



AGD301

3-Axis Controller with Integrated Drives

Product Manual



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Member of Akribis Systems group

Revision History

Version	Description	Date
3.1	Updated description for main power connection.	13 July 2023
3.0	Updated voltage specifications. Updated connector information for electrical interfaces. Added safety inputs specifications and updated Safety Circuitry. Various, minor text corrections.	9 July 2023
2.2	1.4. Corrected Electrical Specifications table: Removed Differential Inputs/Differential Outputs. Added Bi-Directional Differential I/Os (RS422): 8 1.4 Corrected Encoder Ports Specifications table: Opto-isolated 5V with internal power supply only. 3.4.2. Corrected Description in Connector table: Pin 1: 9-36 VDC 3.4.8. Hall Sensors Circuitry: Corrected name of connector: A2/B2/C2 3.4.13 Interface X4: General Purpose I/Os: Added 8 digital outputs in description.	15 May 2022
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1.0	Initial release	3 Aug 2020

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Warranty

This product is warranted to be free of defects in material and workmanship and conforms to the specifications listed in this manual, for a period of 12 months from the shipment date from factory.

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1 Product Description

1.1 General Description

AGD301 is a series of 3-axis, standalone, high performance programmable motion controllers with integrated servo amplifiers.

It is equipped with Ethernet, USB, CAN bus, RS232, and RS485 communication ports to interface with host devices such as PCs, PLCs, and HMIs. It can control any external driver via analog or digital command.

At 16 kHz sampling (profiler, position, velocity, and current control loops) frequency, AGD301 controllers are ideal for any tightly coordinated motion systems.

AGD301 has three integrated amplifiers, enabling it to drive three motors directly. It can drive all types of motors, such as steppers, voice coils, brushed or brushless motors, and including direct-drive linear and rotary motors.

Agito PCSuite software and IDE is used for AGD301 programming, configuration, tuning and operation. Agito PCSuite provides configuration wizard, time domain tuning and analysis, frequency domain identification and design, auto tuning and easy to use GUI for all the features of Agito controllers.



Figure 1. AGD301

1.2 Part Numbering

Product Description	Part Number Format
3-Axis Controller, Integrated Amplifiers	AGD301-ET-2Dxx[-CCC]

ET: Ethernet

2D: 12-90 VDC

xx: Continuous and peak current rating

- 05: (per axis) 5.6 A_{rms} continuous, 11.2 A_{rms} peak
- 09: (per axis) 9.0 A_{rms} (up to 20 A_{rms} for 3 axes) continuous, 18.0 A_{rms} peak

CCC: Optional customization number

Example: **AGD301-ET-2D09-001**, 9 A_{rms} continuous, 18.0 A_{rms} peak current for each axis, with 16-bit analog input.

1.3 System Design

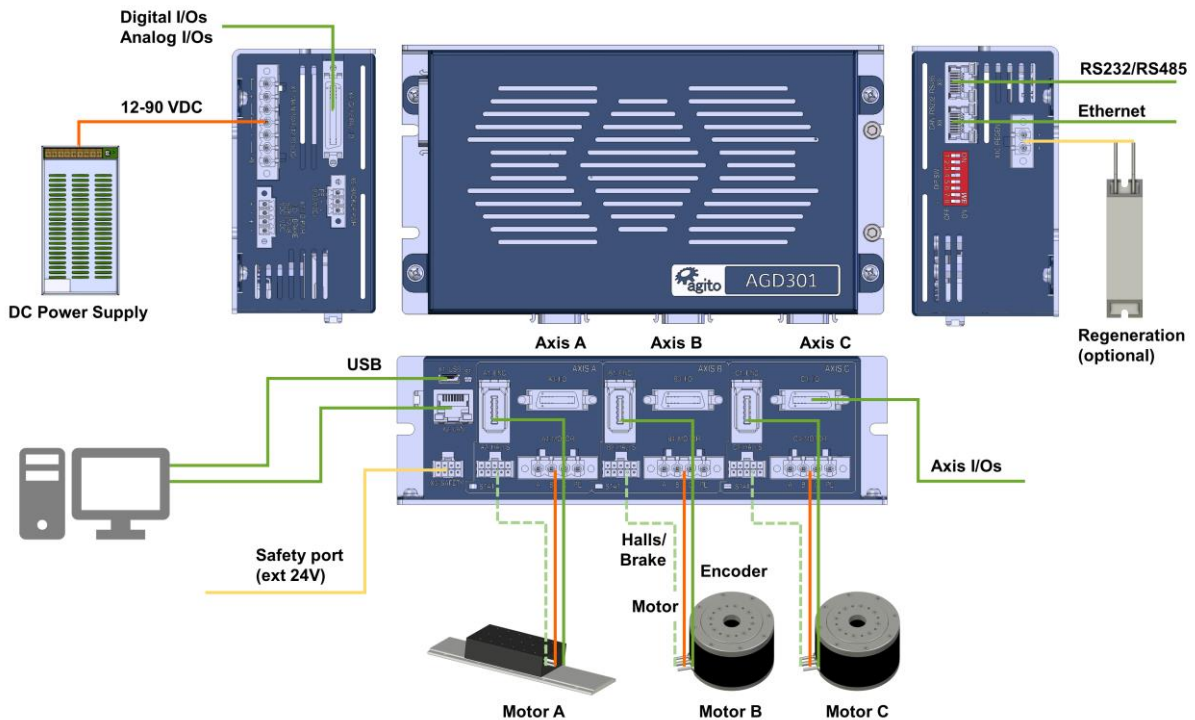


Figure 2. System connections and wiring

1.4 Technical Specifications

Electrical Specifications

Feature	AGD301-ET-2D05	AGD301-ET-2D09
Number of axes	3	
Nominal supply voltage	12–90 VDC	
Minimum supply voltage	11 VDC	
Maximum supply voltage	95 VDC	
Logic power supply (optional)	12–36 VDC	
Continuous output current (Internally limited by firmware)	5.6 A _{rms} per axis	9.0 A _{rms} per axis (limited to 20 A _{rms} total for 3 axes)
Peak output current (Internally limited by firmware)	11.2 A _{rms}	18.2 A _{rms}
Output power @ 90 VDC	504 kVA	810 kVA
Peak current time	3 sec	
Output frequency	0–599 Hz	
Isolated digital inputs	27	
Isolated digital outputs	17	
Bi-directional differential I/Os (RS422)	8	
Analog inputs	4 (12 bit)	

Feature	AGD301-ET-2D05	AGD301-ET-2D09
Analog outputs	4 (16 bit)	
Brake outputs	3	
Encoder ports	3	
Hall sensors ports	3	
Regeneration output	1	
Motor types	Voice coil, brushed or brushless linear or rotary motor. 2-phase steppers (open and closed loop, micro-stepping)	
Communication	Ethernet, CAN RS232, RS485, USB	
PWM frequency	16 kHz	
Power supply to external devices	Voltage: 5V Overall max. current: 1.5A	

Encoder Ports Specifications

Feature	Specification
Encoder types	Incremental AqB, Sin/Cos, Absolute EnDat 2.2, Absolute BiSS-C
Power supply to encoder	0.5 A per encoder port
Max. cable length	40 m
Incremental encoder	Hardware: Differential RS422/RS485 Max. input frequency: 6.25 MHz Termination: 120 Ω Commutation: Auto-phasing, Hall sensors
Sin/Cos encoder (on Main Encoder port only)	Hardware: Differential RS422/RS485, 1V pkp @2.5V Max. input frequency: 250 kHz Termination: 120 Ω Max interpolation: 13 bits (x 8192) Commutation: Auto-phasing, Hall sensors
Absolute BiSS-C	Hardware: Differential RS422/RS485, clock (MA), data (SLO) Clock frequency: 2 MHz Max. position bits: 32 bits Commutation: Auto-phasing, by absolute offset
Absolute EnDat 2.2	Hardware: Differential RS422/RS485, clock, data Clock frequency: 2 MHz Max. position bits: 32 bits Commutation: Auto-phasing, by absolute offset
Hall sensors	Opto-isolated 5V with internal power supply

I/O Specifications

Feature	Specification
Power supply for optically isolated I/Os	Voltage: 5–28 VDC
Optically isolated digital inputs	Type: PNP/NPN Propagation delay: 10 μ s Max. frequency: 100 kHz Functionality: limit switches, home, captures, start motion, gain scheduling, and others
Optically isolated digital outputs	Type: PNP/NPN Max current: 0.5A (for NPN type), 0.3A (for PNP type) Propagation delay: 10 μ s Max. frequency: 100 kHz Functionality: alarm, in-position, event (PEG), and others
Bi-directional differential digital I/O	Hardware: Differential RS422 Termination: 120 Ω Propagation delay: 100 ns Max. frequency: 5 MHz Direction: Input or output, set by Agito PCSuite Functionality: Any differential input or output functionality.
Analog inputs	Operational voltage: \pm 12V Resolution: 12 bit or 16 bit
Analog outputs	Operational voltage: \pm 12V Resolution: 16 bit
Safety inputs	2 independent inputs Voltage: 5–28 VDC
Static brake output	Operational voltage: 24V Maximum current: 3A

Technical Specifications

Mechanical Specifications

Feature	Specification
Unit dimensions (max)	H=57 mm, W=188 mm, D=105 mm
Package dimensions	H=70 mm, W=235 mm, D =145 mm
Unit weight	0.4 kg
Shipping weight	0.5 kg

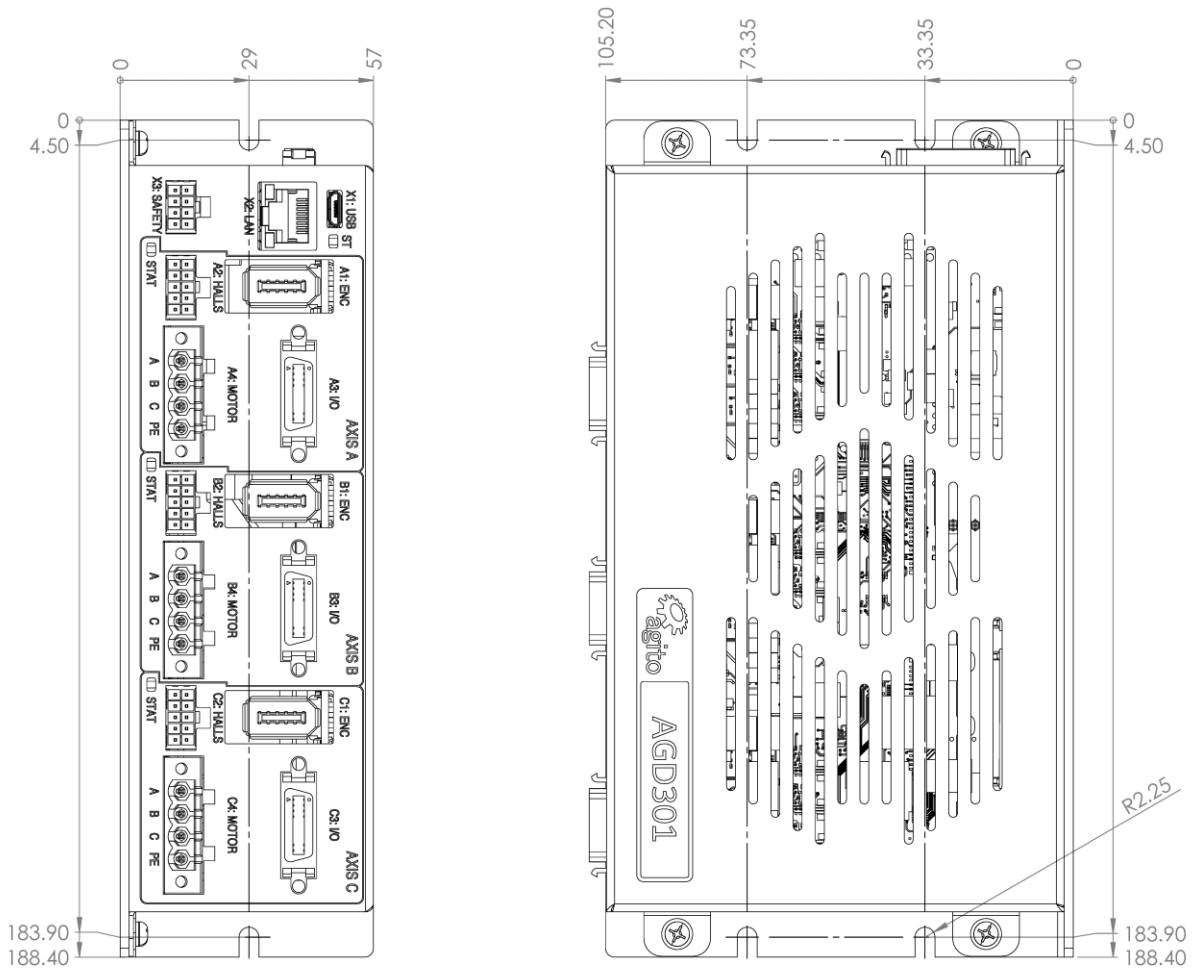


Figure 3. Product Dimensions (mm)

