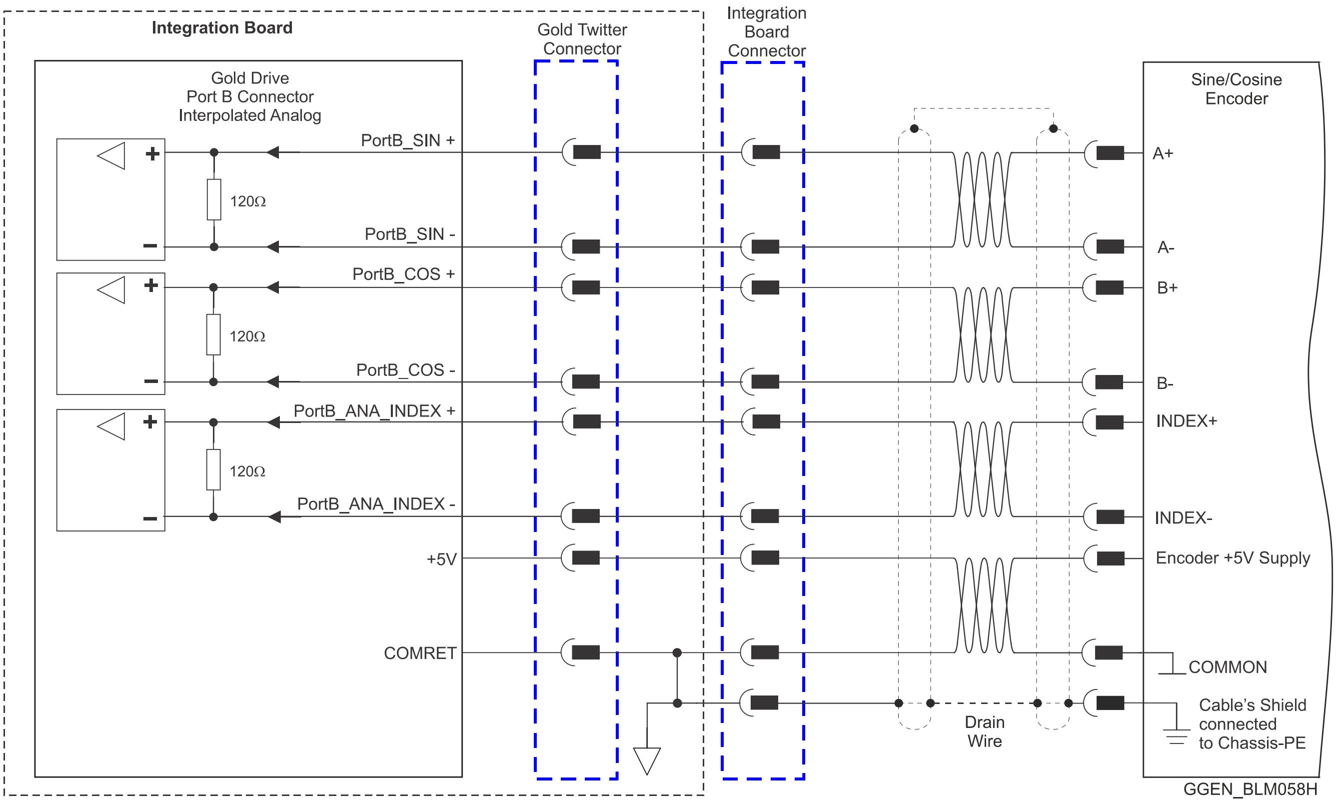


Figure 34: Port B - Interpolated Analog Encoder Connection Diagram

10.4.3. Resolver

Feature	Details
Resolver format	• Sine/Cosine • Differential
Input resistance	Differential 2.49 kΩ
Resolution	Programmable: 2 to 16 bits
Maximum electrical frequency (RPS)	512 revolutions/sec
Resolver transfer ratio	0.5
Reference frequency	Up to 1/Ts (Ts = sample time in seconds)
Reference voltage	Supplied by the Gold Board Level Modules Servo Drive
Reference current	up to ±50 mA RMS
Excitation Voltage	10Vptp, Filtered square wave shape

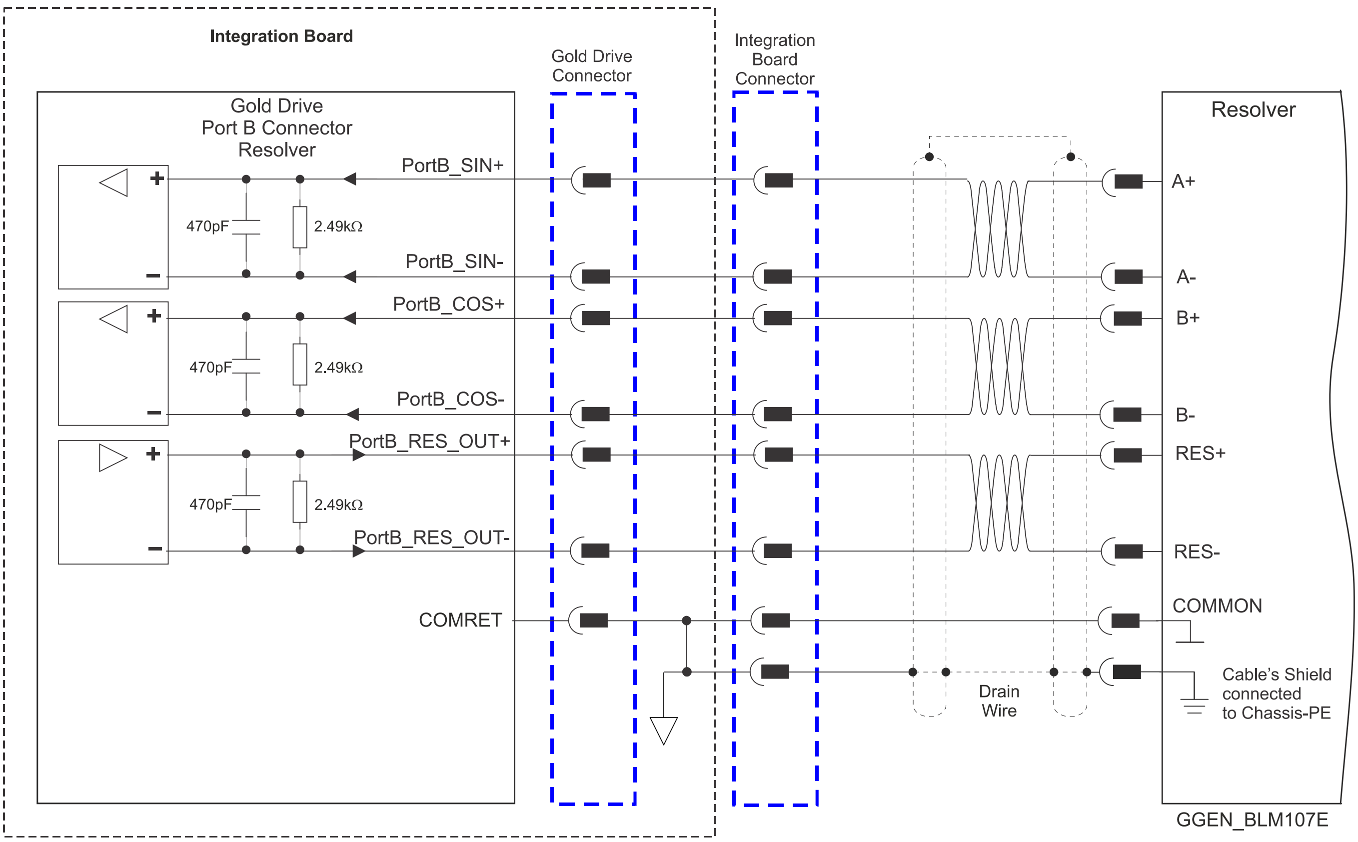


Figure 35: Port B – Resolver Connection Diagram

10.5. Port C –Encoder Output

10.5.1. Introduction

Port C provides emulated encoder output derived from port A or port B feedback inputs, or from internal variables. The output options are:

- Port A/B daisy chain (1:1) for incremental encoder
- Encoder emulation: Emulate any input sensor, digital or analog, or use to emulate an internal variable such as virtual profiler.
- PWM output: Any pair of outputs that is used as an encoder channel (e.g., channel A+ and channel A-) can be configured by software to become PWM output.
- Pulse & Direction output: The output pins that are assigned as channel A and channel B when used as encoder but can be configured by software to become pulse and direction outputs respectively.

This port is used when the Gold Board Level Modules Servo Drive is used:

- As a current amplifier to provide position data to the position controller
- In velocity mode, to provide position data to the position controller
- As a master in follower or ECAM mode

10.5.2. Signals

Port C includes the following signals:

PIN J2	Signal	Function
4	PortC_ENCO_A+	Buffered Channel A output
2	PortC_ENCO_A-	Buffered Channel A complement output
8	PortC_ENCO_B+	Buffered Channel B output
6	PortC_ENCO_B-	Buffered Channel B complement output
12	PortC_ENCO_Index+	Buffered INDEX output
10	PortC_ENCO_Index-	Buffered INDEX complement output

Table 13: Connector J2 – Port C Feedback Out and I/O

10.5.3. Specification

Feature	Details
Emulated output	A, B, Index Differential
Interface	RS-422
Termination	User is required to connect a 120 Ω termination at the end of each differential line
Output current capability	High level output current: I_{OH} (max) = 30 mA Low level output current: I_{OL} > 30 mA
Available as options	Emulated encoder output of any sensor on Port A or Port B Daisy chain Port A or Port B Emulated encoder output of internal variables Emulated encoder outputs of the tachometer Emulated encoder outputs of the potentiometer
Maximum frequency	f_{MAX}: 8 MHz pulses/output
Edge separation between A & B	Programmable number of clocks to allow adequate noise filtering at remote receiver of emulated encoder signals (default 2 MHz)
Index (marker)	Length of pulse is one quadrature (one quarter of an encoder cycle) and synchronized to A&B

10.5.4. Connections

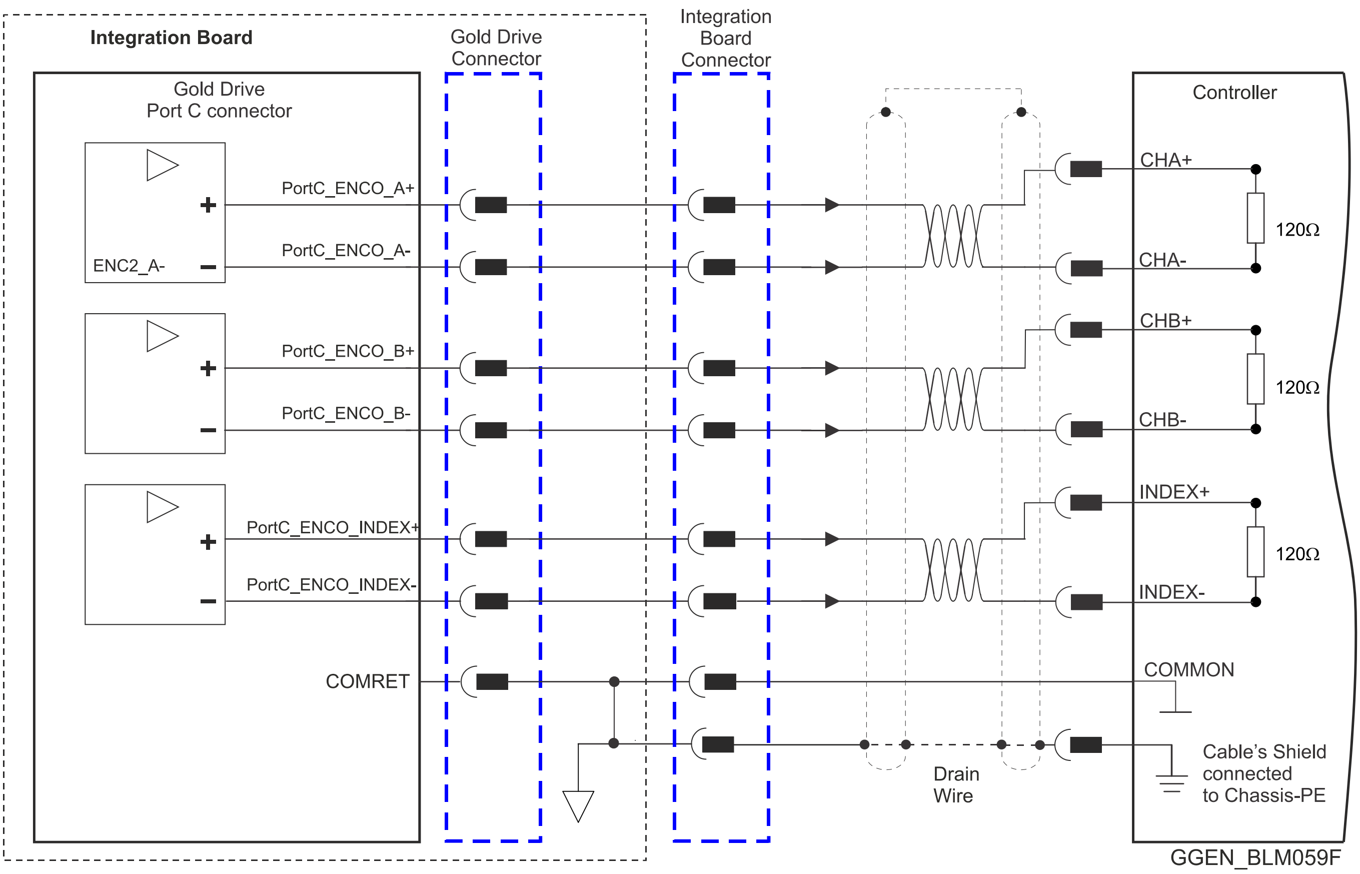


Figure 36: Emulated Encoder Differential Output – Recommended Connection Diagram

10.6. Feedback Layout Design

The **power supply** +5 V conductor should be laid in parallel to the COMRET layer to create a parasitic high frequency capacitor for high frequency noise filtering and RFI reduction.

The Feedback control lines (Port A, Port B and Port C) are RS-422 differential lines. Each pair lines should be routed together and as close as possible

The feedback conductors' actual current is very small but the substantial thickness and width of the conductors will contribute to a better performance and lower interferences.

For optimum feedback, there should be an inner layer with return from both sides. This is optimal from immunity point of view.

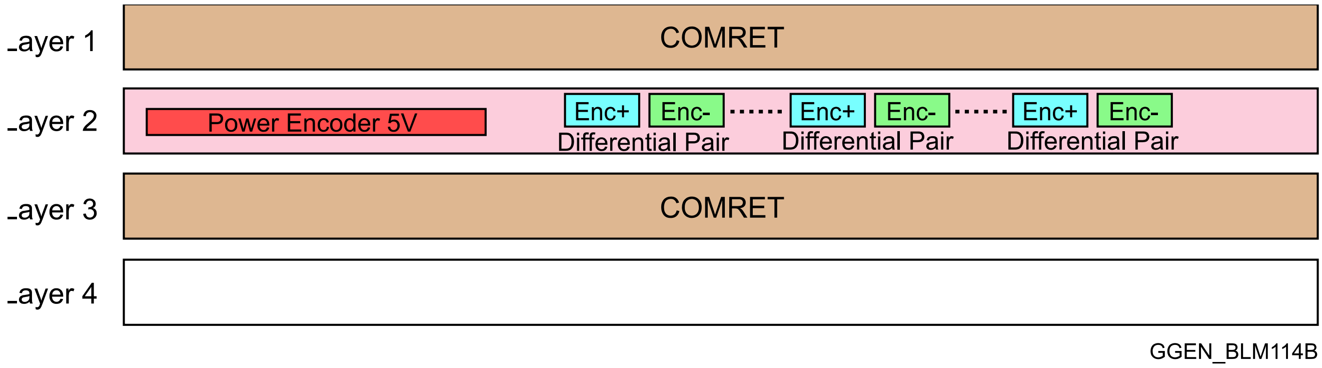


Figure 37: The best feedback

It is possible to layout the feedback with inner return layer in one side.