1.5 Motion Control Specifications

Motion Control Specification

Feature	Specification
Key Features	<ul style="list-style-type: none"> ▪ Encoder error mapping: 1D, 2D or 3D ▪ Auto-loop shaping (auto-tuning) ▪ Frequency domain system identification and modeling ▪ Flexible gain scheduling based on motion conditions ▪ Position lock and event ▪ Advanced Auto-tuning algorithm in frequency domain ▪ Force control and mode switching
Advanced Features	<ul style="list-style-type: none"> ▪ Ultra Precision mode (UPM) ▪ Input-shaping ▪ Profile-shaping ▪ Machine vibration control with external sensor ▪ Spring and friction compensation ▪ Active-yaw gantry control
Control Sampling Rate	16 kHz (profiler, position, velocity, optional force, current)
Motion Modes	<ul style="list-style-type: none"> ▪ Point-to-point ▪ Repetitive ▪ CNC sequential contour (G-codes) ▪ Vector and tracking motion modes ▪ Jog ▪ ECAM ▪ Gearing ▪ Joystick ▪ Handwheel ▪ Pulse and direction
Operational Modes	<ul style="list-style-type: none"> ▪ Position ▪ Velocity ▪ Force ▪ Current (torque) modes
Motion Modes Switching	Motion parameters, such as speed, acceleration, deceleration, and target position can be all modified on-the-fly
Programming Interfaces	<ul style="list-style-type: none"> ▪ Standalone user programs ▪ Multi-threaded with priority setting environment, up to 8 threads ▪ Execution time: 50 low script commands in 1 millisecond ▪ High level C-language-like script programming language integrated in Agito PCSuite

Feature	Specification
IDE and Host Interfaces	<ul style="list-style-type: none"> ▪ Windows PC Suite IDE and configuration software ▪ Windows .NET API available in NuGet package manager ▪ Linux .NET API ▪ The API can also be used in MATLAB, LabVIEW, and other environments compatible with Windows .NET ▪ Standard TCP/IP communication ▪ ASCII string commands or binary CAN format

1.6 Environmental Specifications

Environmental Specifications

Feature	Specification
Operating temperature	0°C to 50°C
Storage temperature	-20°C to 70°C
Operating humidity	< 90%
Storage humidity	< 40%
Pollution degree	2
Vibration	1G @ 150 Hz according to IEC 60068-2-6
Operating conditions	Protection class: IP20




2 Safety

2.1 Safety Symbols

Safety symbols indicate a potential for personal injury or equipment damage if the prescribed precautions and safe operating practices are not followed.

The following safety symbols are used in the product documentation.

Safety Symbols

Symbol	Meaning	Description
	Hazardous voltage	Indicates hazards arising from dangerous voltages.
	Earthing PE (protective earth)	Identifies any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth (ground) electrode.
	Caution, hot surface	Indicates the marked item can be hot and should not be touched without taking care.

2.2 Safety Guidelines

To achieve optimum and safe operation of the product, it is important to follow the safety procedures specified in this manual.

Only qualified personnel may install, maintain, or repair the product. Before starting installation, maintenance or operation, ensure that all system components are connected to protective earth ground (PE).

The PE wire must be colored green-yellow, in accordance with local electrical wiring standards.

This product contains electrostatic-sensitive components. Proper handling procedures must be observed to avoid damage to the product.

To avoid electric arcing and hazards, never connect or disconnect any connector while the power source is on.

The maximum power supply voltage connected to the product must comply with the ratings provided in this manual.

Always disconnect the power cables before servicing the product.

Pay attention to safety symbols on the product or in the manual. Follow proper safety precautions when installing or operating the product.



Attention

All power connectors must be securely tightened before any operation.



Attention

Do not attempt to hinder or override the product's or system's fault detection or protection circuits. You must determine the cause of a fault and correct it before you attempt to operate the system. Failure to correct the fault could result in personal injury and/or damage to equipment.

**Warning**

Connectors A4, B4, C4, X5, X7 and X10 are high power. Do not touch these connectors when the product is powered.

**Warning**

Capacitors on the DC bus can retain hazardous voltages after input power has been removed. In general it is not recommended to touch or plug in/out connectors when unit is powered.

2.3 Compliance

Standards Compliance

Directive	Standard
2014/35/EU EC Machinery Low Voltage Directive	IEC 61800-5-1:2007/A1:2017
2014/30/EU Electromagnetic Compatibility Directive (EMC)	IEC 61800-3-2017
RoHS 2011/65/EU + (EU)2015/863	EN 50581:2012

This product is intended to operate in a machine or equivalent end-product. The machine or end-product must comply with any necessary safety standard as typically required for the same type of machine or end-product. It is the responsibility of the machine or end-product manufacturer to ensure the final machine or end-product meets the requirement of any safety and EMC regulations.

File name: EU Declaration of Conformity - AGD301_v1.3.docx
 Date: October 25, 2021
 Version: 1.3

EU Declaration of Conformity

Product: AGD301: 3-axis controller with integrated servo amplifiers

P/N:	Description
AGD301-ET-2D05	3-axis Drive - 90Vdc, 5.6 Arms continuous current
AGD301-ET-2D09	3-axis Drive - 90Vdc, 9.1 Arms continuous current

Name and address of manufacturer:

Agito Akribis Systems Ltd. 6 Yad-Harutsim St., P.O.Box 7172,
 Kfar-Saba 4464103, Israel
 Tel: +972-9-8909797 Fax: +972-9-8909796

This declaration is declared under the sole responsibility of the manufacturer

The products mentioned above are in accordance with EC Low Voltage Directive 2014/35/EU and EU Electromagnetic Compatibility Directive (2014/30/EU),

Conformity of the products designated above is under the following IEC standards:

Directive	Standard
2014/35/EU EC Machinery Low Voltage Directive	IEC 61800-5-1:2007/A1:2017
2014/30/EU Electromagnetic Compatibility Directive (EMC)	IEC 61800-3:2017
RoHS 2011/65/EU + (EU)2015/863	EN 50581:2012

Certification body: TUV Rheinland
 Low Voltage Directive test report # NN2061A3 002
 EMC Directive test report # NN2061A3 002

Signed for and on behalf of the above-named manufacturer

Place and date of issue: Israel 25 Oct 2021
 Name, function: Eyal Sapir Managing Director
 Signature:



AGITO-AKRIBIS SYSTEMS LTD
51468047

3 Installation

3.1 Unpacking and Packing

Save the original box and packing materials in case you need to pack and return the product to the manufacturer.

To unpack the product:

1. Carefully remove the product from the box and the packing materials.
2. Visually inspect the product to ensure that there is no damage. If any damage has occurred, report it immediately to the carrier that delivered the package.
3. After unpacking, locate the part number label on the product, and make sure it matches the product you ordered, and that the voltage meets your specific requirements.

3.2 Mounting



Warning – Metal Base Plate for Heat Dissipation

The product is supplied with the mounting plate built into the heatsink. At full power operation, the heat sink can be quite warm, around 50°C. It is recommended to mount the product on a large metal panel to help dissipate the heat generated in the product.

3.2.1 Mounting the AGD301

The AGD301 includes 6 slots for mounting the unit, as shown in Figure 3. The unit can be mounted using either the 2 side slots or the 4 bottom slots.

The AGD301 is mounted using M4 screws. It is important to mount the product on metal panel for both grounding and secure connections.

The heatsink of the AGD301 is electrically conductive and serves as the protective earth (PE) ground of the product. However, it is critical to ensure the PE screws are electrically conducting between the PE of AGD301 and the PE of main power supply in the system.

All cables connected to the product must be securely constrained to avoid vibration that causes stress concentration at the cables or connectors which may result in breakage of electrical conductivity.

3.2.2 Mounting Multiple Motion Controllers

When mounting multiple units within a cabinet, clearance between units must be at least 5 mm for vertical mounting and 70mm for horizontal mounting . In addition, top and bottom clearance must be at least 60 mm.

Ambient temperature in the cabinet must not exceed 50°C

If controllers are mounted on a backplane, the backplane temperature must not exceed the 50°C.

It is recommended to install a cooling fan at the bottom of the cabinet for best circulation.

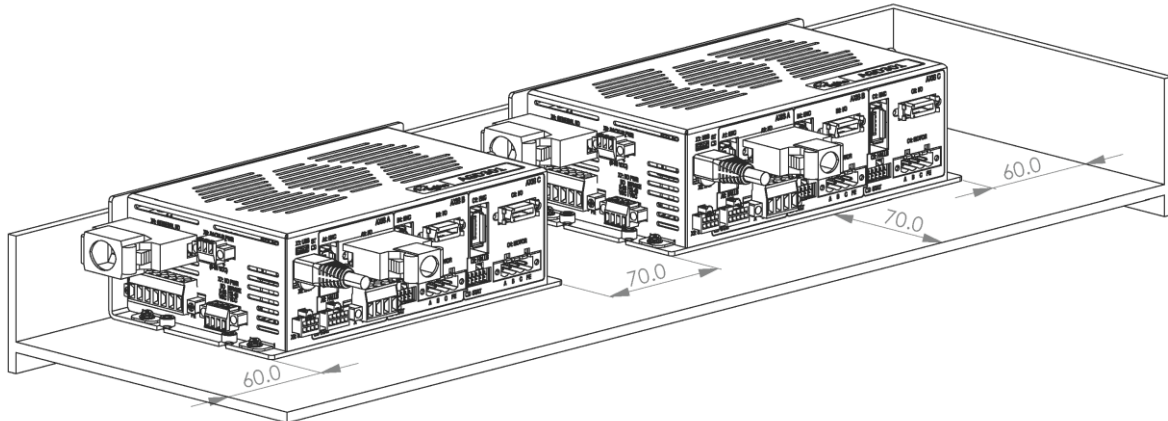


Figure 4. Horizontal mounting multiple amplifiers within cabinet (mm)

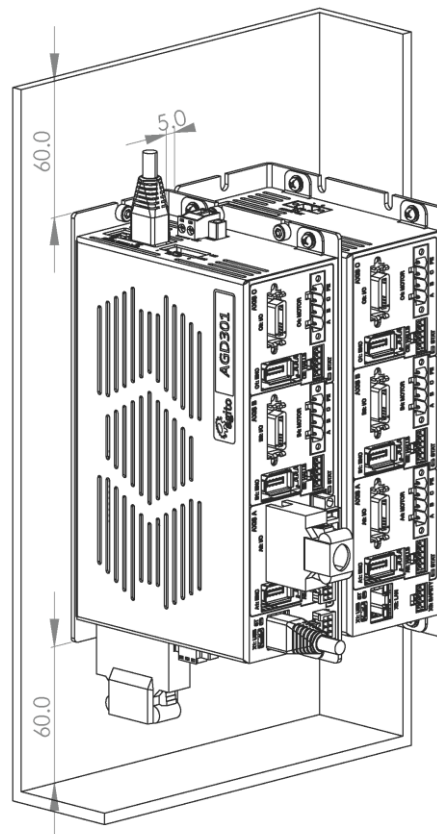


Figure 5. Vertical mounting multiple amplifiers within cabinet (mm)

3.3 Electrical Installation

3.3.1 Power Wiring

AGD301 is designed to operate on voltage ranging from 12 VDC to 90 VDC, which is supplied to bus voltage, to motor, and to logic power.

3.3.2 Regeneration

AGD301 uses the main DC power input to output a controlled electrical power through the phases of the motor. The motor converts this electrical power to a mechanical power that moves the load. During motor deceleration and stopping, the inertia of the load drives the movement of the motor, not the servo drive. Due to back EMF, the motor acts as a generator and returns energy to the DC bus supply, which causes the DC bus voltage to increase to undesirable level.