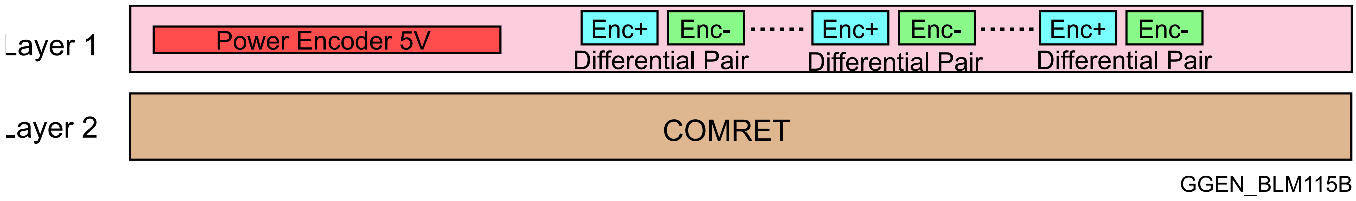


Figure 38: An acceptable feedback

The following is an example of a Feedback with inner return layer, but is not recommended.

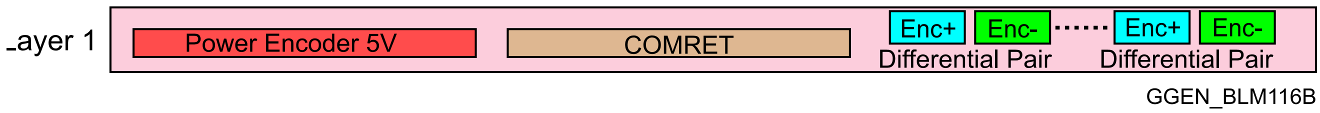


Figure 39: Not recommended feedback

Chapter 11: Digital I/Os

There are a number of differences between the Input/Outputs of the BLM products. This chapter includes three subsections describing the digital IOs of:

- Gold Whistle, Bell, and Guitar
- Gold Trombone
- Gold Twitter

11.1. User I/Os (excluding Gold Trombone & Twitter)

The Gold Whistle Board Level Modules (including Gold Bell, Gold Guitar) have six programmable digital inputs, four digital outputs and two analog inputs.

11.1.1. Digital Inputs

There are six TTL digital inputs. The following are the digital input signals:

Signal	Function
IN1	Programmable digital input 1
IN2	Programmable digital input 2
IN3	Programmable digital input 3
IN4	Programmable digital input 4
IN5	Programmable digital input 5
IN6	Programmable digital input 6
INRET1_6	Programmable input 1 – 6 return The six digital inputs are optically isolated from the other parts of the Gold Board Level Modules Servo Drive

Table 14: Digital Input

11.1.1.1. Source mode – TTL voltage level

Feature	Details
Type of input	Optically isolated
Input current for all inputs	Iin = 3.8 mA @ V_{in} = 5 V
High-level input voltage	3.0 V < V_{in} < 10 V, 5 V typical
Low-level input voltage	0 V < V_{in} < 0.8 V
Minimum pulse width	> 250 µsec
Execution time (all inputs):	0 < T < 250 µsec

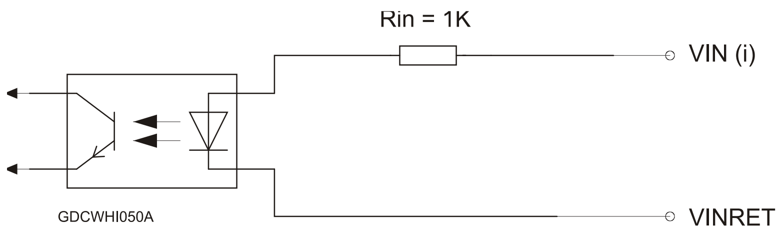
<table>
<tr><th>Feature</th><th>Details</th></tr>
<tr><td>the time from application of voltage on input until execution is complete</td><td></td></tr>
<tr><td>High-speed inputs – 1–6 minimum pulse width, in high-speed mode</td><td>T > 5 μsec if the input functionality is set to latch/capture (index/strobe).
Notes:
Home mode is high-speed mode and can be used for fast capture and precise homing.
Highest speed is achieved when turning on optocouplers.</td></tr>
<tr><td colspan="2">

Figure 40: Digital Input TTL Schematic</td></tr>
<tr><td>Capture with differential input
Port A, Port B Index</td><td>T > 0.1 μsec if the differential input functionality is set to touch probe/capture (index/strobe).</td></tr>
</table>

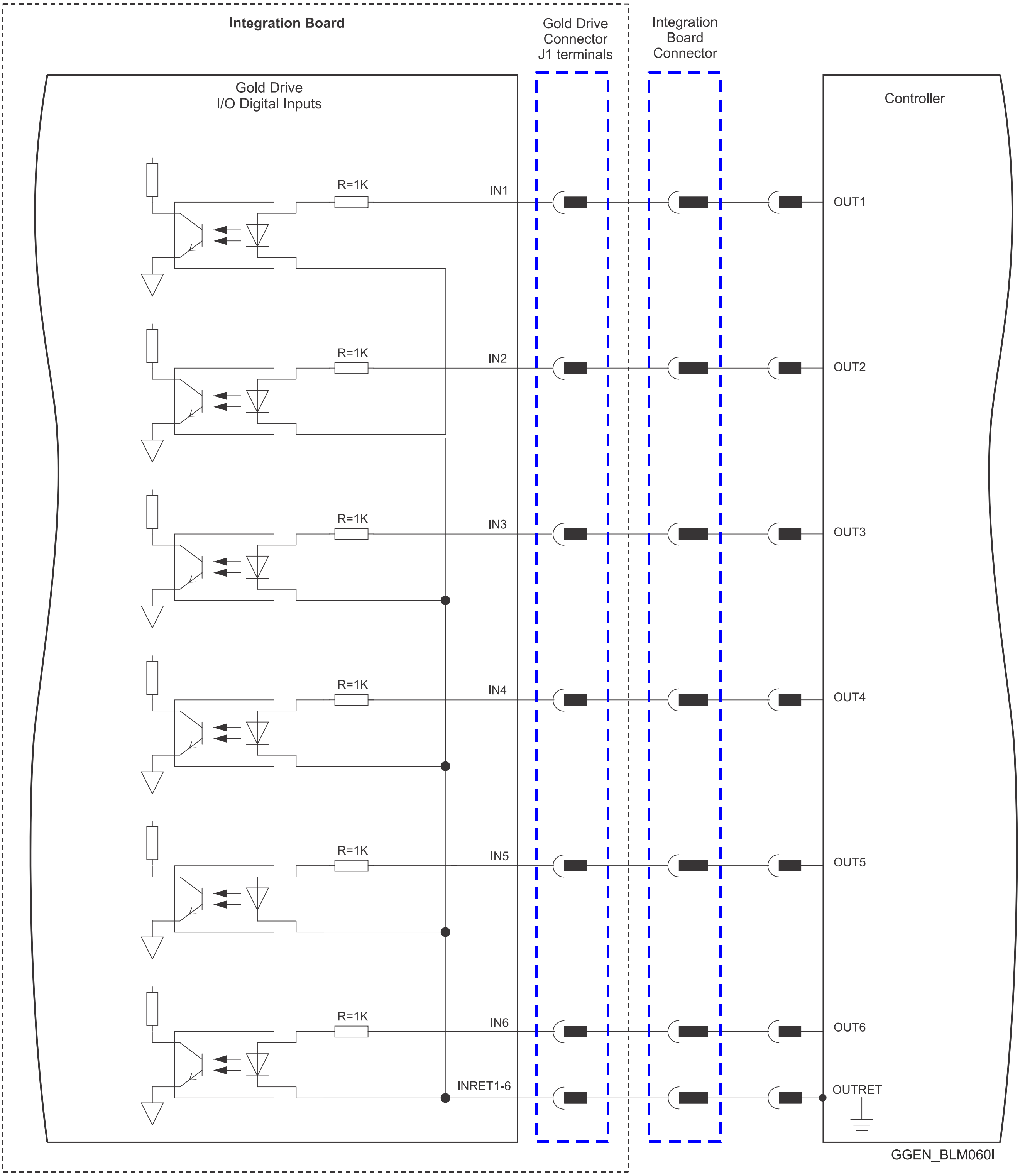


Figure 41: Digital Input TTL Mode Connection Diagram

11.1.1.2. Digital Input Layout Design

The digital inputs conductors' actual current is very small but the substantial thickness and width of the conductors will contribute to a better performance and lower interferences.

The six digital inputs are optically isolated from the other parts of the Gold Board Level Modules Servo Drive. All six inputs share a single common "Return" (INRET1_6). To retain isolation, the Input Return pin, as well as other conductors on the input circuit, must be laid out separately.

11.1.2. Digital Outputs

There are four digital outputs:

- Two optically isolated open collector and open emitter: OUT1 and OUT2
- Two TTL 3.3V non isolated outputs: OUT3 and OUT4

The following are the digital input signals:

J1 Pin	Signal	Function
16	OUT1	Programmable output 1
18	OUTRET1	OUT 1 return
15	OUT2	Programmable output 2
17	OUTRET2	OUT 2 return
22	OUT3	Programmable output 3 not isolated (**3.3V TTL level**)
24	OUT4	Programmable output 4 not isolated (**3.3V TTL level**)

Table 15: Digital Outputs for pin-based nodule products

11.1.2.1. Isolated Open Collector and Open Emitter

The following table describes the electrical specification of theOUT1 and OUT2 outputs:

Feature	Details
Type of output	• Optically isolated Source/Sink
Supply output (VCC)	5 V to 30 V
Max. output current I_{out} (max) (V_{out} = Low)	7 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 7 mA. $R_L = \frac{VCC - VOL}{I_{out}(max)}$
Executable time	0 < T < 250 μsec

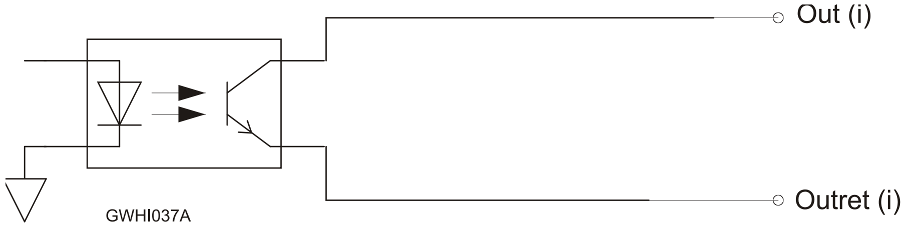


Figure 42: Digital Output Schematic

11.1.2.2. TTL 3.3V Non-Isolated

OUT3 and OUT4 in the BLM, Board Level Module (except Gold Trombone) are TTL 3.3V non isolated outputs. The following table describes the electrical specification of the outputs:

Feature	Details
Type of output	• 3.3V TTL
VOL max (low level)	V_{out} (on) ≤ 0.4 V
VOH min (High level)	2.5V
Max. output current I_{outH} (max)	8 mA

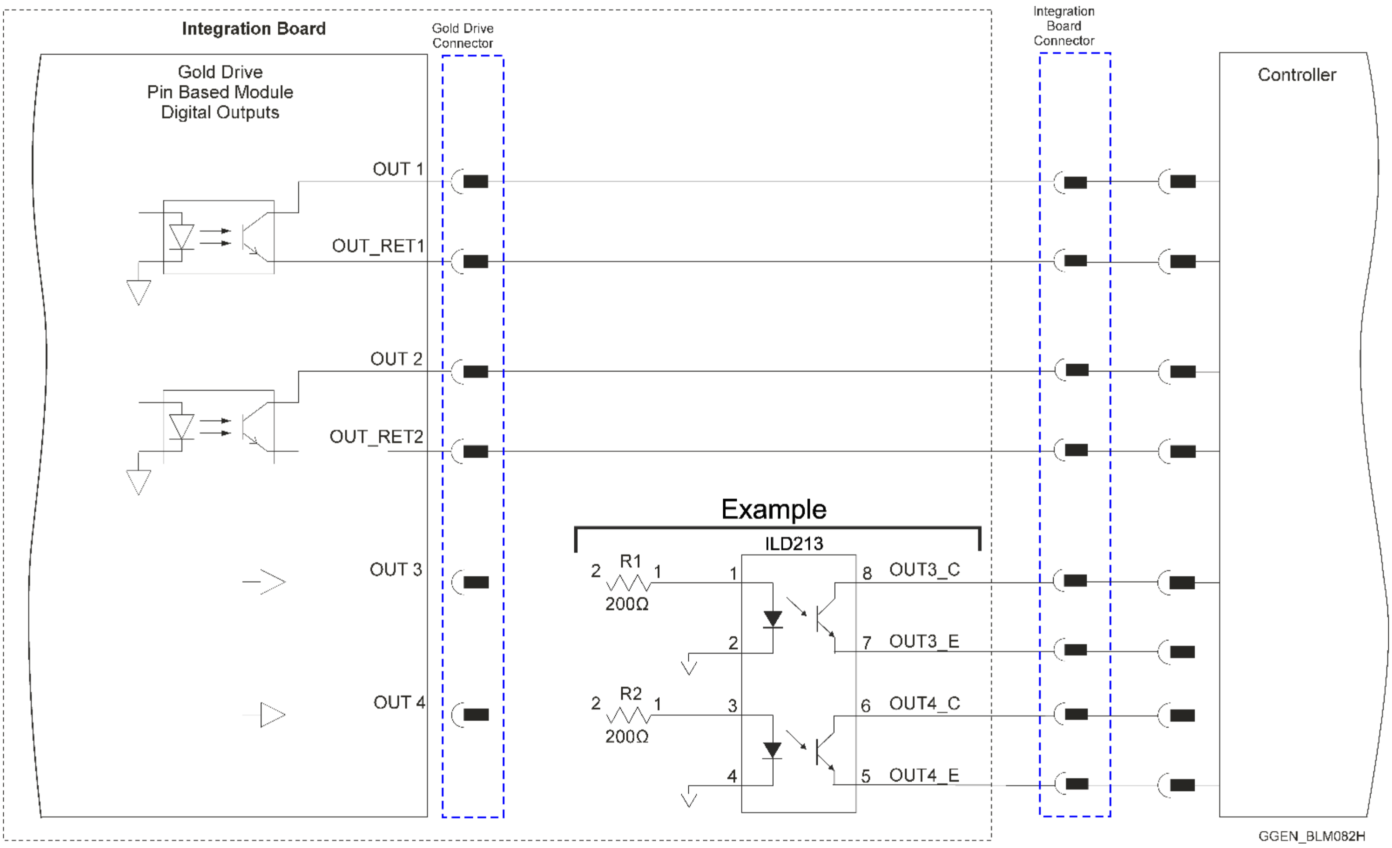


Figure 43: Digital Output Connection Diagram – TTL Connection

11.1.2.3. Digital Output Layout Design

The digital outputs conductors' actual current is very small but the substantial thickness and width of the conductors will contribute to a better performance and lower interferences.

The optically isolated digital outputs are isolated from the other parts of the Gold Board Level Modules Servo Drive. Each output has a separate floating return (OUTRET1 for output 1 and OUTRET2 for output 2). To retain isolation, the Output Return pins, as well as other output circuit conductors, must be laid out separately.

In the Gold Trombone, VDDRET is the common of the Digital output, it also should be isolated from the other parts of the module.

11.2. Gold Trombone User I/Os

The Gold Trombone Board Level Modules have six programmable digital inputs, four digital outputs and two analog inputs.

11.2.1. Digital Inputs

There are six TTL digital inputs. For the Gold Trombone, the digital inputs can be configured to PLC voltage level. The following are the digital input signals:

Signal	Function
IN1	Programmable digital input 1
IN2	Programmable digital input 2
IN3	Programmable digital input 3
IN4	Programmable digital input 4
IN5	Programmable digital input 5
IN6	Programmable digital input 6
INRET1_6	Programmable input 1 – 6 return The six digital inputs are optically isolated from the other parts of the Gold Board Level Modules Servo Drive

Table 16: Digital Input

11.2.1.1. Source mode – TTL voltage level

Feature	Details
Type of input	Optically isolated
Input current for all inputs	Iin = 3.8 mA @ Vin = 5 V
High-level input voltage	2.4 V < Vin < 15 V, 5 V typical
Low-level input voltage	0 V < Vin < 0.8 V
Minimum pulse width	> 250 µsec
Execution time (all inputs): the time from application of voltage on input until execution is complete	0 < T < 250 µsec

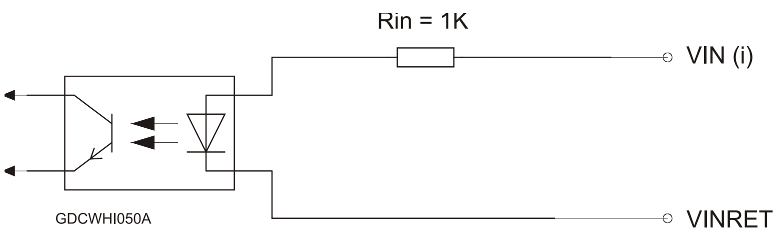
<table>
<tr><th>Feature</th><th>Details</th></tr>
<tr><td>High-speed inputs – 1–6 minimum pulse width, in high-speed mode</td><td>T > 5 µsec if the input functionality is set to latch/capture (index/strobe).
Notes:
Home mode is high-speed mode and can be used for fast capture and precise homing.
Highest speed is achieved when turning on optocouplers.</td></tr>
<tr><td colspan="2">

Figure 44: Digital Input TTL Schematic</td></tr>
<tr><td>Capture with differential input
Port A, Port B Index</td><td>T > 0.1 µsec if the differential input functionality is set to touch probe/capture (index/strobe).</td></tr>
</table>

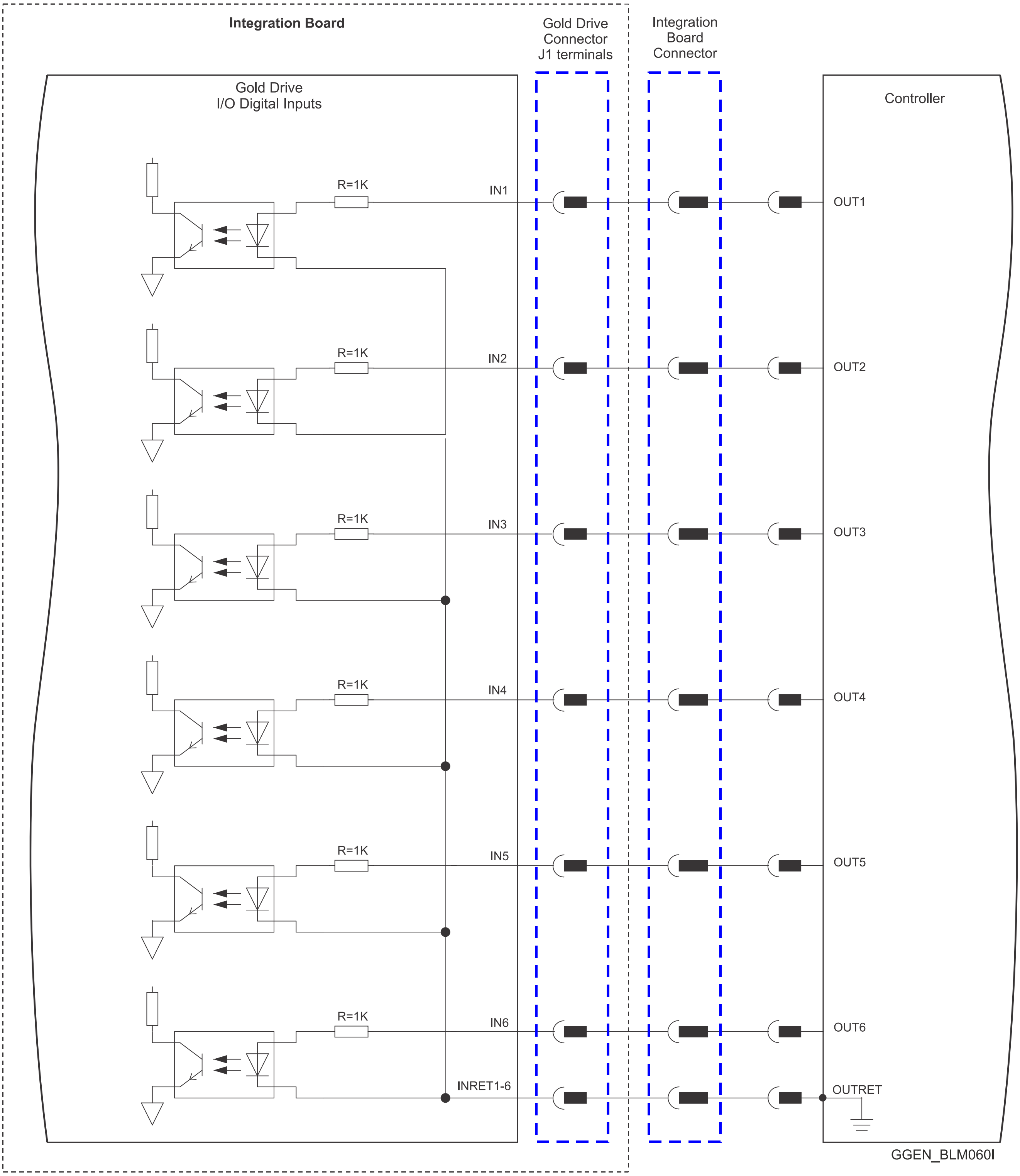


Figure 45: Digital Input TTL Mode Connection Diagram

11.2.1.2. PLC voltage level - Source mode

Feature	Details
Standard	Conforming to IEC 61131-2
Type of input	Optically isolated
Input current for all inputs	Iin = 2 mA @ Vin = 12 V
High-level input voltage	12 V < Vin < 30 V
Low-level input voltage	0 V < Vin < 7 V
Minimum pulse width	>250 µsec
Execution time (all inputs): the time from application of voltage on input until execution is complete	0 < T < 250 µsec
High-speed inputs – 1–6 minimum pulse width, in high-speed mode	T > 5 µsec if the input functionality is set to latch/capture (index/strobe). **Notes:** Home mode is high-speed mode and can be used for fast capture and precise homing. Highest speed is achieved when turning on optocouplers.
Capture with differential input Port A, Port B Index	T > 0.1 µsec if the differential input functionality is set to touch probe/capture (index/strobe).

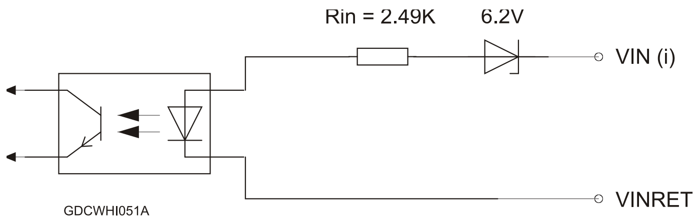


Figure 46: Digital Input Source Schematic

The following is the digital input source mode - PLC voltage level connection diagram for the Gold Trombone:

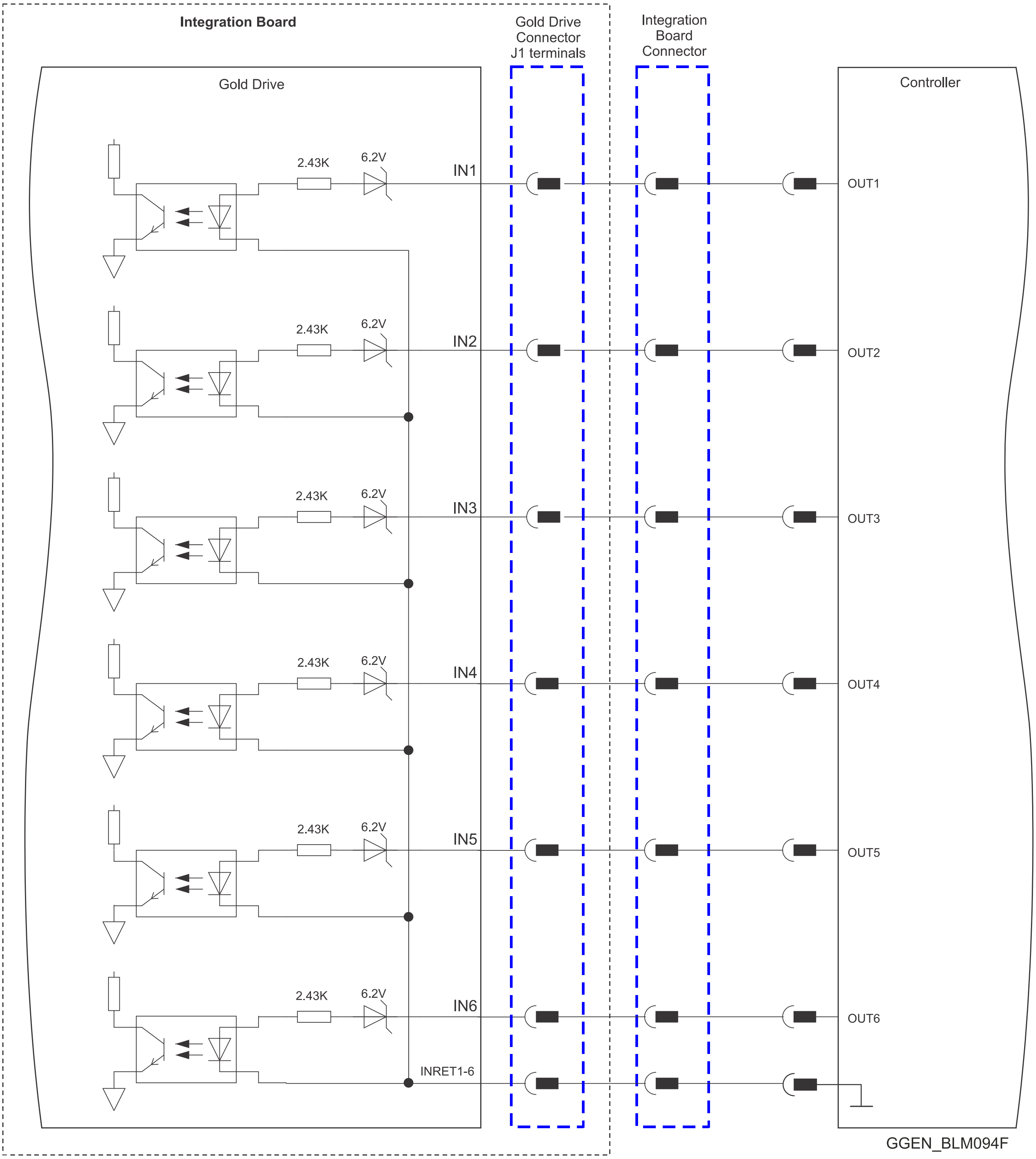


Figure 47: Digital Input Source Mode - PLC voltage level Connection Diagram

11.2.1.3. Digital Input Layout Design

The digital inputs conductors' actual current is very small but the substantial thickness and width of the conductors will contribute to a better performance and lower interferences.

The six **Inputs** of each drive are optically isolated from the other parts of the G-drive. All six inputs share a single common "Return" (INRET1_6). To retain isolation, the Input Return pin, as well as other conductors on the input circuit, must be laid out separately.

11.2.2. Digital Outputs

There are four digital outputs, which can be configured to the following options:

- Source mode – High Current PLC voltage level, Conforming to IEC 61131-2
- Source mode – TTL voltage level

The following are the digital input signals:

J1 Pin	Signal	Function
22	OUT1	Programmable output 4
21	OUT2	Programmable output 3
24	OUT3	Programmable output 2
23	OUT4	Programmable output 1
26	VDD	VDD supply
25	VDDRET	VDD supply return

Table 17: Digital Output

11.2.2.1. TTL voltage level

Feature	Details
Type of output	Optically isolated
Supply output (VDD)	5 V to 15 V
Maximum output current I_{out} (max) (V_{out} = Low)	7 mA
VOL at maximum output voltage (low level)	V_{out} (on) ≤ 0.4 V
T_{on} (Time from low to high)	< 2usec
T_{off} (Time from high to Low)	< 20usec
Executable time	0< T< 250 μsec

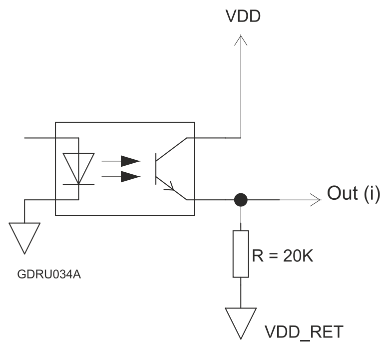


Figure 48: Digital Output TTL Schematic

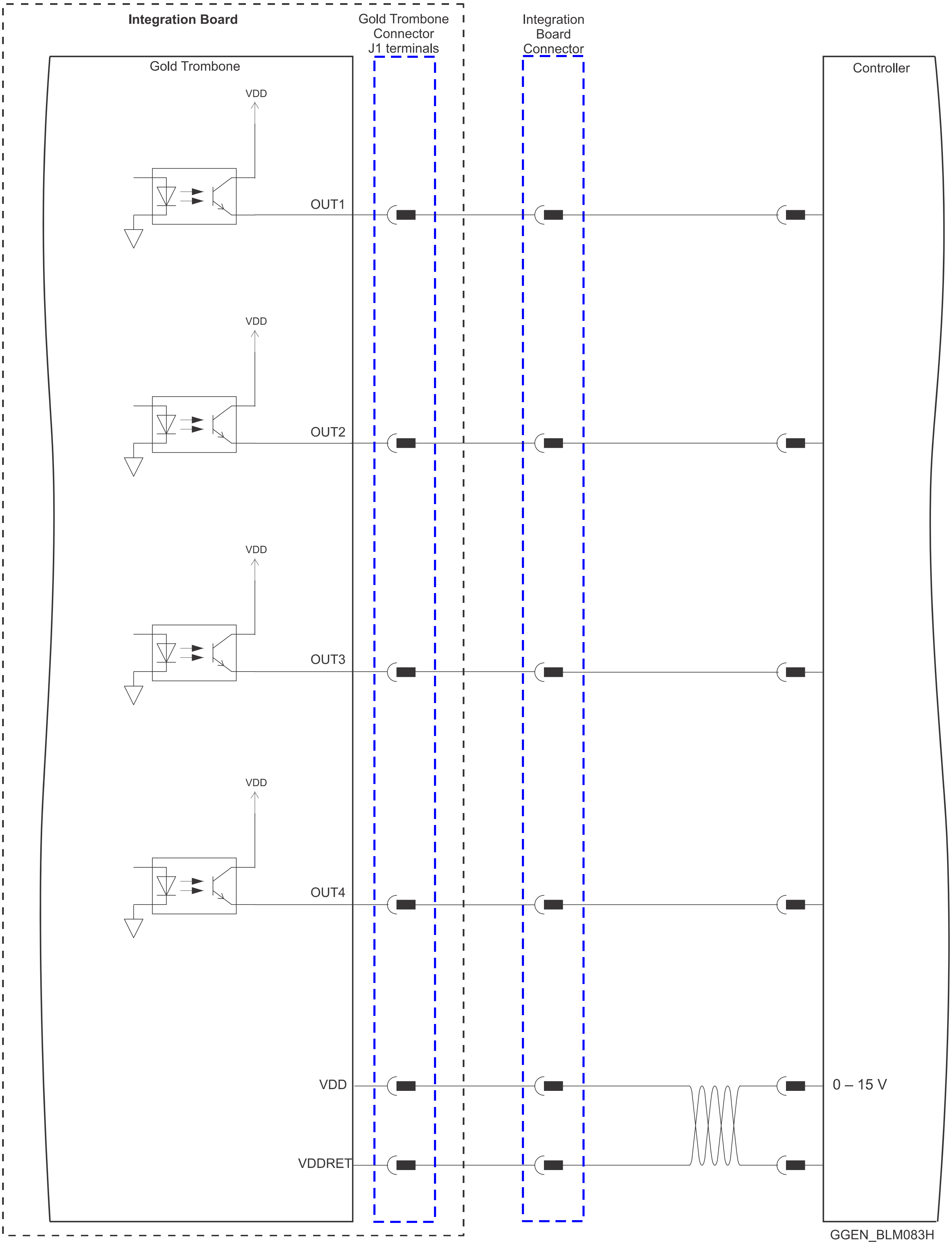


Figure 49: Digital Output Connection Diagram

11.2.2.2. PLC voltage level - Source mode

Feature	Details
Type of output	Optically isolated source
Supply output (VDD)	12 V to 30 V
Max. output current I_{out} (max) (V_{out} = Low)	I_{out} (max) ≤ 500 mA for Output 1 I_{out} (max) ≤ 250 mA for Outputs 2 up to 4
VOL at maximum output voltage (low level)	V_{out} (on) ≤ 0.3 V
T_{on} (Time from low to high) If V_{dd}= 30V If V_{dd} = 12V	 < 10usec < 85usec
T_{off} (Time from high to Low)	< 85usec
R_L	The external R_L must be selected to limit output current to no more than 500 mA (Output 1) or 250 mA (Outputs 2 to 4). $R_L = \frac{VDD - VOL}{I_{out}(max)}$
Executable time	0 < T < 250 µsec