Maximum allowable DC bus voltage is 90 VDC. To prevent excessive DC bus voltage, a regeneration resistor can be connected to the AGD301 X10 connector to dissipate excess regenerated energy, and prevent it from reaching undesirable levels. The regeneration resistor starts to dissipate energy when actual bus voltage reaches threshold defined by RegenOn parameter. Regeneration voltage threshold parameters are software configurable and can be modified according to the motor's maximum voltage specification.

AGD301 controllers have one regeneration resistor input for both axes. Regeneration power of two motors must be taken into consideration when selecting the resistor.



Warning

DC Vbus is monitored, and motors will be disabled if voltage is too high. However, there is no protection against the connection of an excessive voltage power supply that will damage the product.

For connection details, refer to the section *Interface X10: Regeneration*.

Important Notes

- The regeneration feature, once enabled, is always active, regardless of the motor status (enabled/disabled).
- Current will flow in the regeneration resistor depending on the values of RegenOn and RegenOff, and the power supply voltage.
- There are no current or power protections to protect the regeneration resistor or the internal MOSFET.
- Be sure to set the suitable regeneration parameters for the supply voltage and the external regeneration resistor.
- Plug in the regeneration resistor only after all parameters are set properly, and always when the controller power is off.
- Let the regeneration resistor cool down before touching it. Unplug it only when the controller power is off.
- During development, if the supply voltage is to be modified, first disconnect the regeneration resistor and, before reconnecting the regeneration resistor, be sure to adjust the regeneration parameters to match the new supply voltage.
- We recommend adding external protections (such as PTC) to protect the regeneration resistor.

3.3.3 Safe Operating Area

While each specific maximal rating can be safely used, the product cannot support certain combinations of these maximal ratings. For example, the product will not enable operation under the following **combined** maximal ratings usage continuously over long-term period:

- Three axes at 5.6A_{rms} continuous each, at 90% PWM duty cycle
- 1.5A external load on the 5V supply
- Product mounted horizontally and not attached to a suitable base plate
- 50°C ambient temperature.

Permitted combinations, as well as forbidden combinations, cannot be specifically provided since they are a function of multiple conditions, such as continuous current of all three axes, bus voltage, PWM duty cycle of all three motors, 5V consumption, I/O's high current usage, base plate size, product mounting orientation, and ambient temperature.

The SOA of the product is defined as any combination of operational conditions (each within the absolute maximal ratings defined in the Technical Specifications) and assembly options that lead to internal product temperature below 75°C.

The product includes a built-in temperature sensor. Its internal temperature is reported via the status parameter BoardTemp. When BoardTemp reaches 75°C, all motors will be disabled and errors will be reported. A motor-enable request will create an error if BoardTemp is higher than 75°C.

The following figures are examples of safe operating cases. The SOA charts assume 90% duty cycle on PWM output continuously; that is, motors are moving at the maximum speed allowed by the bus voltage.



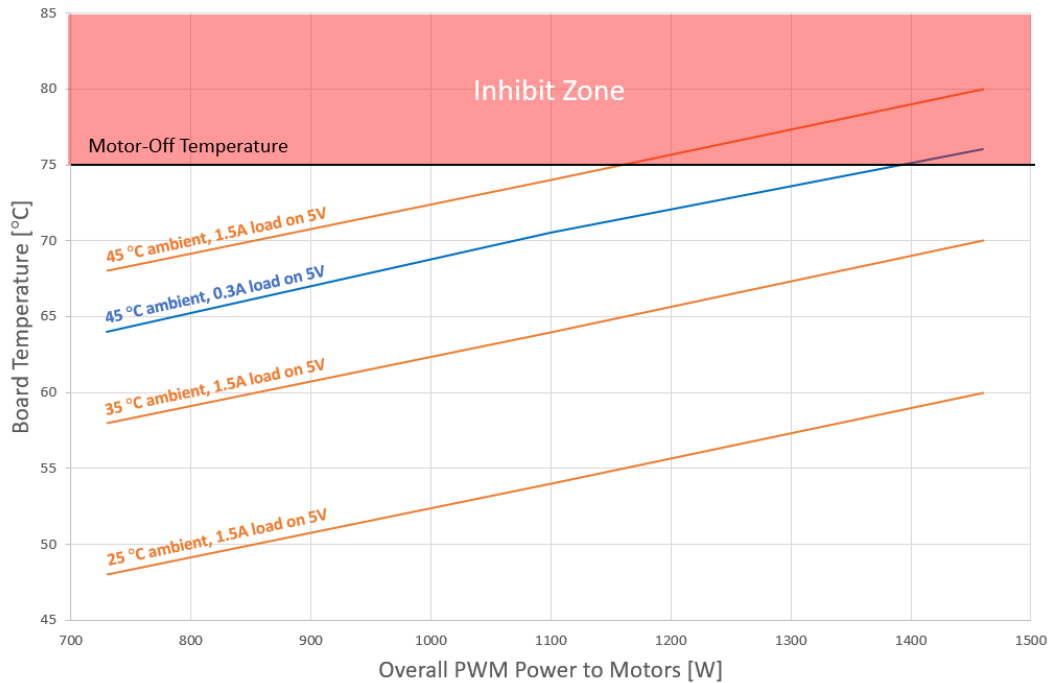
Attention

Each of the power/voltage/current absolute maximal ratings is valid over the overall operating temperature range, subject to the safe operating area (SOA).

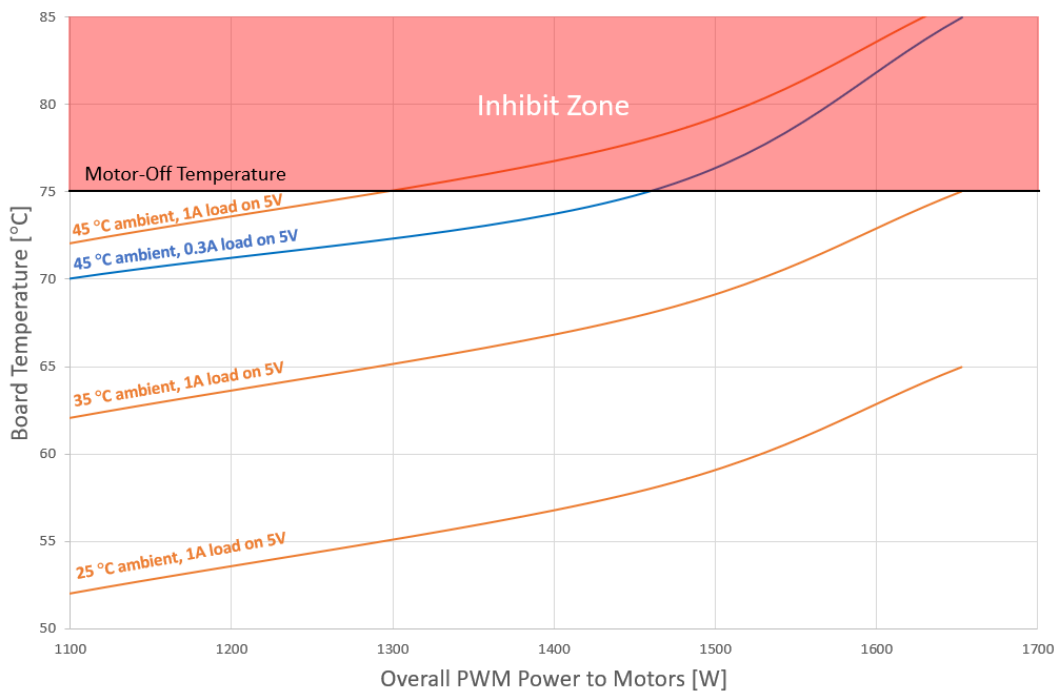


Attention

Operating (or storing) the product contrary to the defined absolute maximal ratings is not allowed and will damage the product.



AGD301-ET-2D05 Safe operating area (SOA) @90 VDC



AGD301-ET-2D09 Safe operating area (SOA) @90 VDC



PWM power

Overall PWM power to motors is the sum of PWM power to all three motors.

$$PWM\ power = 0.95 \times Main_Power_Supply_Voltage\ [V] \times Motor_Continuous_Current\ [Arms]$$

This formula assumes 90% PWM duty cycle.

3.3.4 Grounding

It is recommended to install the AGD301 on a metal plate for better power dissipation, reduced EMI, and grounding connection. Make sure the plate is not painted.

The heatsink of the AGD301 is electrically conductive and serves as the protective earth (PE) ground of the product. However, it is critical to ensure the PE screws are electrically conducting between the chassis connection screw of AGD301 and the PE of main power supply in the system.

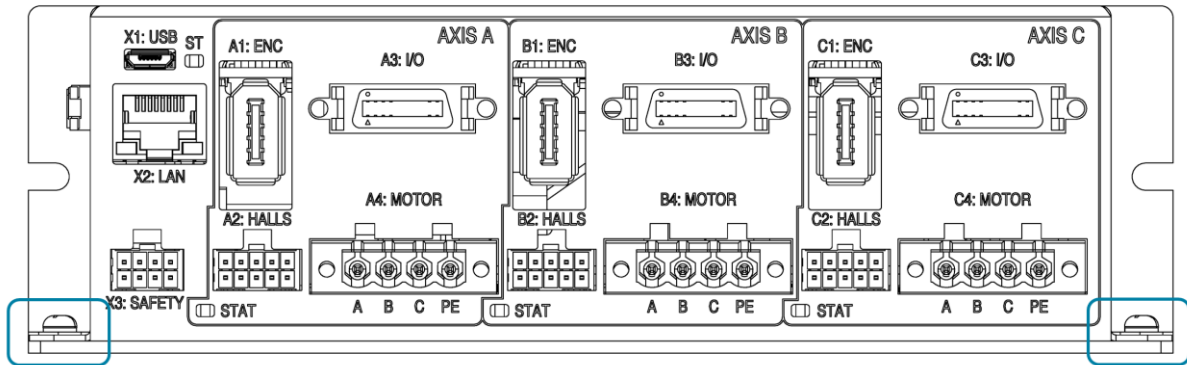


Figure 20: Chassis connection screws

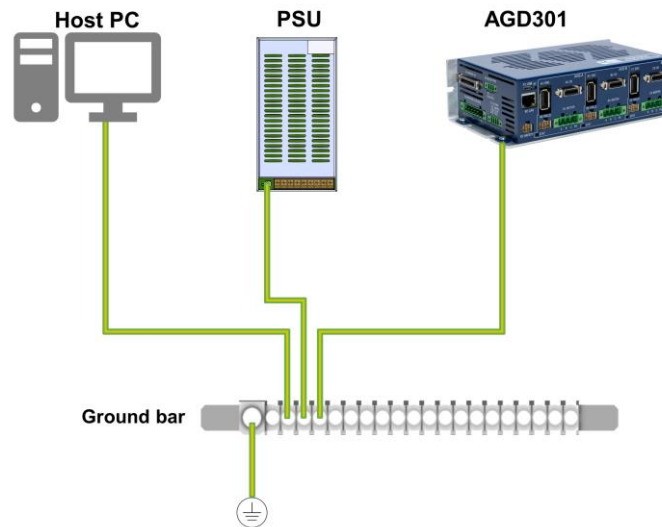


Figure 6. System grounding

Ground Domains

The following table shows the ground domains in the AGD301 system:

- **GND.** Reference voltage for digital/analog circuits and signals.
- **PGND.** High voltage ground domain (internal).
- **General.** Usually at DC potential close to GND, but not connected internally.

Ground Domains

Name	Ground Domain	Notes
DC power input	GND (digital ground)	External DC power supply
Isolated digital inputs/outputs	General	Isolated
Differential inputs/outputs	GND	Not isolated. To controller/PLC.
Analog inputs/outputs	GND	Not isolated
Brake control output	General	Isolated. External DC power supply.
Regeneration output	PGND	
Ethernet communication	General	Isolated
Other communication	GND	Not isolated (unless otherwise stated in manual).

Grounding Policy

Grounding of the product must comply with the following guidelines:

- The enclosures and other external parts that may be touched by the user must be in the safe domain.
- The AGD301 must be connected to protective earth (PE) and connected to the building's ground. PE is protected with an earth-leakage circuit breaker (ELCB); hence it is safe to touch. Refer to Figure 6.
- PGND is connected directly to mains wires, hence it is just as dangerous as mains to the user.
- All shielded cables, including but not limited to motor, encoders, and power input, have their shield connected to PE as part of the external metal enclosure.
- It is critical to avoid ground loops in the system. A ground loop allows currents to return by two or more different paths, causing electromagnetic interference or even damage to wires.
- The system designer must carefully examine all GND connections in the system to ensure that no loops are created, and that all GND-referenced signals have a GND wire nearby (for both return currents and common mode voltage).