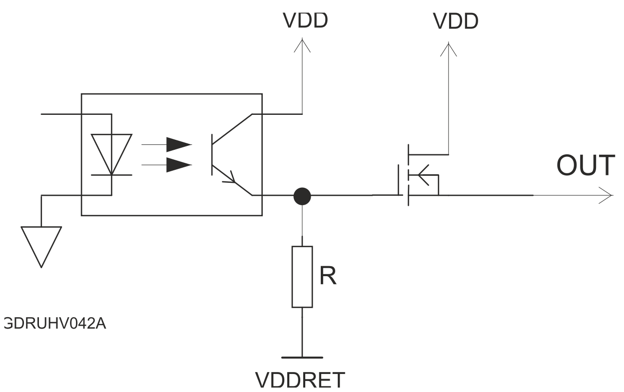


Figure 50: Digital Output Schematic – Source Mode PLC Level

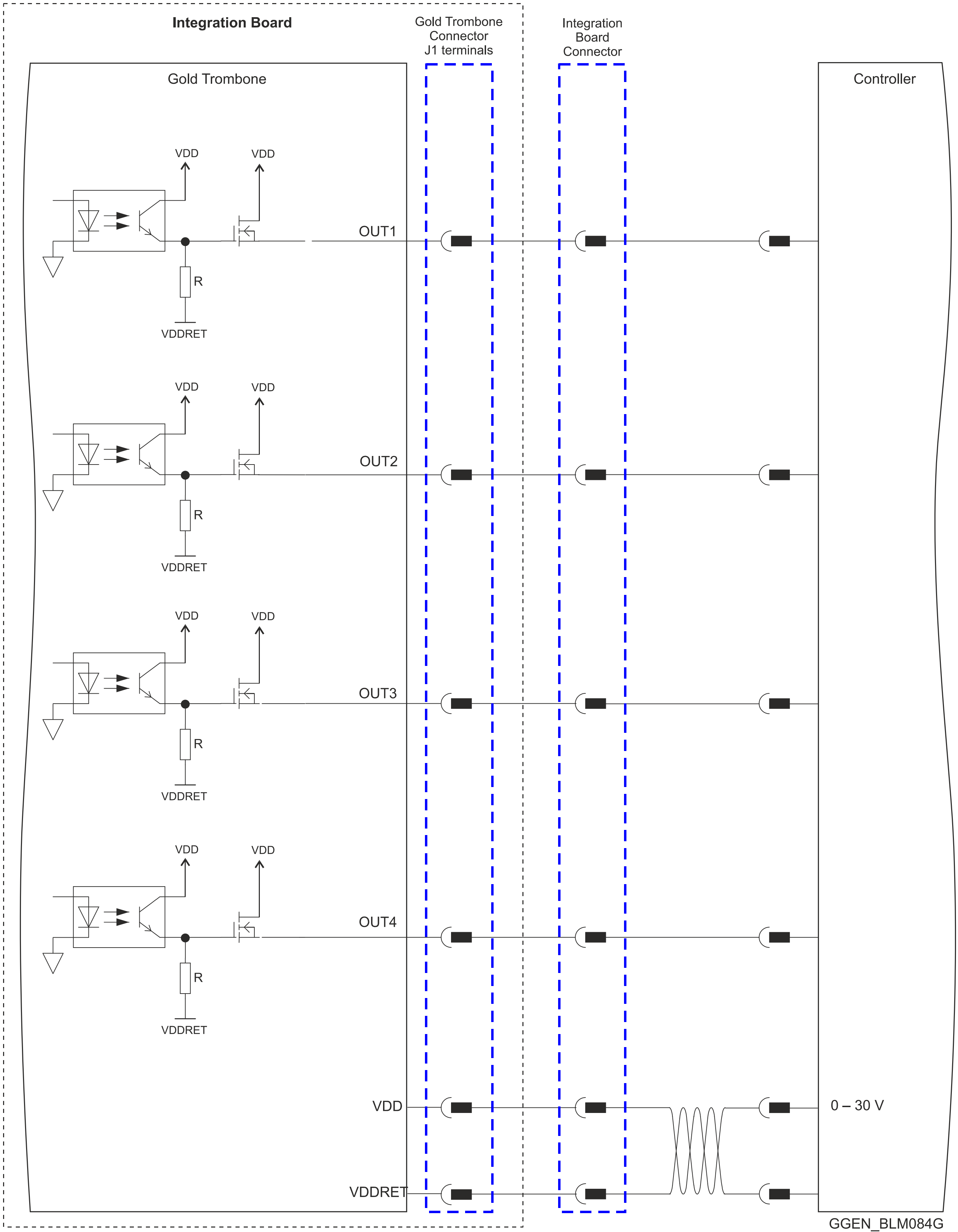


Figure 51: Digital Output Connection Diagram

11.2.2.3. Digital Output Layout Design

The digital outputs conductors' actual current is very small but the substantial thickness and width of the conductors will contribute to a better performance and lower interferences.

The digital output 1-4 are optically isolated from the other parts of the Gold drive. To retain isolation, the VDD and VDDRET pins, as well as other conductors on the output circuit, must be laid out separately.

11.3. Gold Twitter User I/Os

11.3.1. Digital Inputs

The following table describes the electrical specification of the inputs IN1 and IN6:

Feature	Details
Input Voltage (VIN)	• 0 to 6V
V_{ih} min	2.2V
V_{il} max	0.6V
R_1 Pull-up Resistor	If VT = 3.3V, R1<3.3KΩ If VT = 5V, R1<10KΩ
Minimum pulse width	> 250 μsec
Execution time (all inputs): the time from application of voltage on input until execution is complete	0 < T < 250 μsec
High-speed inputs – 1–6 minimum pulse width, in high-speed mode	T = 5 μsec if the input functionality is set to latch/capture (index/strobe). **Note: Home mode is high-speed mode and can be used for fast capture and precise homing.**
Capture with differential input Port A, Port B Index	T > 0.1 μsec if the differential input functionality is set to touch probe/capture (index/strobe).

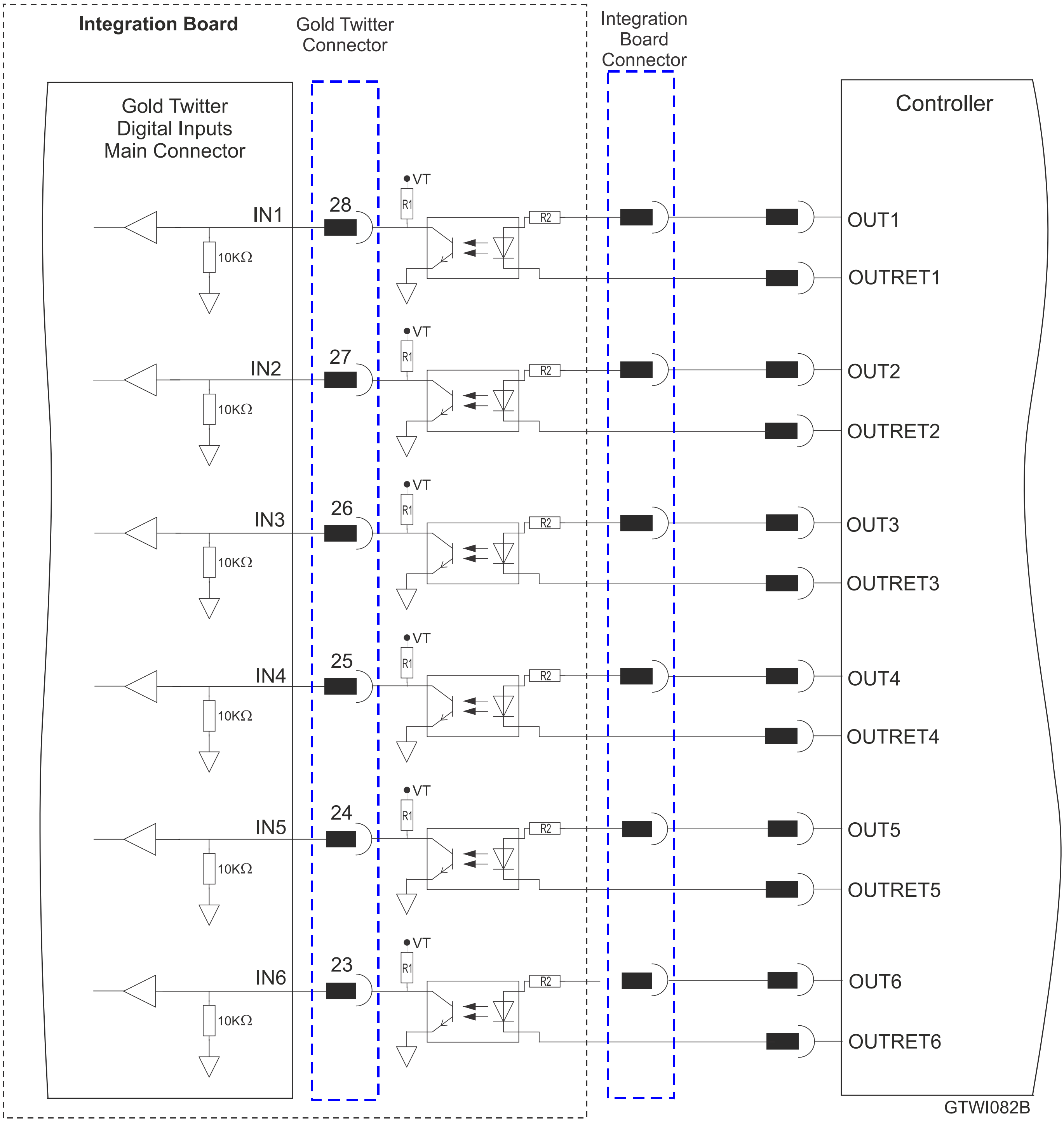


Figure 52: Digital Input 5V Logic level Mode Connection Diagram

11.3.2. Digital Outputs

There are two types of Digital outputs:

- Out1 and Out2 5V Logic
- Out3 and Out4 3.3V Logic

The following table describes the electrical specification of the outputs OUT1 and OUT2:

Feature	Details
Type of output	• 5V Logic
VOL max (low level)	V_{out} (Low) ≤ 0.52V at 10 mA
VOH min (High level)	V_{out} (High) >4.9V at 10 mA
Max. output current I_{outH} (max)	10 mA
Ton (time from low to high)	<1μsec
Toff (time from high to low)	<1μsec
Executable time	0 < T < 250 μsec

The following table describes the electrical specification of the outputs OUT3 and OUT4.

Feature	Details
Type of output	• 3.3V Logic
VOL max (low level)	V_{out} (On) ≤ 0.4V at 8 mA
VOH min (High level)	V_{out} (High) >2.5V at 8 mA
Max. output current I_{outH} (max)	8 mA
Ton (time from low to high)	<1usec
Toff (time from high to low)	<1usec
Executable time	0 < T < 250 μsec

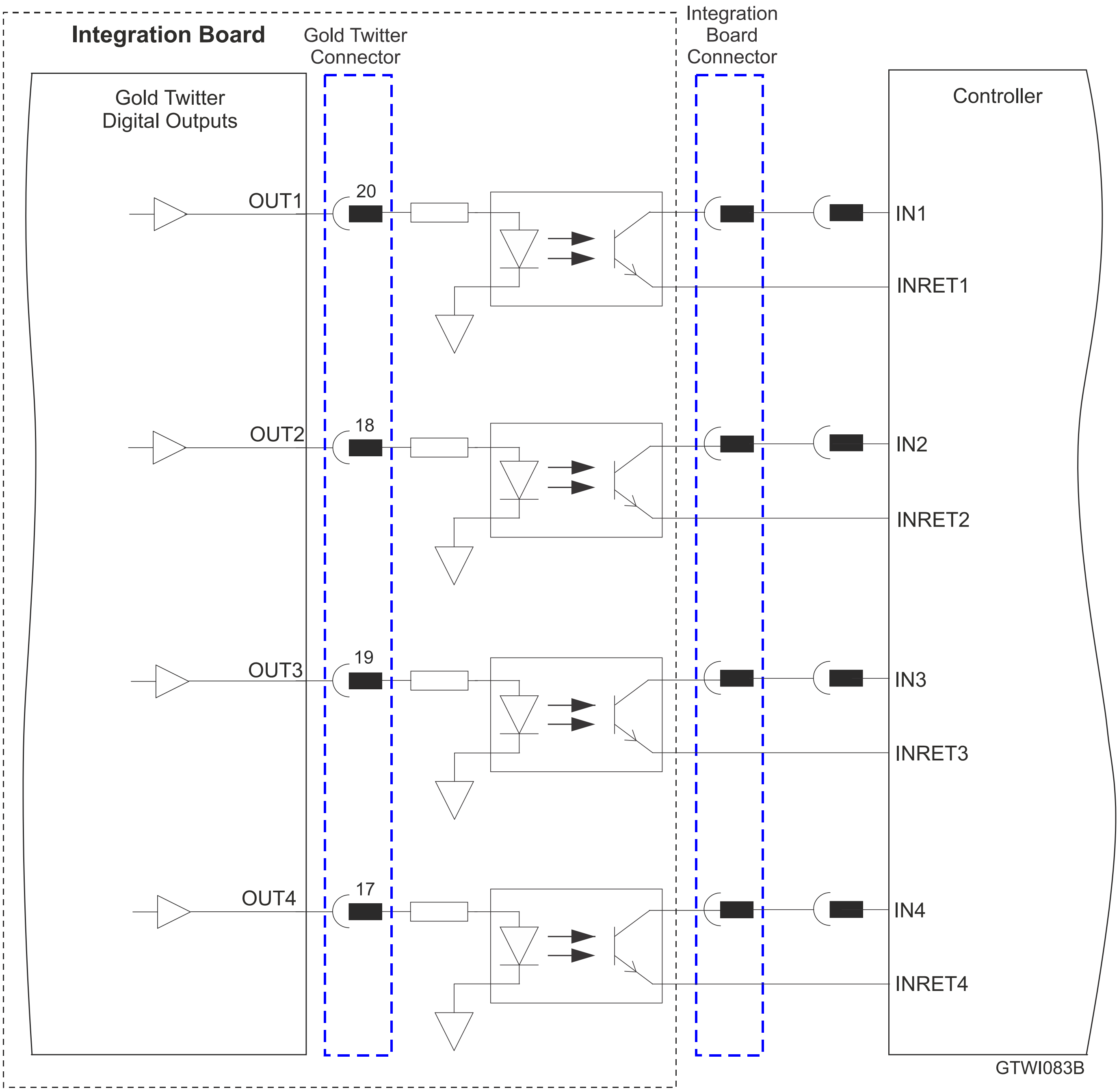


Figure 53: Digital Output 5V and 3.3V Level Mode Connection Diagram

Chapter 12: Analog Input

Analog user inputs can be configured by software to be used as either tachometer velocity sensor input or potentiometer position feedback. The Board Level Module (BLM) has two analog inputs.