3.4 Electrical Interfaces

This section provides a detailed description of all the power and signal interfaces of the product.

3.4.1 Interface X5: Main Power

Connector X5 (MAIN PWR) is used to supply 12–90 VDC to the AGD301.

The input voltage is directly connected to the amplifier power bridge, to drive the motors. In addition, it is used to generate internal logic power to the controller board and to external devices such as encoders and I/Os.

The AGD301 is fully operational with this single power supply.

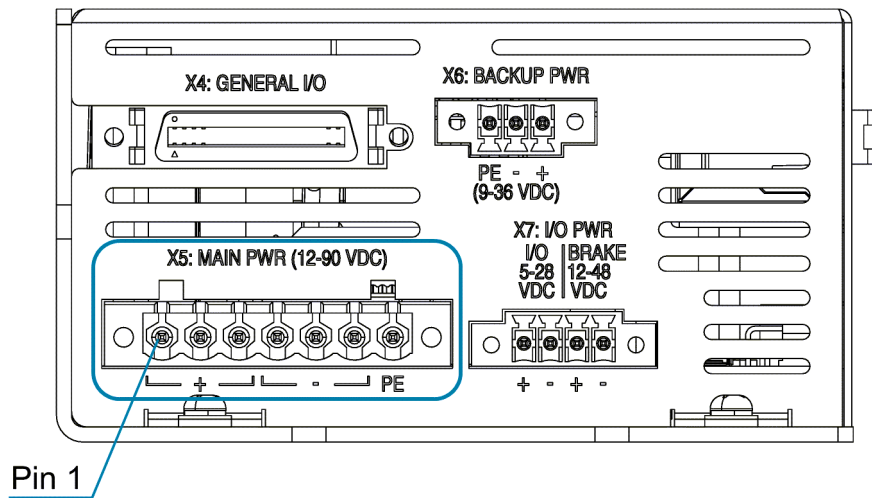


Figure 7: Main Power Connector

Connector X5: MAIN PWR

Pin #	Name	Description
1	Vbus	Motor power input: 12V to 90V
2	Vbus	Motor power input: 12V to 90V
3	Vbus	Motor power input: 12V to 90V
4	Vbus_return	Power GND
5	Vbus_return	Power GND
6	Vbus_return	Power GND
7	PE	Protective earth

Mating connector options	Degson 2EDGKM-5.08-07P-14-00A Phoenix Contact 1778030
Pitch	5.08 mm
Wiring	AWG 12–16, insulation rated for 300 V



Warning

The AGD301 does not include protection against inversed polarity at the input power. Make sure you connect power input according to the connector pinout below.



Warning – Common Vbus Power

Pins 1, 2 and 3 are connected to a common Vbus. The same voltage must be connected to each pin. 3 pins are provided to split the current load on the connector.



Warning - Hot plugging is not supported!

Plug or unplug the power connector only when power is off. Plugging in the power connector when power is on may cause power surges through connected devices and possibly damage them.



Optional schemes for isolated power supplies

The AGD301 can support fully isolated power supplies, one for the power circuitry to drive the motor, and one for the digital logic. If you are interested in such a scheme, contact Technical Support.

3.4.2 Interface X6: Backup Power

Connector X6 (BACKUP PW) provides optional backup (9–36 VDC) power for the logic components, and enables communication with the controller when interface X5: MAIN PWR is disconnected.

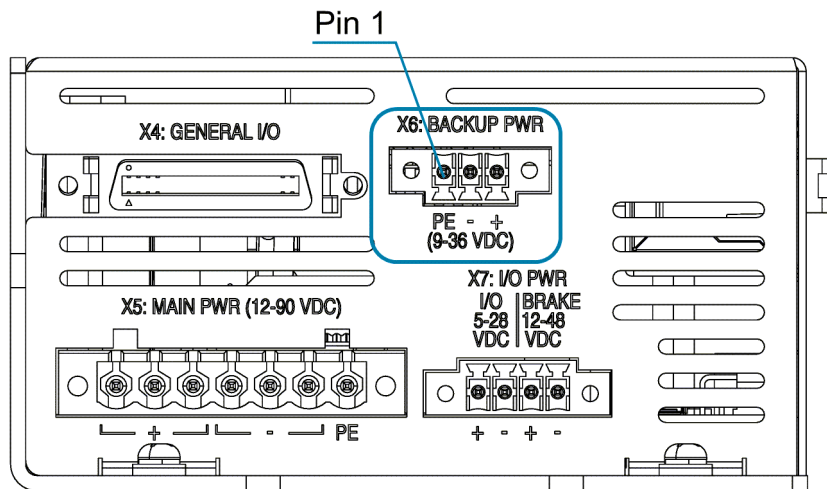


Figure 8: Backup Power Connector

Connector X6: BACKUP PWR

Pin #	Name	Description
1	+ Backup/logic power	9–36 VDC – backup/logic power, up to 50W
2	- Backup power GND	Ground – backup/logic power return
3	PE	Protective earth

Mating connector options	Degson 15EDGKM-3.5-03P-14-00A Phoenix Contact 1847068
Pitch	3.5 mm
Wiring	16–20 AWG, insulation rated for 300V

3.4.3 Interface X7: I/O Power and Brake Power

Connector X7 (I/O PWR) allows users to provide DC power supply to the isolated I/Os and motor brake. Typically, the isolated I/Os use 28 VDC. The I/O power is connected internally to each I/O port to allow users to tap this power supply easily within the same connector.

The brake power supports up to 48 VDC. This power is connected internally to the brake output port.

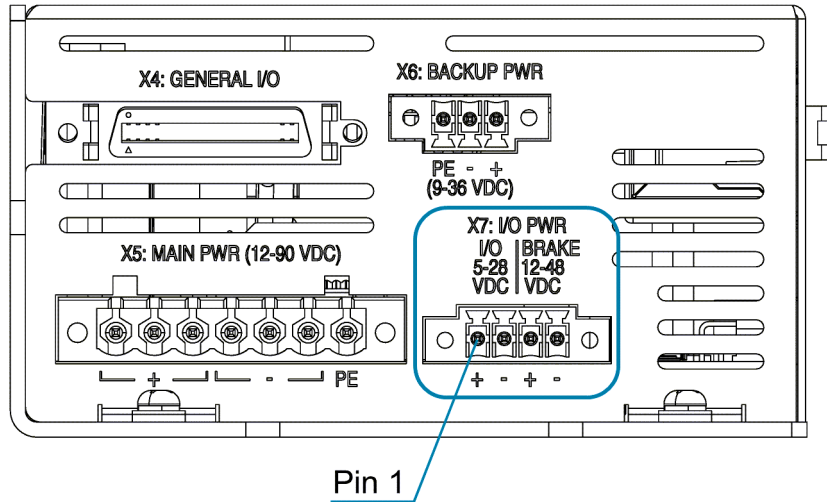


Figure 9: I/O and Brake Power Connector

Connector X7: I/O PWR

Pin #	Name	Description
1	IO_PWR	5 to 28 VDC – User supplied I/O power input, up to 2A
2	IO_PWR_Return	Ground – I/O power return
3	VBrake	12 to 48 VDC – Brake power input, up to 70W
4	VBrake_Return	Ground – Brake power return

Mating connector options	Degson 15EDGKM-3.5-04P-14-00A Phoenix Contact 1847071
Pitch	3.5 mm
Wiring	AWG 16–20, insulation rated for 100 V



Warning - Hot plugging is not supported!

Plug or unplug the power connector only when power is off. Plugging in the power connector when power is on may cause power surges through connected devices and possibly damage them.

Brake Circuitry

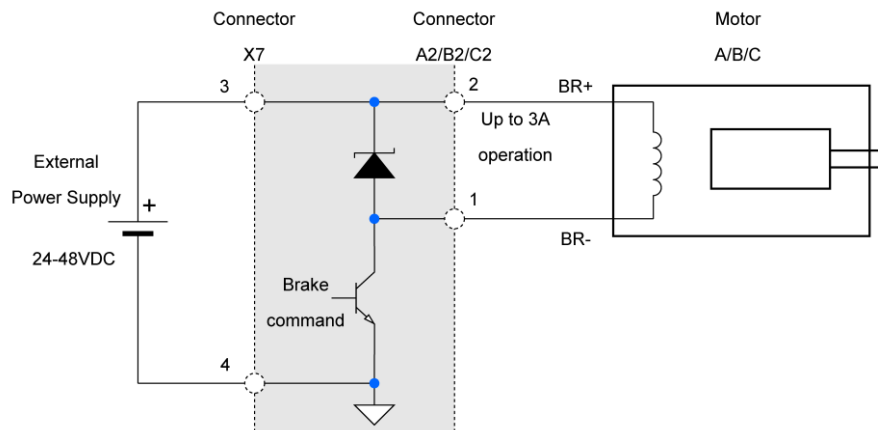


Figure 10. Static brakes

- An external 24–48 VDC power supply, connected to X7 pin 3 and pin 4, is required to provide power to the motor brake.

Connect the Motor Brake+ wire directly to the power supply positive terminal, A2/B2/C2 pin 2 (VBrake).

Connect the Motor Brake- wire to A2/B2/C2 pin 1 (Static_Brake) for motor A brake/B brake/C brake.

- AGD301 includes flyback diodes; therefore, an external diode is not required.
- Motor brake functionality can be configured in Agito PCSuite to automatic mode: Brake released on motor on, and Brake engaged on motor off.

3.4.4 Interfaces A4, B4, C4: Motors

Connectors A4, B4, and C4 (MOTOR) are used to connect to the motor phases of Axes A, B, and C, respectively. The AGD301 supports any combination of 3-phase brushless motors, 1-phase brushed motors, and voice coil motors.

Be sure to follow the wiring specifications for each motor.

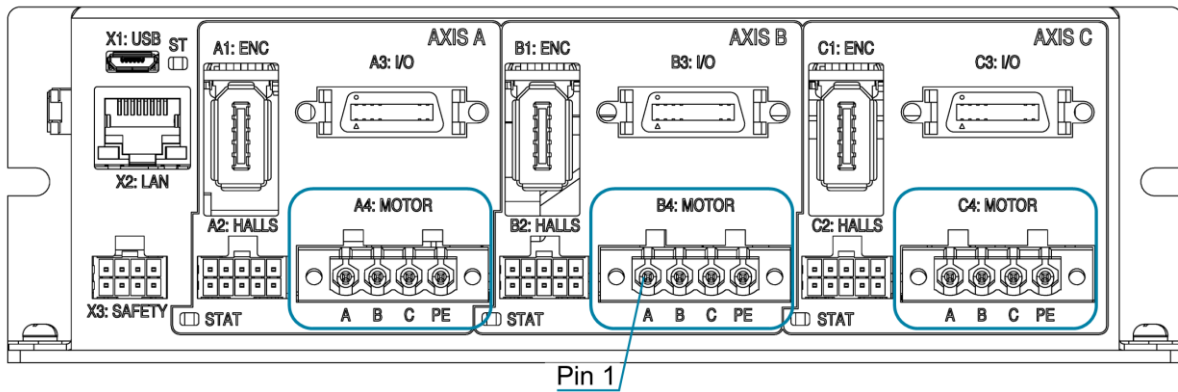


Figure 11: Motor Power Connector

Connectors A4, B4 and C4: MOTOR

Pin #	Label	Brushless Motor	Brushed or Voice Coil Motor
1	A	Motor phase A / M1	Motor phase + / Phase A / M1
2	B	Motor phase C / M2	Motor phase - / Phase B / M2
3	C	Motor phase C / M3	Not connected
4	PE	Protective earth (motor power cable shield)	Protective earth (motor power cable shield)

Mating connector options	Degson 2EDGKM-5.08-04P-14-00A Phoenix Contact 1778001
Pitch	5.08 mm
Wiring	14–20 AWG, insulation rated for 300 V

3.4.5 Interface X3: Safety

Connector X3 (SAFETY) is used for the hardware safety function that disables power to the motor.

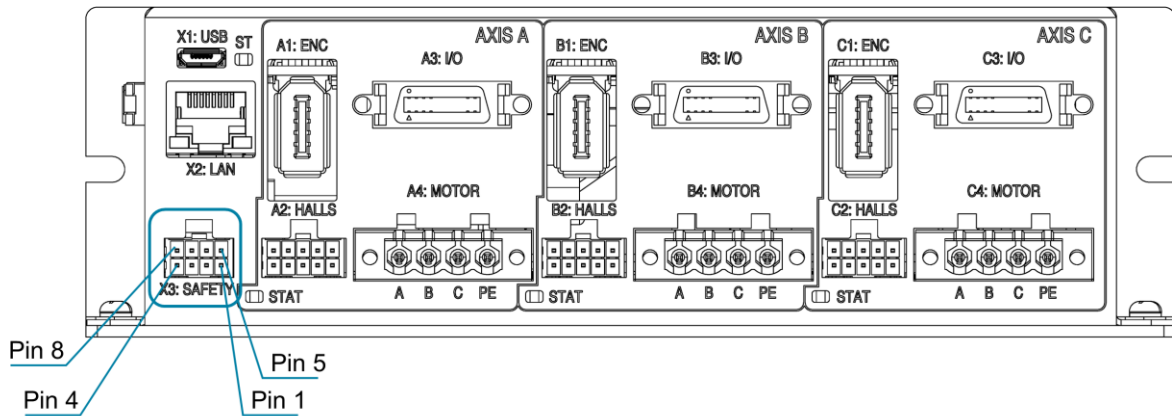


Figure 12. Safety connector

Connector X3: SAFETY

Pin #	Name	Description
1	5V	5V supply for safety circuits
2	Safety_Feedback-	Safety_Feedback negative (emitter) output
3	Safety_Input_2-	Safety_Input_2 negative input
4	Safety_Input_1-	Safety_Input_1 negative input
5	GND	GND
6	Safety_Feedback+	Safety_Feedback positive (collector) output
7	Safety_Input_2+	Safety_Input_2 positive input
8	Safety_Input_1+	Safety_Input_1 positive input

Mating connector options	Samtec	IPD1-04-D-K and CC79L-2630-01-L
Wiring	26 AWG, insulation rated for 100 V	



Disabling Safety function

If the Safety function is not required in your application, you can disable it by using a jumper plug from Agito. Part number: C-AGD301-SFT

Safety Circuitry

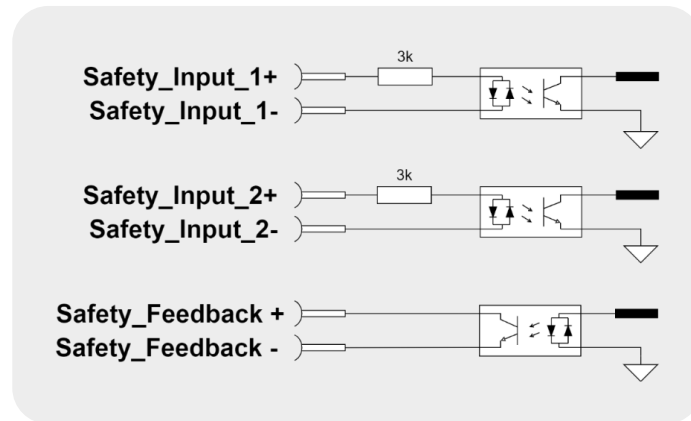


Figure 13. Safety connector

- The safety circuitry consists of two input channels, labeled Safety_Input_1 and Safety_Input_2. Both input channels support a voltage range of 5 VDC to 24 VDC. It is recommended to use 24 VDC for the input voltage as it provides better electromagnetic interference (EMI) immunity.
- Safety_Input_1 and Safety_Input_2 function independently, thus providing safety redundancy. Each one can disable the power to the motor.
- Both Safety_Input_1 and Safety_Input_2 disable the power to the motor through hardware circuitry, without any software intervention.
- Both Safety_Input_1 and Safety_Input_2 are defined with a positive pin (+) and a negative pin (-). However, the opto-coupler at the Safety_Input has two input diodes, which enable operation at “positive” or “negative” input voltage. The input is activated when current is sufficient at one of the input diodes, regardless of the current direction. This enables NPN or PNP connection to the safety inputs.
- The Safety_Input protection logic is designed so that both Safety_Inputs must be powered to enable motor operation. Leaving a Safety_Input disconnected prevents motor operation. This logic is required to ensure that a disconnected safety cable is considered an unsafe condition by the control unit. When sufficient current is driven through a Safety_Input, the state of this input is Safe. When insufficient current is driven through a Safety_Input, the state of this input is Unsafe.
- The two Safety_Inputs must be in the Safe state to enable motor operation.
- Both Safety_Input_1 and Safety_Input_2, although acting on the drive hardware directly, are also monitored by the controller software. The controller software generates a feedback signal to the user (Safety_Feedback), which is also an isolated signal. This feedback is generated by the software, and is activated if at least one of Safety_Input_1 or Safety_Input_2 signals is in the Unsafe state.
- The electrical characteristics of the Safety_Input_1 and Safety_Input_2 are identical to those of all other isolated digital inputs of the controller.
- The safety inputs implemented in the product are currently pending certification Functional Safety Standards.

3.4.6 Interface X10: Regeneration

Connector X10 (REGEN) is used to connect an external power resistor to dissipate energy generated by the motor, typically during deceleration. The motor-generated energy will charge up the internal capacitor. When the internal capacitor is fully charged, the bus voltage will increase. When bus voltage is higher than the operating limit of the product, it will trigger over-voltage protection and disable the motor. To prevent this from happening, users can connect an external power resistor to dissipate the unwanted energy.

Refer to the section *Regeneration* for more information about Regeneration.

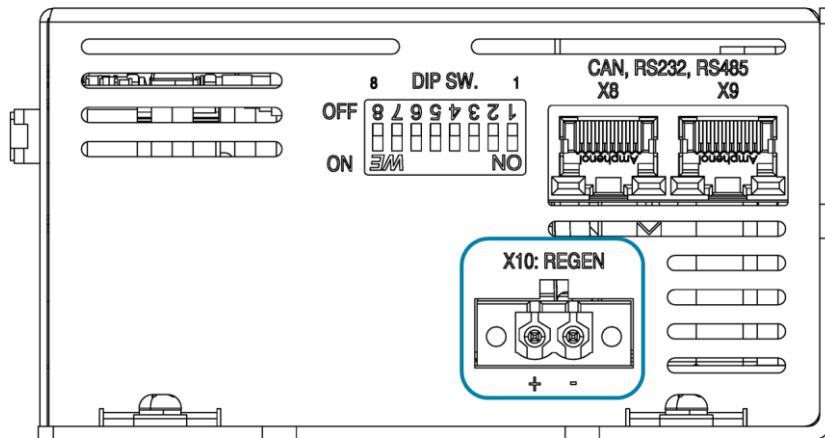


Figure 14. Regeneration Connector

Connector X10: REGEN

Pin #	Name	Description
1	Vbus+	The internal Vbus power (internally connected to Vbus on connector PWR).
2	Regeneration	Regeneration pin to be connected to an external regeneration resistor. Limited to 16A. The external regeneration resistor should be connected between this pin (pin 2) and the Internal DC Bus pin (pin 1).
Mating connector options	Degson Phoenix Contact	2EDGKM-5.08-02P-14-00A 1777989
Pitch	5.08 mm	
Wiring	14–16 AWG, insulation rated for 300 V	

3.4.7 Interfaces A1, B1, C1: Encoders

Connectors A1, B1, and C1 (ENC) are identical, and have the same pinouts. Each one serves as an interface to a single encoder.

Each encoder port supports various encoder types: digital quadrature incremental encoders (AqB), analog sin/cos incremental encoders, absolute BiSS-C encoders, and absolute EnDat2.2 encoders. The type of encoder connected to the AGD301 is configured in the Agito PCSuite software.

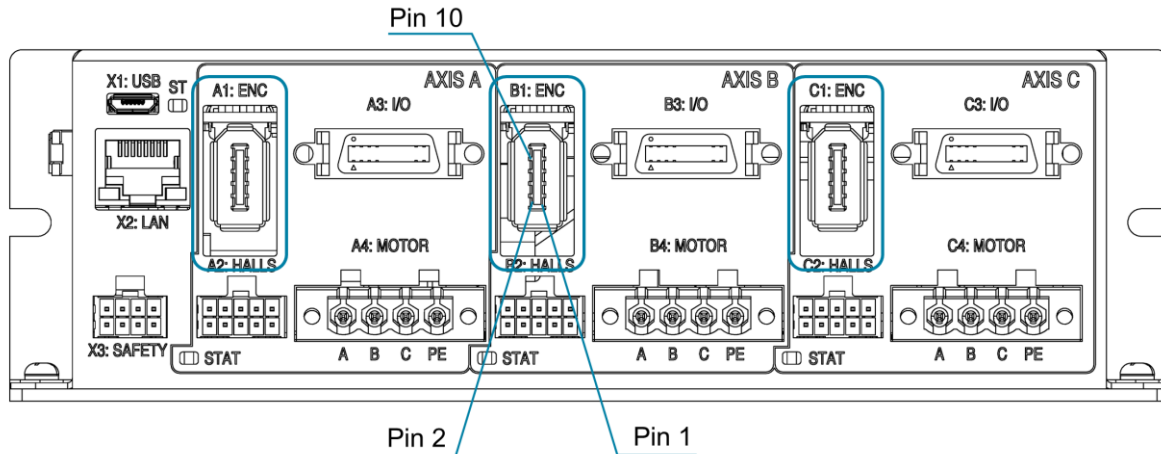


Figure 15: Encoder Connector

Connector A1, B1 and C1: ENC (AXIS A, B and C)

Pin #	Name	Encoder Types				Description
		AqB	Sin/Cos	BiSS-C	EnDat 2.2	
1	5V					5V power supply (limited to 0.5A per connector)
2	GND					5V return and reference for differential signals
3	Encoder_1+			CLOCK+	CLOCK+	Clock+ pin for absolute encoders
4	Encoder_1-			CLOCK-	CLOCK-	Clock- pin for absolute encoders
5	Encoder_2+	A+	SIN+			A+ (for AqB) or sin+ (for analog sin/cos)
6	Encoder_2-	A-	SIN-			A- (for AqB) or sin- (for analog sin/cos)
7	Encoder_3+	B+	COS+			B+ (for AqB) or cos+ (for analog sin/cos)
8	Encoder_3-	B-	COS-			B- (for AqB) or cos- (for analog sin/cos)
9	Encoder_4+	Z+	Z+	DATA+	DATA+	Data+ for absolute encoders, or Z+ for both AqB and analog sin/cos encoder
10	Encoder_4-	Z-	Z-	DATA-	DATA-	Data- for absolute encoders, or Z- for both AqB and analog sin/cos encoder

Mating connector options	Sunchu 3M	SC-10-4P 36210-0100PL and 36310-3200-008
Wiring	AWG 26, insulation rated for 100 V	



Note – Incremental encoder interface details

Each differential-pair includes a built-in 120Ω terminator and the required hardware circuits to detect a disconnected encoder cable. When a disconnected encoder cable is detected, the controller will disable the motor. The detection is done on the A and B channels only (not on the index or Z-channel).

By default, the product does not support single-ended encoder. For use of single-ended encoder, contact Technical Support.



Note – 5V supply limitation

The 5V supply provided at pin 1 of each ENC connector is internally limited to 0.5A per connector. The maximum total current provided by all the 5V pins in the product is limited to 1.5A.

3.4.8 Interfaces A2, B2, C2: Hall Sensors and Static Brake

Connectors A2, B2, and C2 (HALLS), one for each axis, have identical pinouts. Each port provides 3 Hall sensor inputs. In addition, each connector includes 1 RTD input for resistance temperature detection (typically for motor temperature), and 1 digital output for static braking.

Additional I/Os are available on interfaces A3, B3, C3 (Digital and Analog I/Os), and on interface X4 (General I/Os)

For schematics and more information about these interfaces, refer to the section *I/O Interfaces – Circuitry*.