Analog input 1 is differentially ended and analog input 2 is single ended

The following are the analog input signals:

Signal	Function
ANALOG1+	Analog input 1
ANALOG1-	Analog input 1 complement
ANALOGRET	Analog Return
ANALOG_IN2	Analog input 2

12.1. Analog Input 1

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	12-bit
Sample time	250 µsec

The following circuit describes the internal interface of the Analog input.

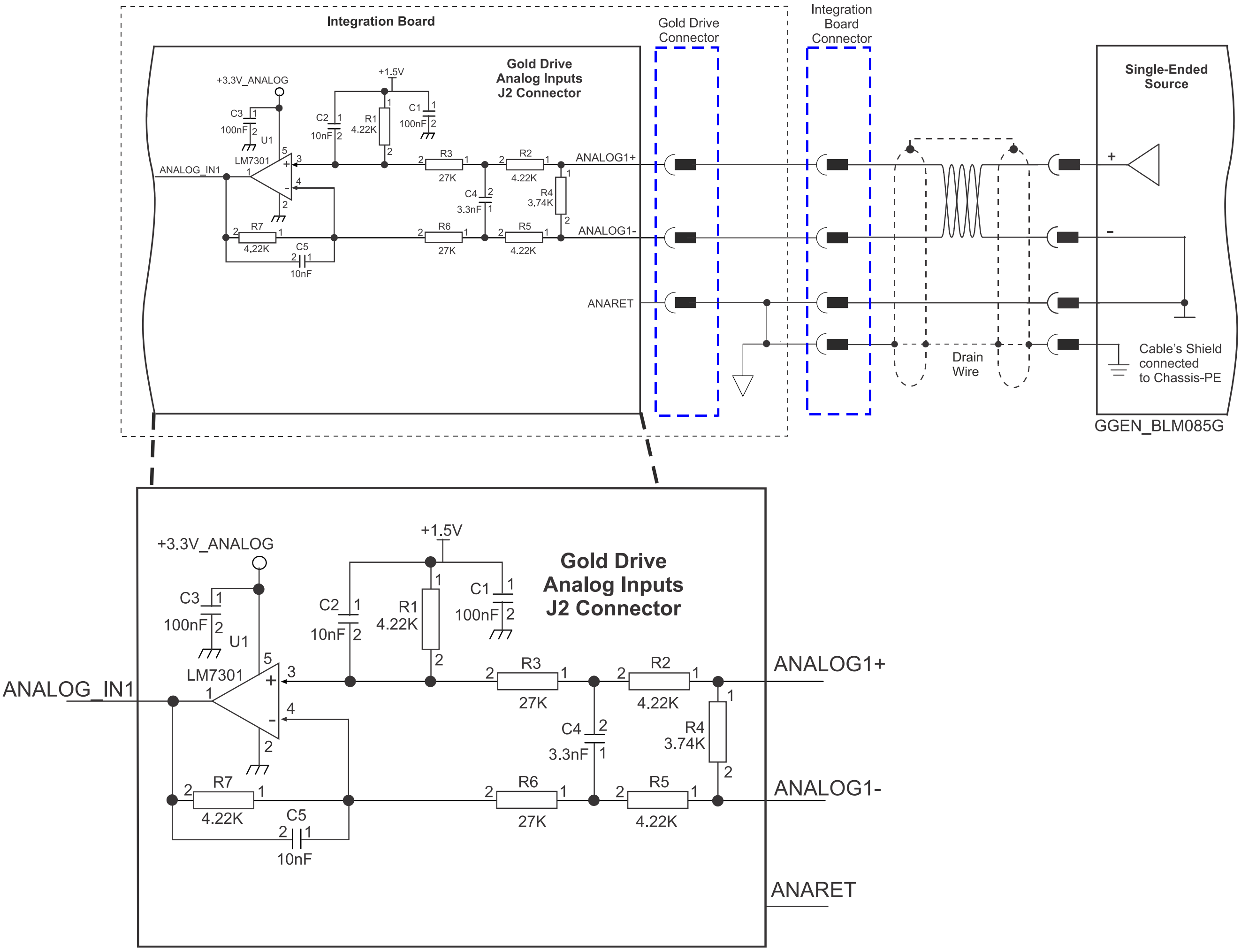


Figure 54: Analog Input with Differential -Ended Source

12.2. Analog Input 2

The BLM, Board Level Module allows an additional single ended Analog input. The Analog_input is connected directly to the Analog to Digital convertor.

Specification	Min	Type	max	units
Analog input voltage	0		3	V
Analog sample time		250		Usec
Analog input command resolution		12		bit

Figure 55 describes the input interface of the Analog_input2 in the BLM drive. It also describes implementation examples for a differential analog input of 10V:

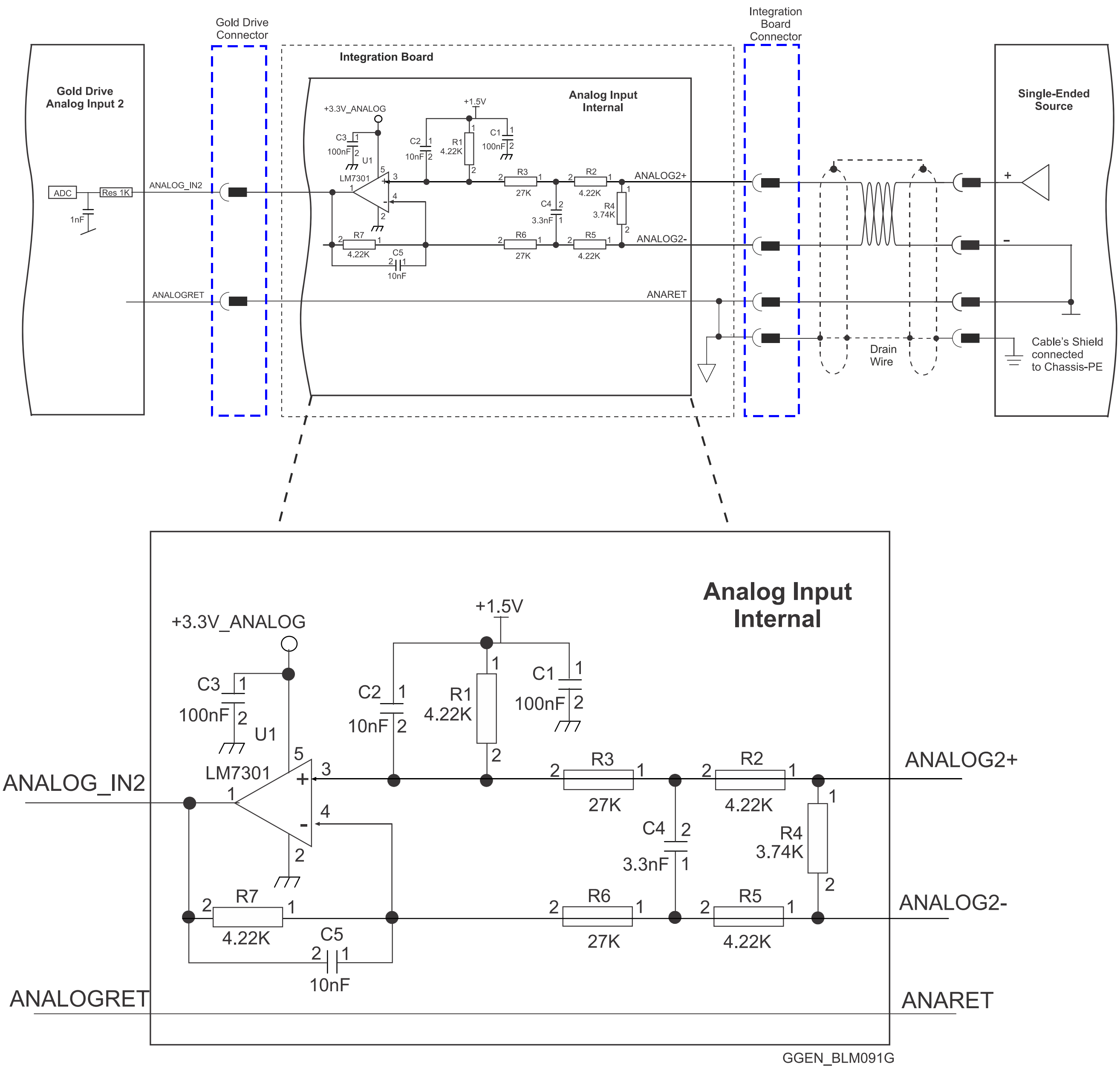


Figure 55: Analog Input Example

The following table describes the specification of the above example:

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	12-bit
Analog input sample time	250usec

12.3. Analog Input Layout Design

The Analog 2 lines are differential lines. They should be routed together and as close as possible. The **Analog Inputs** signals should be separated. The analog return should be laid in parallel to the Analog inputs signals.

Chapter 13: Extended I/Os

Optionally, the PCB-Mounted Module allows extension of the input/ output capability in the integration board in a simple and inexpensive manner.

The I/O can be extended to:

- Up to 32 Digital Inputs
- Up to 32 Digital output

The capability to extend the digital I/Os is based on a proprietary serial bus. This digital I/O is updated every 250usec. For further information, refer to the Extended IO Application Note.

Chapter 14: Communications

The Gold line supports different communication channels:

- EtherCAT
- USB
- CAN
- RS232 (TTL Level)
- Differential RS232 (RS-422)

14.1. USB 2.0

14.1.1. Specification

Specification	Details
USB Type	USB 2.0 Device mode
Speed	Up to 12 Mbit/s "Full Speed"
Cable length	maximum 5 m
Cable Type	Standard USB cable • constructed with 4 wires of 20AWG to 28AWG, shield with a foil • D+ and D- comprise a twisted pair in the cable • The shield of the cable is connected to the shield of the connector used for communication
Protocols	For setup and control

14.1.2. Signals

The following table describes the USB signals:

Signal	Function
USB VBUS	Input USB VBUS 5 V
USBD-	USB _N line
USBD+	USB _P line
COMRET	Common return

Table 18: USB 2.0 - Pin Assignments

14.1.3. Interfaces

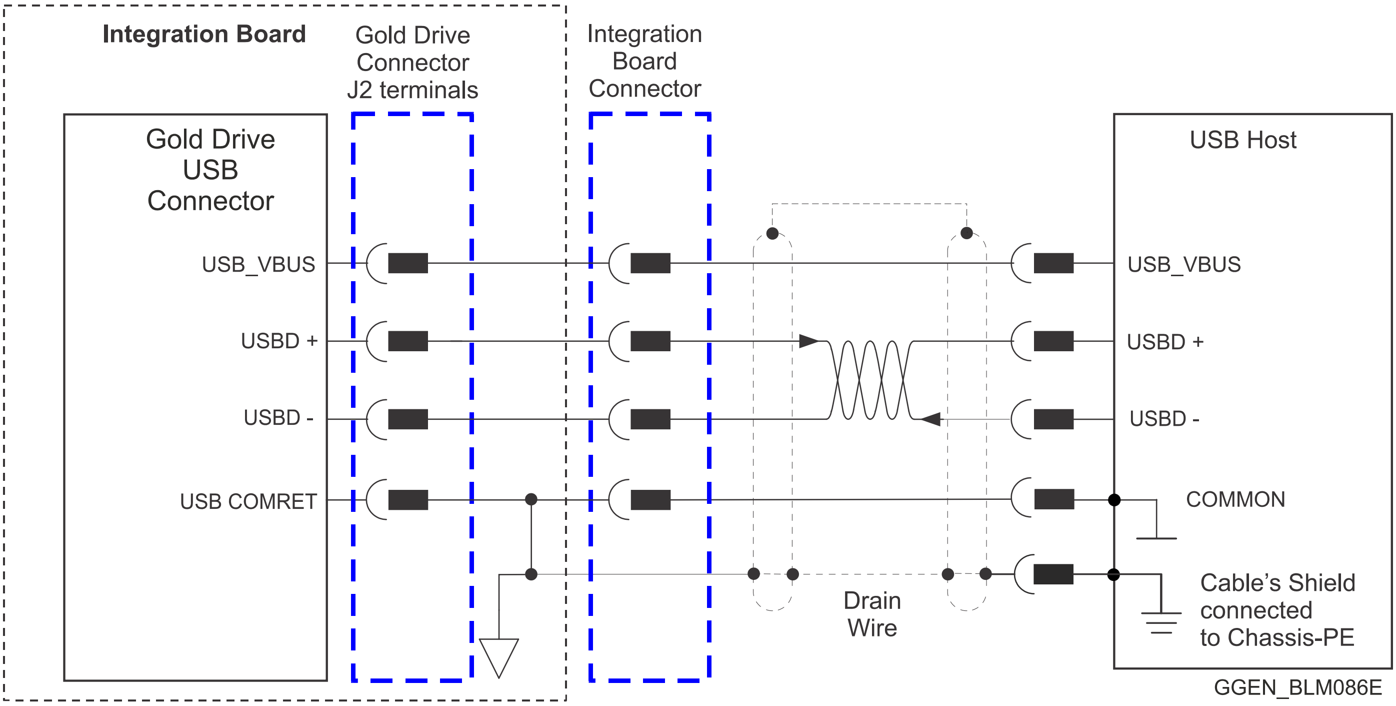


Figure 56: USB Network Diagram

Note: **In the G-WHI, G-Bell, and G-GUT, the shield of the USB connector should be connected to the COMRET and not the PE.**
In the G-TRO, the shield of the USB connector should be connected to the PE.

14.1.4. USB Layout Design

The following are the basic Layout Guidelines for the USB signals:

- The differential USB pairs should be routed as close as possible.
- Route the differential pairs running in parallel, symmetric, equal length and close whenever possible.
- The digital ground plane (COMRET) should be placed under the signals.
- The trace length should be as short as possible.

14.2. EtherCAT/Ethernet

14.2.1. Introduction

The Gold Board Level Modules Servo Drive serves as an EtherCAT slave device, therefor it includes EtherCAT_IN and EtherCAT_OUT ports. It also includes LED indicators. The EtherCAT_IN port can be configured to an Ethernet port.

14.2.2. Specification

Specification	Details
Physical layer	100base-T
	The PCB-Mounted Module does not include isolation transformer which is required for Ethernet Communication. Therefore, isolation must be added when designing the integration board. In case that RJ-45 is used the isolation transformer can be integrated inside the RJ-45 connector. In case that M12 connector is used the isolation transformer need to be added in the Interface board.
Speed	100 Mbit/sec
Cable Type	CAT5e (Category 5 cable is a high signal integrity cable with four twisted pairs.
EtherCAT	
EtherCAT Type	EtherCAT Type
Protocols	CoE, FoE, EoE Distributed clock **Note: During the FoE operation, the USB cable connection must be disconnected.**
Ethernet (EtherCAT IN Port)	
Protocols	UDP

14.2.3. Signals

The following table describes the EtherCAT signals of PCB-Mounted Module. Refer to the specific pin number of the following EtherCAT signals in the relevant installation guide.

Signal	Function
3.3V	Power Supply 3.3V for transformer and LEDs
PHY_IN_RX+	EtherCAT In receive+/Ethernet receive+
PHY_IN_RX-	EtherCAT In receive-/Ethernet receive-
PHY_IN_TX+	EtherCAT In transmit+/Ethernet transmit+
PHY_IN_TX-	EtherCAT In transmit-/Ethernet transmit-
PHY_IN_LINK_ACT	EtherCAT In active LED
PHY_IN_SPEED	EtherCAT In Speed LED
PHY_OUT_RX+	EtherCAT out transmit+
PHY_OUT_RX-	EtherCAT out transmit-
PHY_OUT_TX+	EtherCAT out receive+
PHY_OUT_TX-	EtherCAT out receive-
PHY_OUT_LINK_ACT	EtherCAT out active LED
PHY_OUT_SPEED	EtherCAT out Speed LED

Signal	Function
LED_ETHERCAT ERR	LED Status EtherCAT ERR (Cathode)
LED_ETHERCAT RUN	LED Status EtherCAT RUN (Cathode)

Table 19: EtherCAT – Pin Mounted Pin Assignments

14.2.4. Interface to RJ-45 with Magnetic

The following figure describes EtherCAT connection with a standard RJ-45 connector that includes transformer isolation.

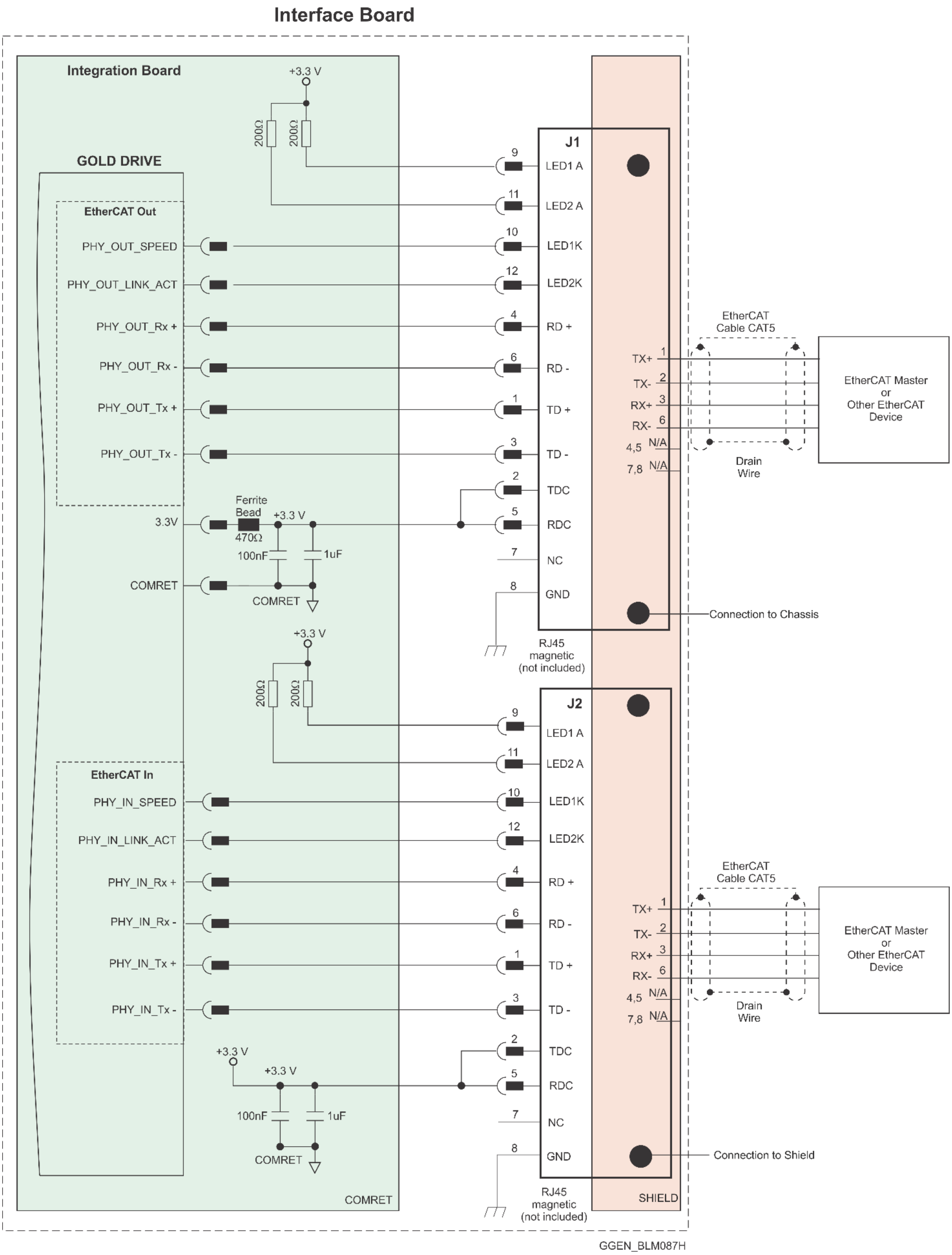


Figure 57: EtherCAT Connection Schematic with Diagram Sign of 3.3V

The below is an example of RJ-45.

Manufacture	P/N	Descriptions
ERNI	203336	RJ45 MAGNETIC 8PINS RIGHT ANGLE + 2LEDS

14.2.5. Interface to Connector without Magnetic (such as M12)

The following figure describes EtherCAT connection with a connector and separate transformer isolation.

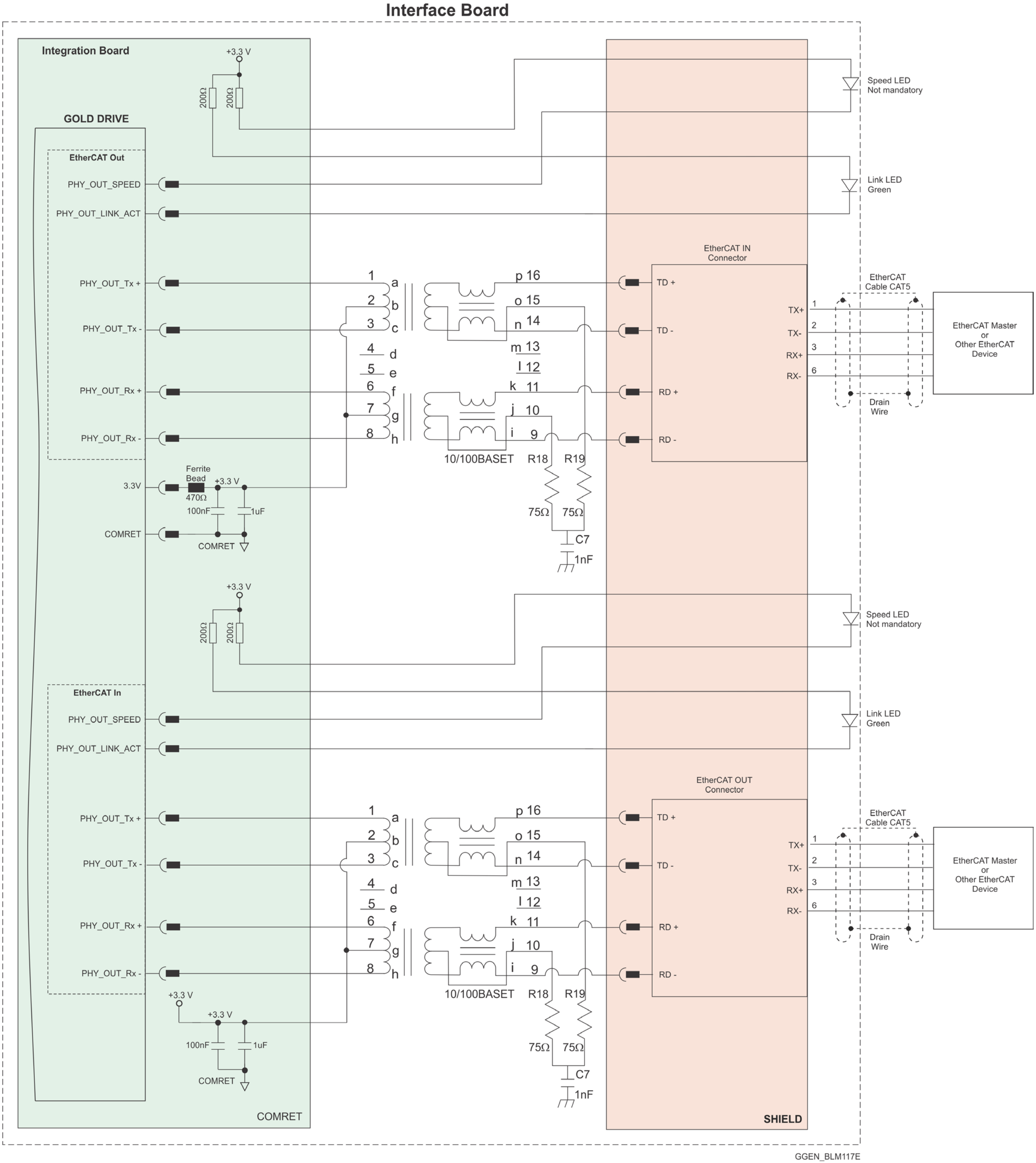


Figure 58: EtherCAT Connection Schematic without Magnetic Diagram

The below is an example of transformer.

Manufacture	P/N	Descriptions
BEL	S558-5999-U7-F	MAGNETICS 10/100 BASE-T

14.2.6. EtherCAT Status Indicator

The EtherCAT status indicator is a red/green dual LED. It combines run indication (when green) and error indication (when red) of the EtherCAT device. For further details, see the EtherCAT Application Manual.

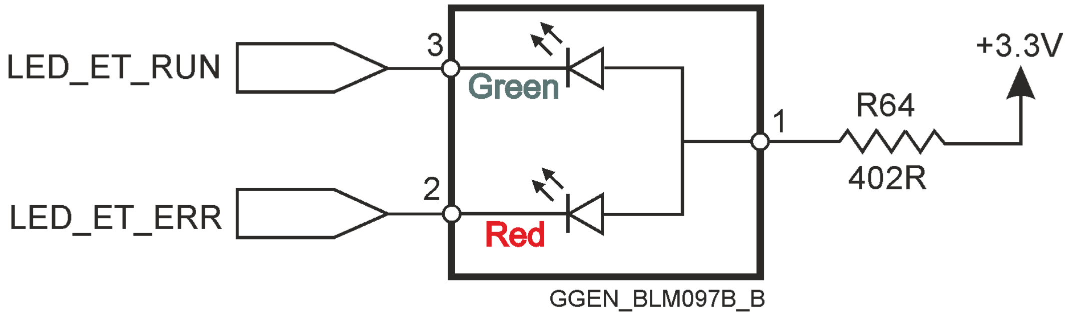


Figure 59: EtherCAT Status Indicator

The above is an example of bi-directional LEDs.

Manufacture	P/N	Descriptions
Kingbright	KPBA-3010SURKCGKC	bi-directional LEDs

14.2.7. EtherCAT Layout Design

14.2.7.1. PCB

It is recommended to use at least four layers on the PCB, for the routing of the EtherCAT signals. The following is an example of the Stackup:

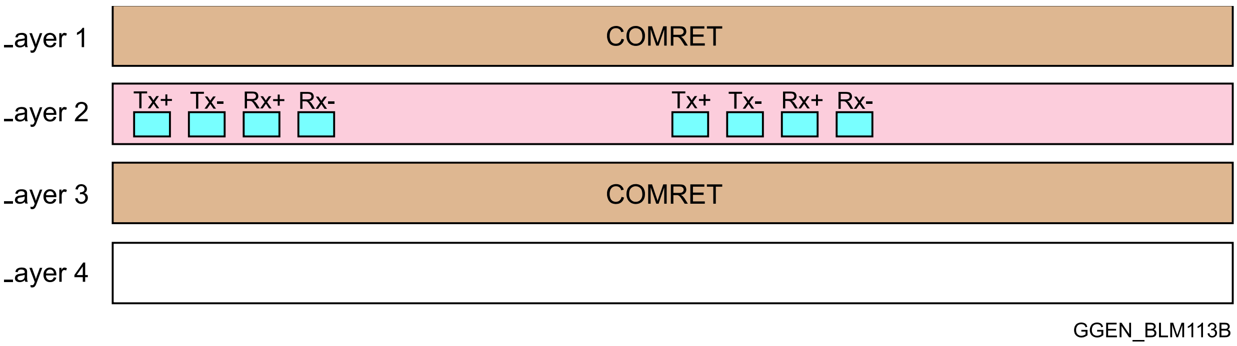


Figure 60: Example of Layered Stackup on PCB

14.2.7.2. COMRET

The COMRET plan should be continuous and not fragmented, and should not be placed under the transformer.

14.2.7.3. Differential Signals

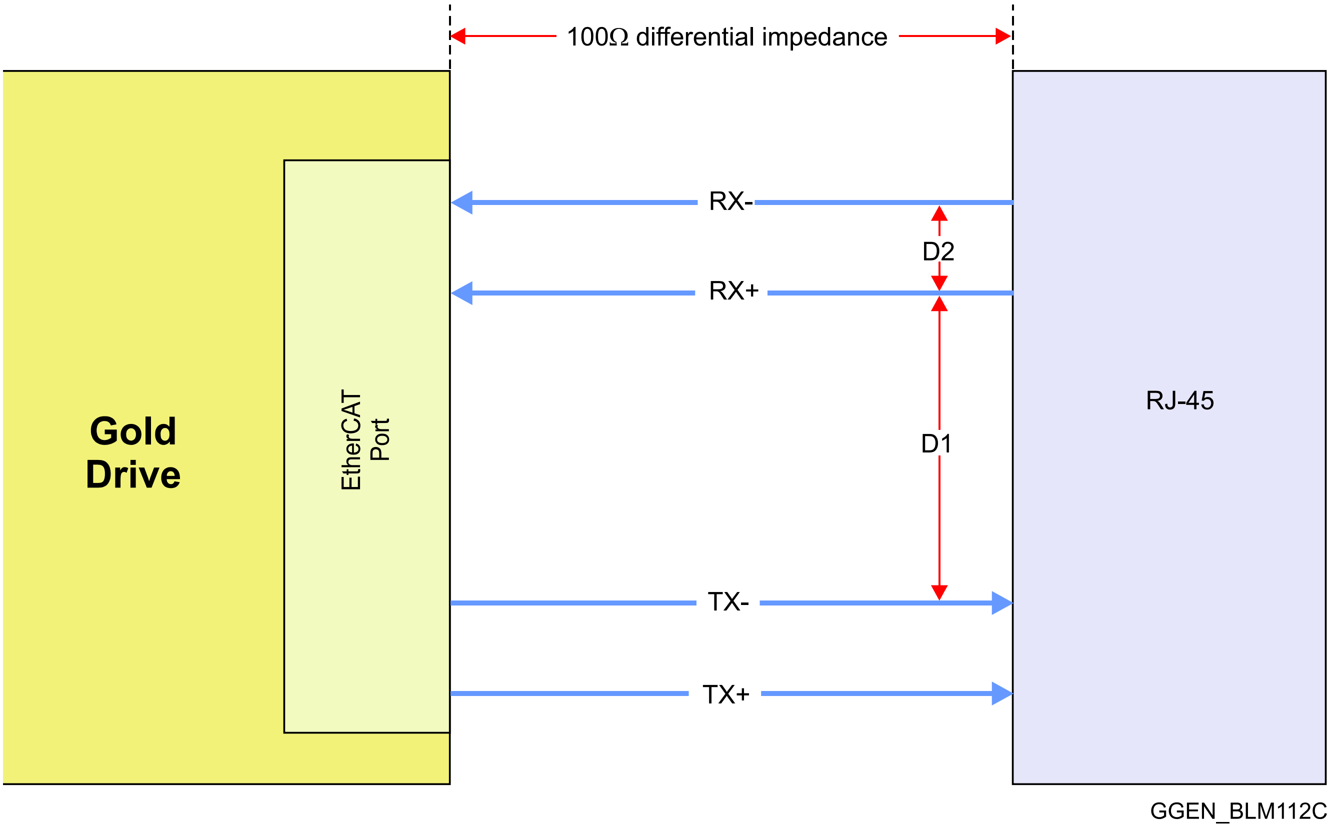


Figure 61: Differential Signal Layout

- TSEC1_TX± , TSEC1_RX± should be designed to a 100 ohm differential impedance.
- Should be routed as close as possible (D2).
- The trace width should be determined by the required trace impedance.
- Spacing D1 between them should be as large as possible.
- Should be routed as straight as possible, maintaining them in parallel for differential pairs.
- Routed symmetrically, at equal lengths and close together whenever possible.
- Make sure to:
  - Not route digital signals under the magnetic parts
  - Avoid using VIAS on the traces of the differential pairs.
  - Avoid routing the signal trace at a right-angle. Instead route it using multiple 45˚ angles.