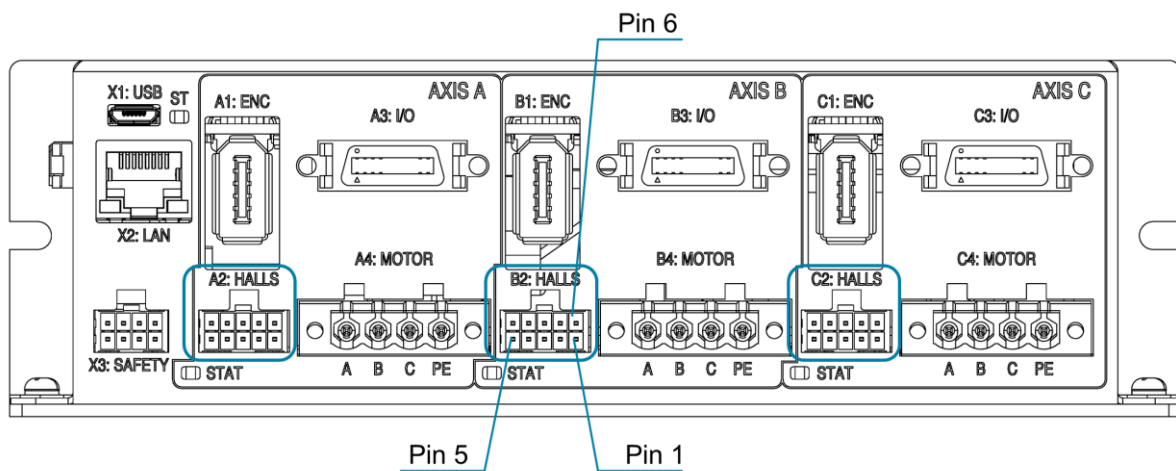


Figure 16: Brake and Hall Sensors Connector

Connector A2: HALLS (Axis A)

Pin #	Name	Software Representation	Description
1	Static_Brake		Brake output, sinking up to 3A
2	VBrake		Brake power supply, connected internally to X7: I/O PWR Connector Pin 3 (VBrake)
3	Hall_A	DInPort.bit(18)	Isolated digital input 19 Hall A signal. To use Hall input, go to the Agito PCSuite Digital Input page, and configure input 18 as Hall A. The following inputs (19 and 20) will be set automatically as Hall B and Hall C.
4	Hall_B	DInPort.bit(19)	Isolated digital input 20 Hall B signal.
5	Hall_C	DInPort.bit(20)	Isolated digital input 21 Hall C signal.
6	5V		5V power supply for Hall sensors
7	GND		GND for 5V
8	RTD+	AMotorTemp	PT100+
9	RTD-		PT100-
10	PE		Protective earth

Connector B2: HALLS (Axis B)

Pin #	Name	Software Representation	Description
1	Static_Brake		Brake output, sinking up to 3A
2	VBrake		Brake power supply, connected internally to X7: I/O PWR Connector Pin 3 (VBrake)
3	Hall_A	DInPort.bit(21)	Isolated digital input 22 Hall A signal. To use Hall input, go to the Agito PCSuite Digital Input page, and configure input 21 as Hall A. The following inputs (22 and 23) will be set automatically as Hall B and Hall C.
4	Hall_B	DInPort.bit(22)	Isolated digital input 23 Hall B signal.
5	Hall_C	DInPort.bit(23)	Isolated digital input 24 Hall C signal.
6	5V		5V power supply for Hall sensors
7	GND		GND for 5V
8	RTD+	BMotorTemp	PT100+
9	RTD-		PT100-
10	PE		Protective earth

Connector C2: HALLS (Axis C)

Pin #	Name	Software Representation	Description
1	Static_Brake		Brake output, sinking up to 3A
2	VBrake		Brake power supply, connected internally to X7: I/O PWR connector pin 3 (VBrake)
3	Hall_A	DInPort.bit(24)	Isolated digital input 25 Hall A signal. To use Hall input, go to the Agito PCSuite Digital Input page, and configure input 24 as Hall A. The following inputs (25 and 26) will be set automatically as Hall B and Hall C.
4	Hall_B	DInPort.bit(25)	Isolated digital input 26 Hall B signal.
5	Hall_C	DInPort.bit(26)	Isolated digital input 27 Hall C signal.
6	5V		5V power supply for Hall sensors
7	GND		GND for 5V
8	RTD+	BMotorTemp	PT100+
9	RTD-		PT100-
10	PE		Protective earth

Mating connector options	Samtec Inc. IPD1-05-D-K and CC79L-2630-01-L
Wiring	26 AWG, insulation rated for 100V



Note – 5V supply limitation

The 5V supply provided at pin 6 is limited to 0.5A per connector. The maximum total current provided by all the 5V pins in the product is limited to 1.5A.

Hall Sensors Circuitry

Motor Hall sensors should be connected to opto-isolated digital inputs on connector A2/B2/C2 (Halls). The Hall sensors must be connected to three consecutive inputs Hall_A, Hall_B, Hall_C. The first input mode must be configured to mode 23-Hall A.

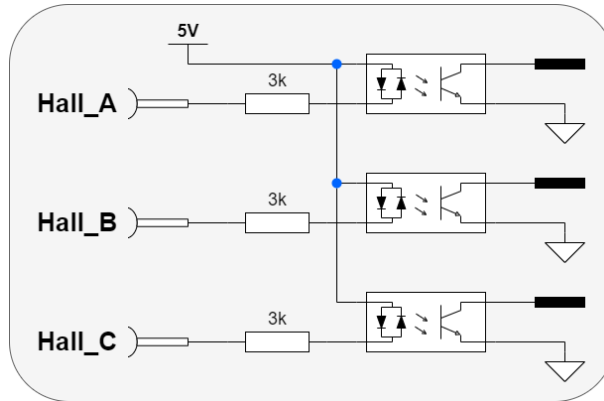


Figure 17. Motor Hall sensors

- It is recommended that Hall sensors be used with incremental encoders. Typically, Hall sensors are called Ha-Hb-Hc, or Hu-Hv-Hw, or H1-H2-H3, which correspond to the motor phases. A typical Hall sensor is an open collector (NPN) type and requires a 5 VDC power supply.
- Any three consecutive digital inputs can be used as Hall sensor inputs.
- Motor Hall sensors are wired as standard digital inputs.

3.4.9 Interfaces A3, B3, C3: Digital and Analog I/Os

Connectors A3, B3, and C3 (I/Os), one for each axis, each provide 6 isolated inputs, 3 isolated outputs, 1 analog output, and 1 analog input.

Additional I/Os are available on interfaces A2, B2, C2 (Halls), and on interface X4 (General I/Os)

For schematics and more information about these interfaces, refer to the section *I/O Interfaces – Circuitry*.

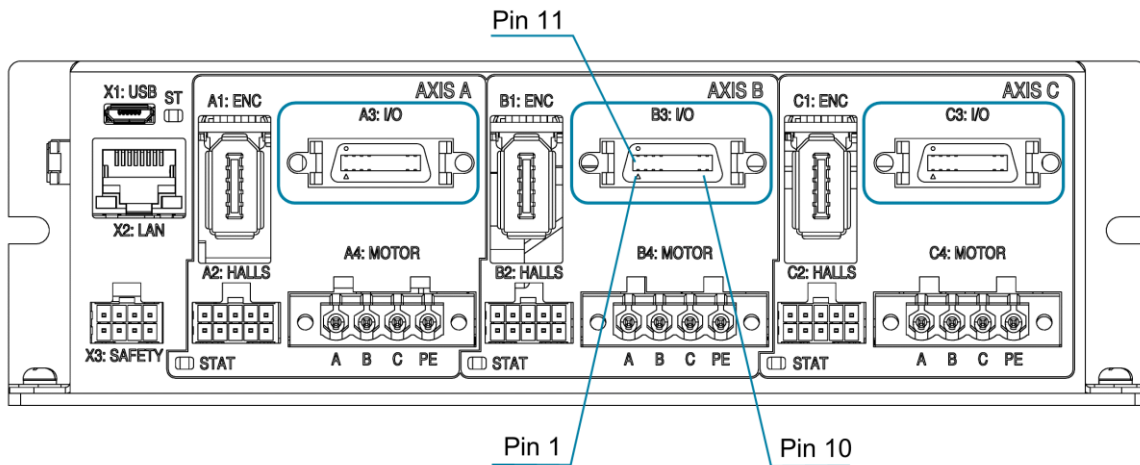


Figure 18: Axis I/O Connector



Note – 5V supply limitation

The 5V supply provided at pin 9 of each AXIS connector is internally limited to 0.5A per connector. The maximum total current provided by all the 5V pins in the product is limited to 1.5A.

Connector A3: I/O (Axis A)

Pin #	Name	Software Representation	Description
1	Digital_Input_1	DInPort.bit(0)	Isolated digital input 1 (NPN or PNP, depending on the connection of the group's common pin).
2	Digital_Input_3	DInPort.bit(2)	Isolated digital input 3 (NPN or PNP, depending on the connection of the group's common pin).
3	Digital_Input_5	DInPort.bit(4)	Isolated digital input 5 (NPN or PNP, depending on the connection of the group's common pin).
4	Digital_Output_1	DOutPort.bit(0)	Isolated digital output 1, programmable sink or source
5	Digital_Output_2	DOutPort.bit(1)	Isolated digital output 2, programmable sink or source
6	Digital_Output_3	DOutPort.bit(2)	Isolated digital output 3, programmable sink or source
7	Analog_Input_1+	AInPort[1]	±12V, 12-bit resolution.
8	Analog_Input_1-		Analog input 1 return. Must be connected to GND if analog input is single-ended.
9	5V		5V power supply, limited to 0.5A
10	GND		Ground for 5V and differential signals

Pin #	Name	Software Representation	Description
11	Digital_Input_Common		Common pin for all digital inputs in the same port. Can be power or return, depending on external connection.
12	Digital_Input_2	DInPort.bit(1)	Isolated digital input 2 (NPN or PNP, depending on the connection of the group's common pin).
13	Digital_Input_4	DInPort.bit(3)	Isolated digital input 4 (NPN or PNP, depending on the connection of the group's common pin).
14	Digital_Input_6	DInPort.bit(5)	Isolated digital input 6 (NPN or PNP, depending on the connection of the group's common pin).
15	Digital_Output_Common_Power		Common power pin for all digital outputs in the same port.
16	Digital_Output_Common_Return		Common power return pin for all digital outputs in the same port.
17	Analog_Output_1	AOutPort[1]	Analog output 1
18	GND		Ground for analog output.
19	IO_Power		I/O power output. Connected internally to X7: IO PWR pin 1
20	IO_Power_Return		Connected internally to X7: IO PWR pin 2

Connector B3: I/O (AXIS B)

Pin #	Name	Software Representation	Description
1	Digital_Input_7	DInPort.bit(6)	Isolated digital input 7 (NPN or PNP, depending on the connection of the group's common pin).
2	Digital_Input_9	DInPort.bit(8)	Isolated digital input 9 (NPN or PNP, depending on the connection of the group's common pin).
3	Digital_Input_11	DInPort.bit(10)	Isolated digital input 11 (NPN or PNP, depending on the connection of the group's common pin).
4	Digital_Output_4	DOutPort.bit(3)	Isolated digital output 4, programmable sink or source
5	Digital_Output_5	DOutPort.bit(4)	Isolated digital output 5, programmable sink or source
6	Digital_Output_6	DOutPort.bit(5)	Isolated digital output 6, programmable sink or source
7	Analog_Input_2+	AInPort[2]	±12V, 12-bit resolution.
8	Analog_Input_2-		Analog input 2 return. Must be connected to GND if analog input is single-ended.
9	5V		5V power supply, limited to 0.5A
10	GND		Ground for 5V and differential signals
11	Digital_Input_Common		Common pin for all digital inputs in the same port. Can be power or return, depending on external connection.