14.3. CAN

14.3.1. Introduction

Typically, the CANbus is set with a pair of twisted wires. The Bus **ends** are terminated with a 120 ohm resistor at each end. This results in a bus load of 60 ohm. Close matching of the termination resistor with the cable impedance ensures that the data signals are not reflected at the bus ends.

It must be emphasized that the CANbus is actually a triple-wire communication, especially out of the board. Theoretical the number of units that can be connected to the CAN bus is not limited. However, the total actual number of units that can be connected will be limited by the delay times and the bus loads in the bus lines.

The CANbus includes the following signals: CAN_LOW, CAN_HIGH and GND.

Make sure that the GND signal also connected via the cable. Figure 62 displays the CAN connectivity.

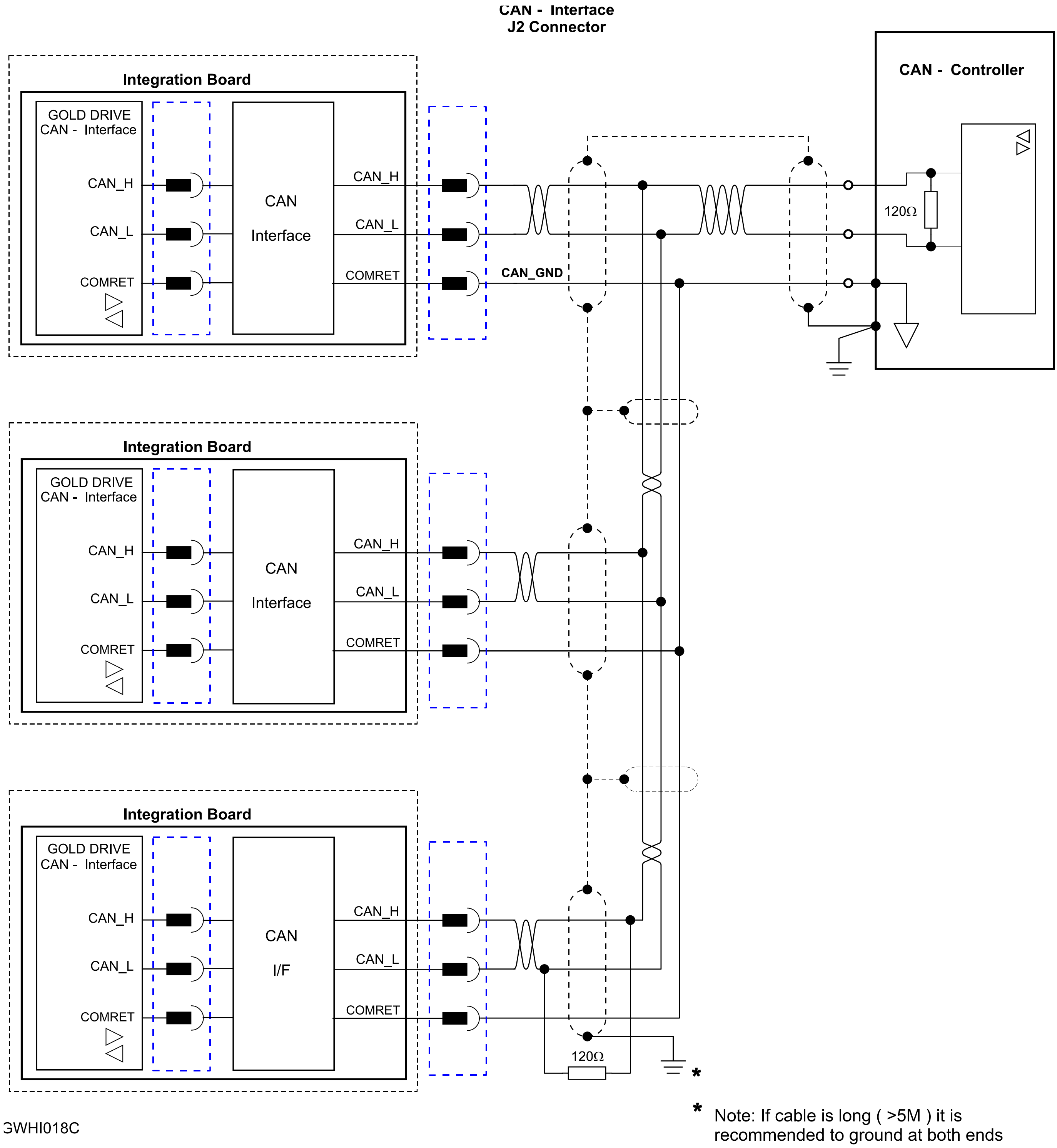


Figure 62: CANbus Connections

Important: **A 120 Ω termination resistor should be connected at each end of the network cable.**

14.3.2. CAN Speed

The CAN Bus standard specifies the Max theoretical cable length @1Mbits/sec as 40 meters. However, the CAN is determined by various factors such as:

- Loop delays of the connected bus nodes and the delay of the bus lines, consist of:
- CAN controller and Transceiver Delays (vary between 30÷150 nano-sec)
- Optional Isolation Delays (vary between 20÷75 nano-sec)
- Typical Bus line delays
- Delay connector
- Differences in bit time quantum length due to relative oscillator tolerance between nodes.
- Signal amplitude drop due to the series resistance of the bus cable and the input resistance of bus nodes.

In order to analyze the actual max cable length and number of nodes that can be safely used in a specific configuration, all the above factors should be taken into consideration.

14.3.3. Specification

Specification	Details
Physical layer	• CAN_H, CAN_L, CAN_RET
Speed	• Maximum Baud Rate of 1 Mbit/sec
Protocols	**Version:** • DS 301 v4.01 **Layer Setting Service and Protocol Support:** • DS 305 **Device Profile** (drive and motion control)**:** • DS 402

14.3.4. Signals

The following table describes the CAN signals:

J2 Pin	Signal	Function
40	CAN_H	CAN_H bus line (dominant high)
38	CAN_L	CAN_L bus line (dominant low)

14.3.5. Interface

The PCB-Mounted Module includes the CAN transceiver. Therefore it is required to add a common mode choke and CAN Bus Protector for ESD and other harmful transient voltage events.

The following signals describe how to connect CAN to the external connector.

Note: For details of the Gold Twitter, Gold Bee, interface refer to their specific installation guides.

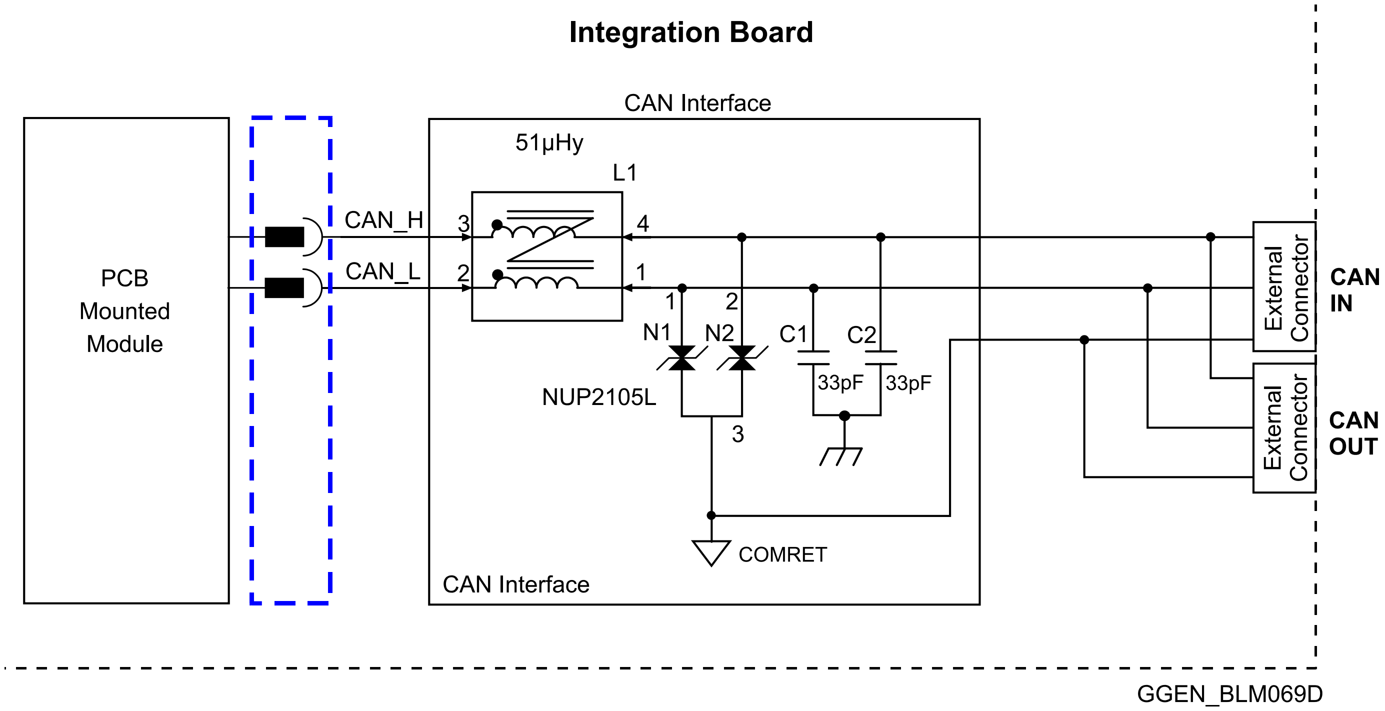


Figure 63: CAN Interface

The following are examples of the components described in Figure 63.

Interface Components	Part	P/N
COMMON MODE CHOKE 51UHY	EPCOS	B82799S0513N001
33PF/50V,NPO,10%	AVX	06035A330JAT1A
DUAL BIDIRECTIONAL VOLTAGE SUPPRESSOR,NUP2105L	ON SEMIC	NUP2105LT1G

14.3.6. CAN Layout Design

The guidelines are recommended:

- Locate the CAN Bus Protector Diodes, Common Mode Choke and filter capacitor close to the CAN Connector.
- The length traces of the CAN Bus Protector Diodes should be as short as possible.
- For optimum layout, there should be an inner ground layer. This is optimal from the immunity point of view.

- The digital ground planes should not be placed under the magnetic parts (common mode choke)
- The CAN lines are differential lines. They should be routed together and as close as possible.
- Do not route digital signals under the magnetic parts (Common mode choke)

14.3.7. Cable connection

The following is recommended for CAN cabling:

- 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-Ohms resistor at each of the two ends of the network cable.

14.4. RS232

All BLM drives provide the RS232 with a TTL voltage level. Similarly, the Gold Twitter also provides Standard RS232, and for details of the standard RS232 signals in the Gold Twitter, refer to its specific installation guide.

14.4.1. RS232 TTL Logic Level

The following table describes the PCB-Mounted Module RS232 signals:

Signal	Function
RS232_Rx	RS232 receive (TTL logic level)
RS232_Tx	RS232 transmit (TTL logic level)

Table 20: RS232 Signals

Specification	Details
Physical layer	Signals: RS232_Rx, RS232_Tx COMRET Full duplex, serial communication Baud Rate of 4,800 to 115,200 bit/sec
Protocols	For setup and control

Electrical Characteristic					
		Min	Type	Max	Unit
V_{IH}	High-level input voltage	2		3.3	V
V_{IL}	Low-level input voltage			0.8	V
V_{OH}	High-level output voltage	2.4			V
V_{OL}	Low-level output voltage			0.4	V

The following section describes how to implement Standard RS232 and differential RS232.

14.4.2. Implementation of Standard RS232

It is required to add a RS232 TX/RX Transceiver (for example MAX3221E) on the integration board in order to implement standard RS232. This RS232 TX/RX Transceiver translates the RS232 TTL logic level to the standard RS232 voltage level.

Figure 64 describes the standard RS232 connection diagram.

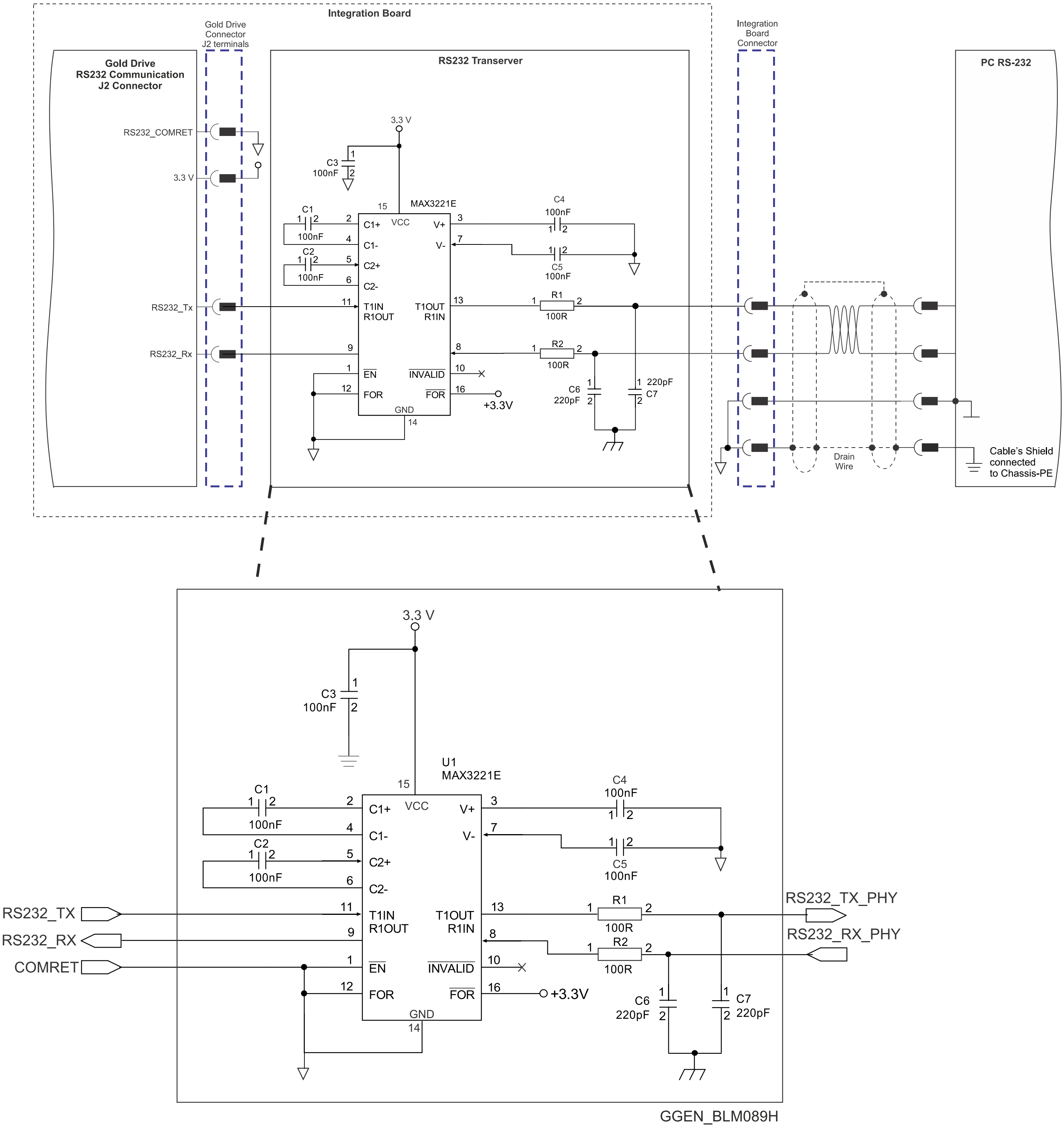


Figure 64: Standard RS232 Voltage Level incorporating RS232 TX/RX Transceiver Connection Diagram

To connect the RS232 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 RS232 communication port is **non-isolated**.
- Ensure that the shield of the cable is connected to the shield of the connector used for RS232 communications. The drain wire can be used to facilitate the connection.