Pin #	Name	Software Representation	Description
12	Digital_Input_8	DInPort.bit(7)	Isolated digital input 8 (NPN or PNP, depending on the connection of the group's common pin).
13	Digital_Input_10	DInPort.bit(9)	Isolated digital input 10 (NPN or PNP, depending on the connection of the group's common pin).
14	Digital_Input_12	DInPort.bit(11)	Isolated digital input 12 (NPN or PNP, depending on the connection of the group's common pin).
15	Digital_Output_Common_Power		Common power pin for all digital outputs in the same port.
16	Digital_Output_Common_Return		Common power return for all digital outputs in the same port.
17	Analog_Output_2	AOutPort[2]	Analog output 2
18	GND		Ground for analog output
19	IO_Power		I/O power output. Connected internally to X7: IO PWR pin 1
20	IO_Power_Return		Connected internally to X7: IO PWR pin 2

Connector C3: I/O (AXIS C)

Pin #	Name	Software Representation	Description
1	Digital_Input_13	DInPort.bit(12)	Isolated digital input 13 (NPN or PNP, depending on the connection of the group's common pin).
2	Digital_Input_15	DInPort.bit(14)	Isolated digital input 15 (NPN or PNP, depending on the connection of the group's common pin).
3	Digital_Input_17	DInPort.bit(16)	Isolated digital input 17 (NPN or PNP, depending on the connection of the group's common pin).
4	Digital_Output_7	DOutPort.bit(6)	Isolated digital output 7, programmable sink or source
5	Digital_Output_8	DOutPort.bit(7)	Isolated digital output 8, programmable sink or source
6	Digital_Output_9	DOutPort.bit(8)	Isolated digital output 9, programmable sink or source
7	Analog_Input_3+	AInPort[2]	±12V, 12-bit resolution.
8	Analog_Input_3-		Analog input 3 return. Must be connected to GND if analog input is single-ended.
9	5V		5V power supply, limited to 0.5A
10	GND		Ground for 5V and differential signals

Pin #	Name	Software Representation	Description
11	Digital_Input_Common		Common pin for all digital inputs in the same port. Can be power or return, depending on external connection.
12	Digital_Input_14	DInPort.bit(13)	Isolated digital input 14 (NPN or PNP, depending on the connection of the group's common pin).
13	Digital_Input_16	DInPort.bit(15)	Isolated digital input 16 (NPN or PNP, depending on the connection of the group's common pin).
14	Digital_Input_18	DInPort.bit(17)	Isolated digital input 18 (NPN or PNP, depending on the connection of the group's common pin).
15	Digital_Output_Common_Power		Common power pin for all digital outputs in the same port.
16	Digital_Output_Common_Return		Common power return for all digital outputs in the same port.
17	Analog_Output_3	AOutPort[3]	Analog output 3
18	GND		Ground for analog output
19	IO_Power		I/O power output. Connected internally to X7: IO PWR pin 1
20	IO_Power_Return		Connected internally to X7: IO PWR pin 2

Connector manufacturer	Dowei 3M	DW-20-3 10120-3000PE and 10320-52A0-008
Wiring	AWG 26, insulation rated for 100 V	

3.4.10 Interface X2: Ethernet (LAN)

Connector X2 is an Ethernet communication port.

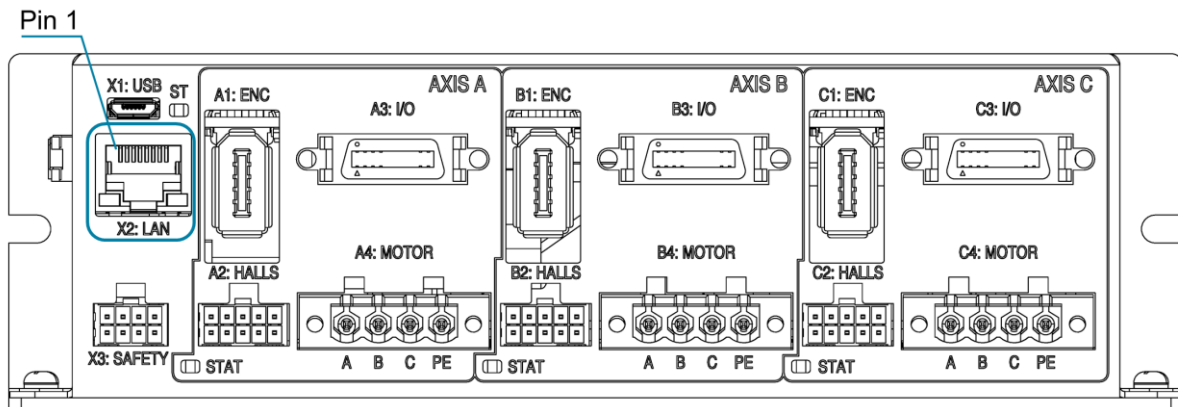


Figure 19: Ethernet Connector

Connector X13: LAN (Ethernet)

Pin #	Name	Description
1	TX+_D1	Transmit data +
2	TX-_D1	Transmit data -
3	RX+_D2	Receive data +
4	BI+_D3	Bi-directional +
5	BI-_D3	Bi-directional +
6	RX-_D2	Receive data -
7	BI+_D4	Bi-directional +
8	BI-_D4	Bi-directional -

Connector type	RJ45 LAN 10/100Base-T connector
Mating connector options	Any CAT5e compatible shielded connector
Cable	CAT5e or higher, standard Ethernet straight cable
Wiring	26 AWG, insulation rated for 100 V

3.4.11 Interfaces X8, X9: CAN, RS232, RS485

Connectors X8 and X9 are serial RJ45 communication ports.

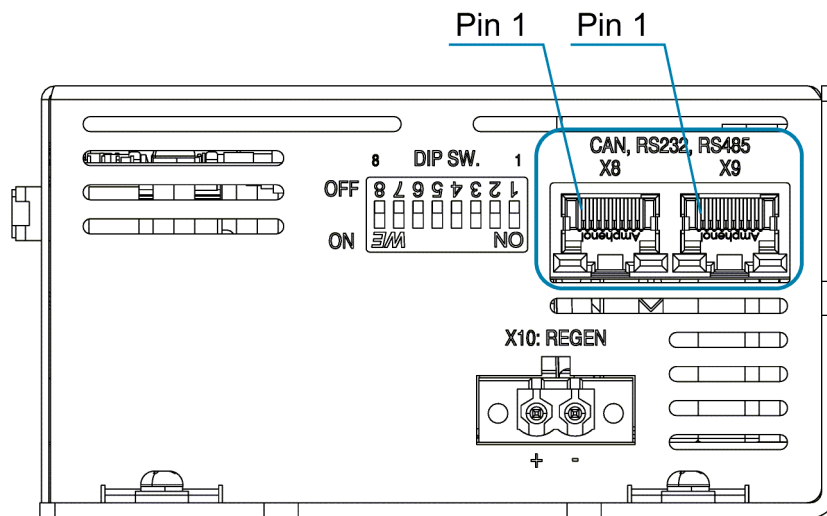


Figure 20: Serial Communication Connectors

Connector X8 and X9: CAN, RS232, RS485

Pin #	Name	Description
1	GND	Digital Ground
2	RS232_RX	RS232 input (product receive)
3	RS232_TX	RS232 output (product transmit)
4	RS485_B	RS485 bus, inverted
5	RS485_A	RS485 bus, not inverted
6	Sync	Reserved for future use
7	CAN_L	CAN bus, Low
8	CAN_H	CAN bus, High

Connector type	RJ45 LAN 10/100Base-T connector
Mating connector options	Any CAT5e compatible shielded connector
Cable	CAT5e or higher, standard Ethernet straight cable
Wiring	26 AWG, insulation rated for 100V



Dual port connector

The serial port is a dual-port RJ45 connector. The two ports have identical pinouts and are interchangeable. Two ports are provided to support daisy chain connection of a CAN bus or RS485. It can be also used to connect two types of communication channels at the same time, instead of splitting a cable from a single RJ45 connector.



CAN bus and RS485 terminators

The CAN bus lines have an optional 120Ω terminator that is connected/disconnected by DIP switch #1 in the DIP software interface (on the top panel). Setting dip switch #1 to the ON position connects a 120Ω terminator between CAN_H and CAN_L. The terminator is required only in the last unit in the CAN bus chain.

The RS485 lines have a built-in (not optional) 120Ω terminator. Communication performance may be degraded if too many units are placed on the RS485 chain.

3.4.12 Interface X1: Micro-USB

Connector X1 is a Micro-USB communication port.

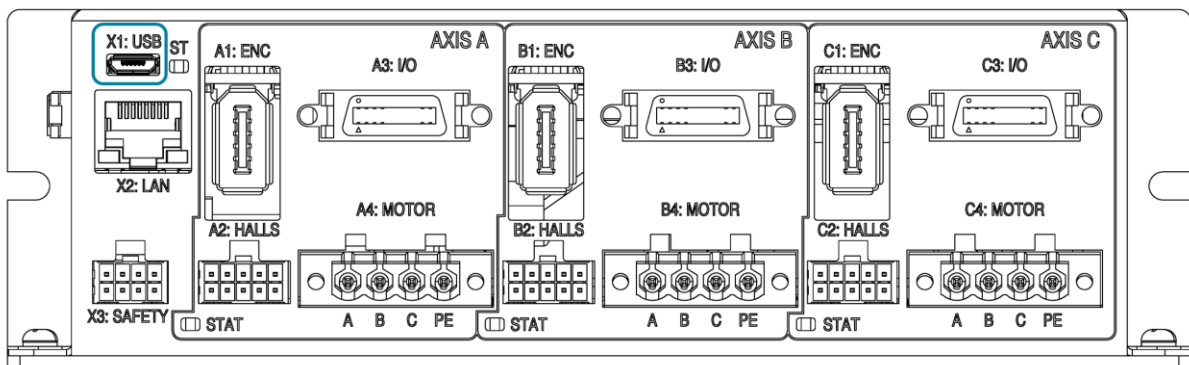


Figure 21: USB Connector

Connector X1: Micro-USB

Pin #	Name	Description
1	Vcc	5V
2	D-	Data-
3	D+	Data+
4	ID	USB OTG ID
5	GND	GND

Connector type	Micro-USB 2.0 B
Cable	Any Micro-USB 2.0 B-type cable
Wiring	26–28 AWG, insulation rated for 100V



USB to RS232 bridge

The Micro-USB connection is implemented using an internal converter/adaptor from USB to RS232 (UART). Typically, the Windows OS contains a built-in driver for the convertor/adaptor. If necessary, you can access drivers at: <http://www.ftdichip.com/Drivers/D2XX.htm>.

3.4.13 Interface X4: General Purpose I/Os

Connector X4 (GENERAL I/O) provides I/Os for the connection of external devices to the AGD301: 1 analog input, 1 analog output, 8 digital outputs, and 8 bi-directional differential I/Os, configurable as either input or output by software.

Additional I/Os are available on interfaces A2, B2, C2 (Halls), and interfaces A3, B3, and C3 (General I/Os).

For schematics and more information about these interfaces, refer to the section *I/O Interfaces – Circuitry*.

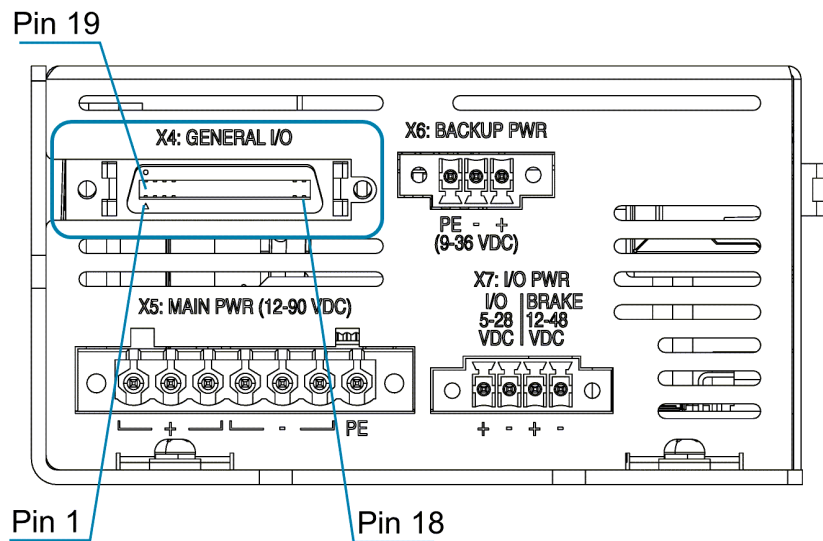


Figure 22: General Purpose I/O Connector



Bi-directional differential I/Os

The electrical interfaces of the 8 bi-directional differential I/Os are all identical.