14.4.3. Implementation of Differential RS232 (RS422)

It is required to add a RS422 TX/RX Transceiver (for example AM26LV31 and AM26LV32E) on the integration board in order to implement differential RS232. This RS422 TX/RX Transceiver translate the RS232 TTL logic level to the RS422 differential signals.

Figure 65 describes the connection diagram:

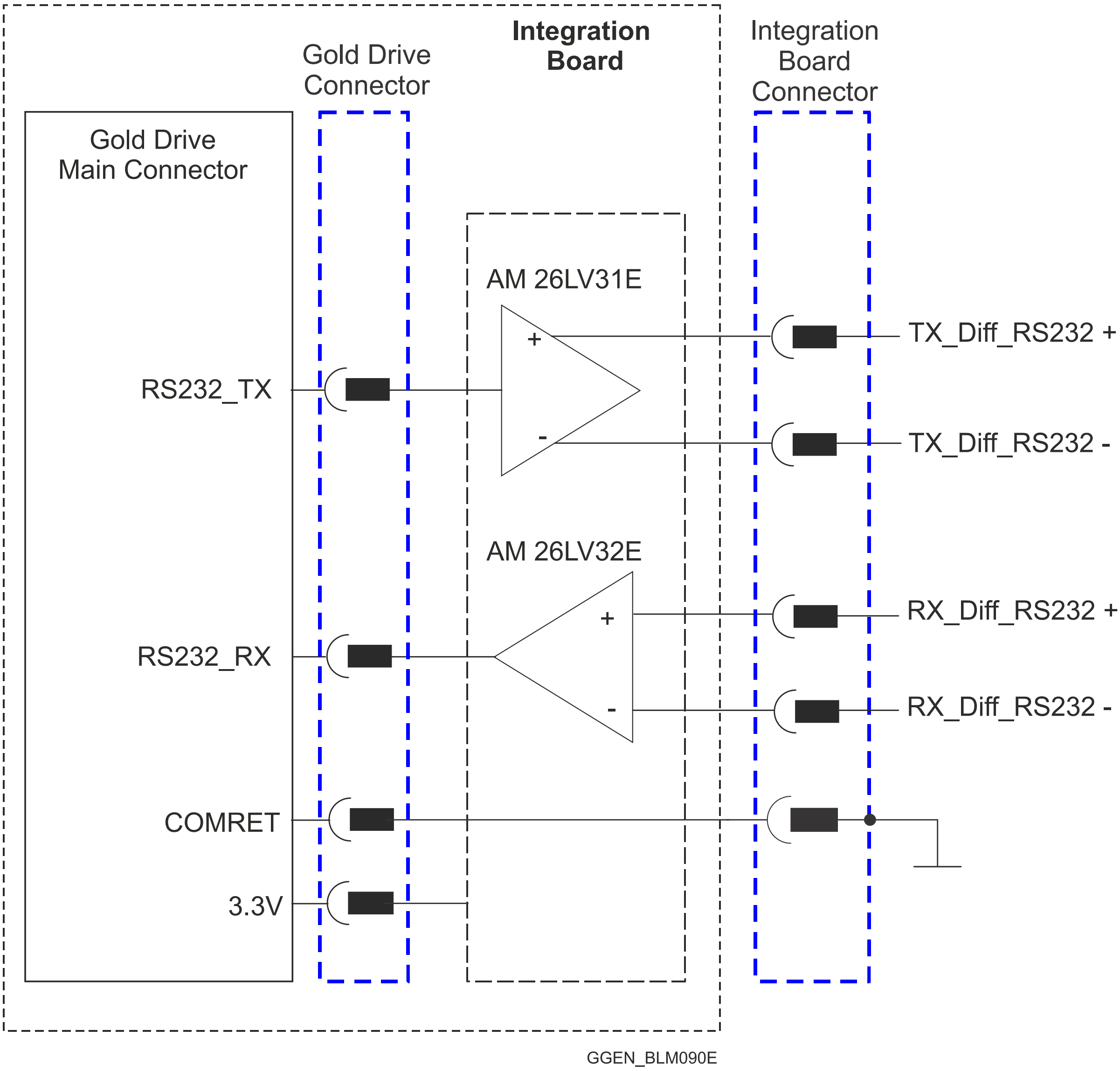


Figure 65: Differential RS232 Interfacing

Chapter 15: Environmental Conditions

You can guarantee the safe operation of the Gold Board Level Modules Servo Drive by ensuring that it is installed in an appropriate environment.

15.1. Gold Line

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) It should be noted that servo drives capable of higher operating altitudes are available on request.
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

15.2. ExtrIQ Series

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

Feature	Operation Conditions	Range
Ambient Temperature Range	Non-operating conditions	-50 °C to +100 °C (-58 °F to 212 °F)
	Operating conditions	-40 °C to +70 °C (-40 °F to 160 °F)
Temperature Shock	Non-operating conditions	-40 °C to +70 °C (-40 °F to 160 °F) within 3 min
Altitude	Non-operating conditions	Unlimited
	Operating conditions	-400 m to 12,000 m (-1312 to 39370 feet)
Maximum Humidity	Non-operating conditions	Up to 95% relative humidity non-condensing at 35 °C (95 °F)
	Operating conditions	Up to 95% relative humidity non-condensing at 25 °C (77 °F), up to 90% relative humidity non-condensing at 42 °C (108 °F)
Vibration	Operating conditions	20 Hz to 2,000 Hz, 14.6 g
Mechanical	Non-operating conditions	±40g; Half sine, 11 msec

Feature	Operation Conditions	Range
Shock	Operating conditions	±20g; Half sine, 11 msec
Atmosphere	Operating area atmosphere	No flammable gases or vapors permitted in area

Chapter 16: Control Specifications

16.1. Current Loop

Feature	Details
Controller type	Vector (for Brushless), digital
Compensation for bus voltage variations	"On-the-fly" automatic gain scheduling
Motor types	• Linear and Rotary motors • AC brushless (sinusoidal) • DC brush • "Voice" coils
Current control	• Fully digital • Sinusoidal with vector control (for Brushless motors) • Programmable PI control filter based on a pair of PI controls of AC current signals and constant power at high speed
Current loop bandwidth	> 4 kHz closed loop
Current sampling time	Programmable 40 to 125 μsec
Current sampling rate	Up to 25 kHz

16.2. Velocity Loop

Feature	Details
Controller type	PI + Four advanced filters + Two advanced gain scheduling filters
Velocity control	• Fully digital • Programmable PI and feed forward control filters • On-the-fly gain scheduling according to either speed or position command or feedback. • Feedback control filters • Automatic, quick, advanced or expert tuning
Velocity and position feedback options	• Incremental Encoder • Digital Halls • Interpolated Analog (sin/cos) Encoder • Resolver Absolute serial encoder **Note:** With all digital feedback options, 1/T with automatic mode switching is activated (gap, frequency and derivative).
Velocity loop bandwidth	< 500 Hz

Feature	Details
Velocity sampling time	50 to 250 μsec; default is 100 μsec
Velocity sampling rate	Up to 20 kHz; default is 10 kHz
Velocity command options	• Internally calculated by jogging • Any supported sensor for tracking • By host communication (Can/EtherCAT) **Note:** All software-calculated profiles support on-the-fly changes.

16.3. Position Loop

Feature	Details
Controller type	PID equivalent (PIP with feed forward)+ two advanced filters + one advanced gain scheduling filter
Position command options	• Software • Pulse and Direction • Any supported sensor for tracking • By host communication (Can/EtherCAT)
Position loop bandwidth	< 200 Hz
Position sampling time	50 to 250 μsec (2x current loop sample time)
Position sampling rate	Up to 20 kHz; default is 10 kHz

Chapter 17: Gold Line Standards

The Gold Board Level Modules Servo Drive 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.

17.1. Functional Safety

Safe Torque Off (STO) Safety Standard	Item
The related standards below apply to the performance of the servo drives as stated in the environmental conditions Chapter 15: Environmental Conditions.	
IEC 61800-5-2:2007 SIL 3	Adjustable speed electrical power drive systems – Safety requirements – Functional
EN ISO 13849-1:2008 PL e, Cat 3	Safety of machinery — Safety-related parts of control systems.
EN 61508-1:2010 SIL 3	Functional safety of electrical/electronic/ programmable electronic safety-related systems
EN 61508-2:2010 SIL 3	Functional safety of electrical/electronic/ programmable electronic safety-related systems
EN 61508-3:2010 SIL 3	Functional safety of electrical/electronic/ programmable electronic safety-related systems

Safe Torque Off (STO) Safety Standard	Item

ZERTIFIKAT ◆ CERTIFICATE ◆ 認証書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z10 13 08 84596 001

Holder of Certificate: **Elmo Motion Control Ltd.**
60 Amal St. P.O. Box 3078
49516 Petach-Tikva
ISRAEL

Factory(ies): 84596

Certification Mark:

Product: **Safety Related Programmable Electronic System**

Model(s): **Drive System GOLD LINE**

Parameters: Safety Function: STO (EN 61800-5-2)
PL e, CAT 3 (EN ISO 13849)
SIL 3 (EN 61508)

Further approvals can be found in the report below.

The report below and the user documentation in the currently valid revision are mandatory part of this certificate. The product complies with the following listed safety requirements only if the specifications documented in the currently valid revision of this report are met.

Tested according to:
EN 61508-1:2010 (SIL 3)
EN 61508-2:2010 (SIL 3)
EN 61508-3:2010 (SIL 3)
EN 61800-5-2:2007
EN ISO 13849-1:2008 (Cat 3, PL e)

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. See also notes overleaf.

Test report no.: EP85169C

Date, 2013-08-12 (Peter Weiss)

Page 1 of 1

A1 / 04.11

TÜV SÜD Product Service GmbH · Zertifizierstelle · Ridlerstraße 65 · 80339 München · Germany

The following GOLD LINE system components are covered by Certificate no. Z10 13 08 84596 001 and the report to the certificate, report no. EP85169C.

Gold BELL		
Model Name	**Model Part Number**	**Version**
Gold Bell	G-BEL	V03
Gold DC Bell	G-DCBEL	V03
Gold Solo Bell	G-SOLBEL	V03
Gold DRUM		
Model Name	**Model Part Number**	**Version**
Gold Drum	G-DRU	V03
Gold Eagle	G-EAG	V03
Gold GUITAR / Gold CELLO		
Model Name	**Model Part Number**	**Version**
Gold Guitar	G-GUT	V03
Gold Solo Guitar	G-SOLGUT	V03
Gold Cello	G-CEL	V03
Gold Falcon	G-FAL	V03
Gold Hawk	G-HAK	V03
Gold Solo Hawk	G-SOLHAK	V03
Gold WHISTLE		
Model Name	**Model Part Number**	**Version**
Gold Whistle	G-WHI	V03
Gold DC Whistle	G-DCWHI	V03
Gold Solo Whistle	G-SOLWHI	V03
Gold Hornet	G-HOR	V03
Gold Solo Hornet	G-SOLHOR	V03
Gold DC Hornet	G-DCHOR	V03
Gold Duo	G-DUO	V03
Gold Duo AMBA	G-DUO-AMBA	V03
Gold Uno AMBA	G-UNO-AMBA	V03

Gold TROMBONE		
Model Name	**Model Part Number**	**Version**
Gold Trombone	G-TRO	V03
Gold DC Trombone	G-DCTRO	V03
Gold Solo Trombone	G-SOLTRO	V03
Gold Panther	G-PAN	V03
Gold Solo Panther	G-SOLPAN	V03
Gold DC Panther	G-DCPAN	V03

Gold DRUM HV		
Model Name	**Model Part Number**	**Version**
Gold Drum HV	G-DRU	V03
Gold Eagle HV	G-EAG	V03
Gold BASSOON		
Model Name	**Model Part Number**	**Version**
Gold Bassoon	G-BAS	V03
Gold Tuba		
Model Name	**Model Part Number**	**Version**
Gold Tuba	G-TUB	V03

17.2. Safety

Specification	Details
The related standards below apply to the performance of the servo drives as stated in Chapter 15: Environmental Conditions.	
Approved **IEC/EN 61800-5-1**	Adjustable speed electrical power drive systems Safety requirements – Electrical, thermal and energy
Recognized **UL 61800-5-1**	Adjustable speed electrical power drive systems Safety requirements – Electrical, thermal and energy
Conformity with **CE 2006/95/EC**	Low-voltage directive 2006/95/EC
Recognized **CSA C22.2 NO. 14-13** Or Recognized **CSA C22.2 NO. 274-13**	Industrial Control Equipment Adjustable drive speeds

17.3. Environmental

Specification	Details
Approved **IEC60068-2-78**	Environmental testing – Damp heat, steady state
Approved **IEC60068-2-6**	Environmental testing –Vibration (sinusoidal)
Approved **IEC60068-2-2**	Environmental testing – Dry heat
Approved **IEC60068-2-27**	Basic environmental testing procedures - Shock

17.4. EMC

Specification	Details
Approved **IEC/EN 61800-3**	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)
Approved **IEC 61326-3-1**	Electrical equipment for measurement, control and laboratory use. Standard required for STO.

17.5. EtherCAT Conformance

EtherCAT Conformance Test – certification

EtherCAT Technology Group

Certificate
EtherCAT Conformance Test

Elmo Motion Control Ltd.
64 Gisin St. Petach Tikva 49103 Israel

EtherCAT Technology Group hereby confirms the above named company that the following family devices are successfully **EtherCAT Conformance Tested**.

Device under Test 1

Product Name:	G-DCWHI
Product Code:	0x30924
Revision Number:	0x103F6

Device under Test 2

Product Name:	G-DCTRO
Product Code:	0x30924
Revision Number:	0x103F6

Device family is listed on one following page.

Assigned Vendor ID:	0x9A
Test Report Number:	0x9A_001
EtherCAT Test Center:	Beckhoff Automation GmbH, Nuremberg, Germany

The following tests were performed:
- EtherCAT Protocol Test (CTT Ver.1.20.52.0)
- Indicator Test
- Labeling Test
- Interoperability Test

Nuremberg, February 27, 2012

Martin Rostan, Executive Director
EtherCAT Technology Group

17.6. Other Compliant Standards

Quality Assurance	
ISO 9001:2008	Quality Management
Design	
• IPC-D-275 • IPC-SM-782 • IPC-CM-770	Printed wiring for electronic equipment (clearance, creepage, spacing, conductors sizing, etc.)
Reliability	
MIL-HDBK- 217F	Reliability prediction of electronic equipment (rating, de-rating, stress, etc.)
Workmanship	
In compliance with **IPC-A-610**, level 3	Acceptability of electronic assemblies
PCB	
In compliance with **IPC-A-600**, level 3	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)

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For a list of Elmo's branches, and your local area office, refer to the Elmo site www.elmomc.com

Elmo Motion Control