Connector X4: GENERAL I/O

Pin #	Name	Software Representation	Description
1	Bi-Dir_Diff_IO_1+	DInPort.bit(27) DOutPort.bit(17)	Bi-directional differential I/O 1+ Axis A Pulse Input+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
2	Bi-Dir_Diff_IO_1-		Bi-Directional differential I/O 1- Axis A Pulse Input -
3	Bi-Dir_Diff_IO_3+	DInPort.bit(29) DOutPort.bit(19)	Bi-directional differential I/O 3+ Axis B Pulse Input+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
4	Bi-Dir_Diff_IO_3-		Bi-Directional differential I/O 3- Axis B Pulse Input-

Pin #	Name	Software Representation	Description
5	Analog_Input_4+	AIInPort[4]	±12V, 12-bit.
6	Analog_Input_4-		Must connect to GND if analog input is single-ended.
7	5V		Limited to 0.5A
8	GND		GND for 5V and differential signals
9	Bi-Dir_Diff_IO_6+	DInPortHigh.bit(1) DOutPort.bit(22)	Bi-directional differential I/O 6+ Axis C Direction Input+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
10	Bi-Dir_Diff_IO_6-		Bi-Directional differential I/O 6- Axis C Direction Input-
11	Digital_Output_10	DOutPort.bit(9)	Isolated digital output 10, programmable sink or source
12	Digital_Output_11	DOutPort.bit(10)	Isolated digital output 11, programmable sink or source
13	Digital_Output_12	DOutPort.bit(11)	Isolated digital output 12, programmable sink or source
14	Digital_Output_13	DOutPort.bit(12)	Isolated digital output 13, programmable sink or source
15	Digital_Output_14	DOutPort.bit(13)	Isolated digital output 14, programmable sink or source
16	Digital_Output_15	DOutPort.bit(14)	Isolated digital output 15, programmable sink or source
17	Digital_Output_16	DOutPort.bit(15)	Isolated digital output 16, programmable sink or source
18	Digital_Output_17	DOutPort.bit(16)	Isolated digital output 17, programmable sink or source
19	Bi-Dir_Diff_IO_2+	DInPort.bit(28) DOutPort.bit(18)	Bi-directional differential I/O 2+ Axis A Direction Input+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
20	Bi-Dir_Diff_IO_2-		Bi-Directional differential I/O 2- Axis A Direction Input-
21	Bi-Dir_Diff_IO_4+	DInPort.bit(30) DOutPort.bit(20)	Bi-directional differential I/O 4+ Axis B Direction Input+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
22	Bi-Dir_Diff_IO_4-		Bi-directional differential I/O 4- Axis B Direction Input-

Pin #	Name	Software Representation	Description
23	GND		GND for 5V and differential signals
24	Analog_Output_4	AOutPort[4]	Analog output 4, +/-12V, 16 bits
25	Bi-Dir_Diff_IO_5+	DInPortHigh.bit(0) DOutPort.bit(21)	Bi-directional differential I/O 5+ Axis C Pulse Input+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
26	Bi-Dir_Diff_IO_5-		Bi-directional differential I/O 5- Axis C Pulse Input-
27	Bi-Dir_Diff_IO_7+	DInPortHigh.bit(2) DOutPort.bit(23)	Bi-directional differential I/O 7+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
28	Bi-Dir_Diff_IO_7-		Bi-directional differential I/O 7-
29	Bi-Dir_Diff_IO_8+	DInPortHigh.bit(3) DOutPort.bit(24)	Bi-directional differential I/O 8+ Software configurable: BiDirConfig.bit(0) = 0 for input BiDirConfig.bit(0) = 1 for output
30	Bi-Dir_Diff_IO_8-		Bi-directional differential I/O 8-
31	Digital_Output_Common_Power (10 to 13)		Common power pin for isolated digital outputs 10 to 13
32	Digital_Output_Common_Return (10 to 13)		Common power return pin for isolated digital outputs 10 to 13
33	Digital_Output_Common_Power (14 to 17)		Common power pin for isolated digital outputs 14 to 17
34	Digital_Output_Common_Return (14 to 17)		Common power return pin for isolated digital outputs 14 to 17
35	IO_PWR		I/O power supply, connected internally to X7: I/O PWR pin 1
36	IO_PWR_RTN		I/O power supply, connected internally to X7: I/O PWR pin 2

Mating connector options	Dowei 3M	DW-36-3 10136-3000PE + 10336-52F0-008
Wiring	26 AWG, insulation rated for 100V	



Note – 5V supply limitation

The 5V supply provided at pin 7 is limited to 0.5A. The maximum total current provided by all the 5V pins in the product is limited to 1.5A.

3.4.14 I/O Interfaces – Circuitry

Isolated Digital Inputs

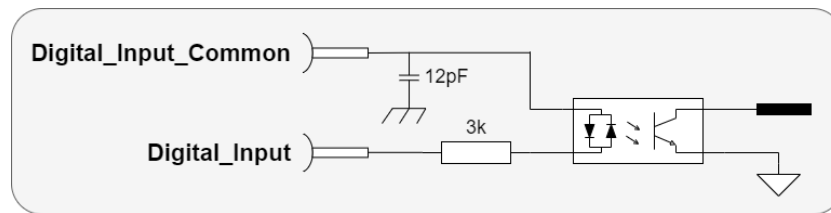


Figure 23. Isolated digital inputs

- Isolated digital inputs are organized as groups with a dedicated common pin. This enables connection to different voltage supplies. Each group is fully isolated and independent of the other groups.
- The AGD301 has three groups of inputs: digital inputs 1 to 6, digital inputs 7 to 12, and digital inputs 13 to 18.
- Each group can be connected as NPN or PNP interfaces, depending on the wiring of the group's common pin. If the common pin is connected to power (5V to 28V), then the inputs of this group can be used with external NPN devices (external current sinking devices). If the common is connected to the GND of some external power, then the inputs can be used with external PNP devices (external current sourcing devices).
- The input circuit of the opto-couplers includes two diodes. This enables use as NPN or PNP.
- One group can be wired to interface external NPN devices and another group can be wired to interface PNP devices. However, within a group, all interfaces (NPN or PNP) must be the same, as they are based on the connection of the group's common pin.

Isolated Digital Outputs

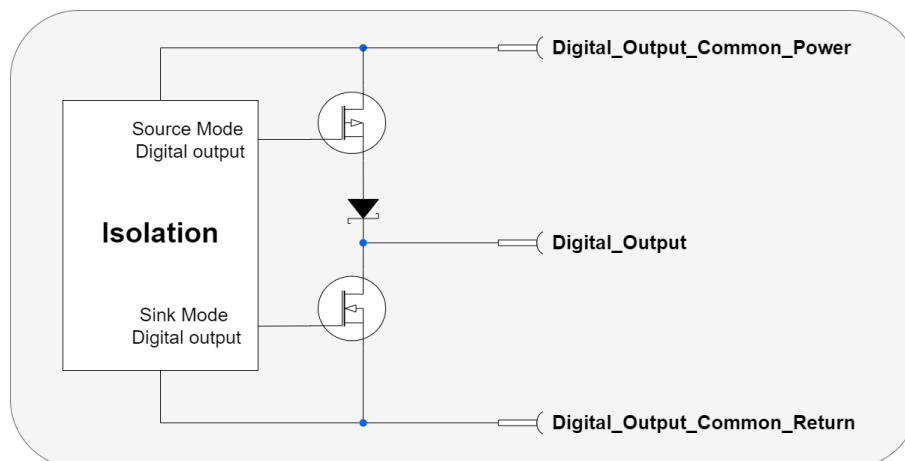


Figure 24. Isolated digital outputs

- The AGD301 has 5 groups of digital output , digital outputs 1 to 3, 4 to 6, 7 to 9, 10 to 13 , and 14 to 17.
- The digital output interface circuit is identical for all 17 outputs.
- Each output can be programmed (by a software parameter) to act as a current sourcing output (up to 300mA) or as a current sinking output (up to 500 mA).

Electrical Interfaces

- The outputs are designed for resistive loads. For inductive loads, an external flyback diode is required.
- Digital outputs specifications:
 - Digital_Output_Common_Power voltage range is between 5V and 28V.
 - Maximal load current, per each output:

Sink mode, any Digital_Output_Common_Power voltage:	500 mA
Source mode, at 24V Digital_Output_Common_Power:	300 mA
Source mode, at 5V Digital_Output_Common_Power:	60 mA (see Note below)



Note – 5V Digital_Output_Common_Power source mode limitation.

When using 5V Digital_Output_Common_Power, higher current (but less than the absolute maximum value of 250 mA) can be driven. However, the output high voltage will drop significantly. To maintain output high voltage at >4.5V, limit the current to 60 mA.

Analog Input

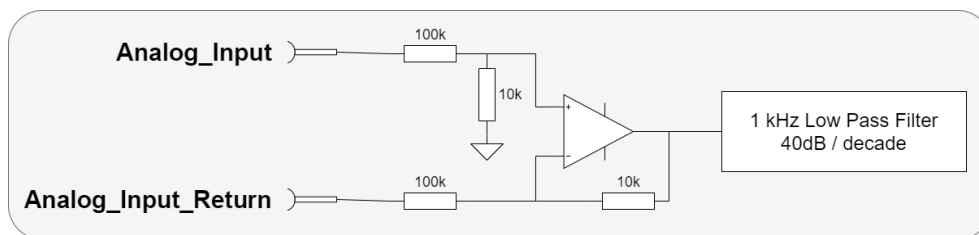


Figure 25. Analog inputs

- The electrical interfaces of analog inputs 1, 2, 3, and 4 are identical.
- The analog input range is -12V to +12V, and resolution is 16 bits.
- The analog input is designed for standard differential analog input, with a simple input circuit, having an input resistance of ~60 kΩ.
- For single-ended analog inputs, be sure to connect the return line to GND. Do not leave it unconnected.
- Input circuit bandwidth: 1 kHz, -40 dB/decade
- The controller software provides the following parameters to control the analog input reading:
 - Filter
 - Offset
 - Deadband
 - Gain

Analog Output

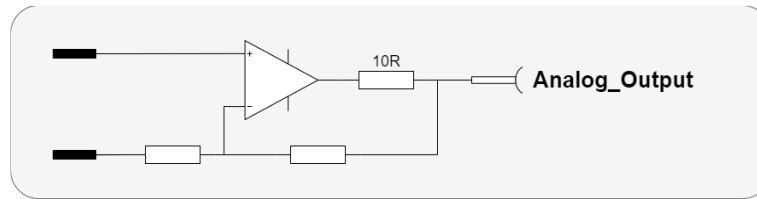


Figure 26. Electrical Interfaces – Analog Output 1 to 2

- The electrical interfaces of all analog outputs are identical.
- The analog output range is from -12V to +12V, with resolution of 16 bits.
- Output resistance is 10Ω.
- Output current is up to ±2 mA, without internal current limitation.
- Analog outputs are controlled by the controller software in few operational modes:
 - Analog output controlled by the user program for a general purpose.
 - Analog output reflects the internal value of a user selected parameter (position, position error, velocity, current, or any parameter/status of the controller), with a user defined scaling factor, for easy monitoring using an external oscilloscope.

Differential Inputs

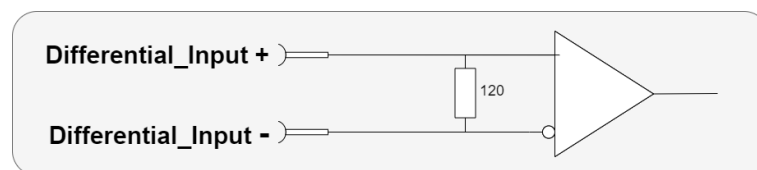


Figure 27. Differential inputs

- Differential inputs use two complementary signals (Differential_Input+ and Differential_Input-) to receive information.
- The same electrical signal is sent as a differential pair, each in its own conductor. The pair is wired as a twisted pair.
- The differential inputs in the AGD301 are implemented according to the RS422 standard.
- Each differential input has a 120 Ω terminator.

Differential Outputs

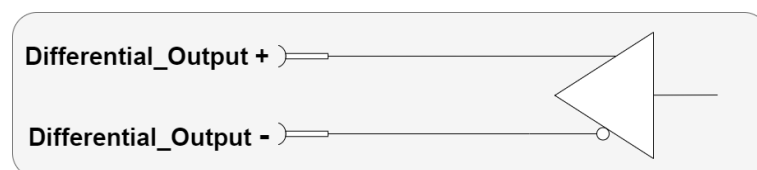


Figure 28. Differential outputs

- Differential outputs use two complementary signals (Differential_Output+ and Differential_Output-) to receive information.

Electrical Interfaces

- The same electrical signal is sent as a differential pair, each in its own conductor. The pair is wired as a twisted pair.
- The differential outputs in the AGD301 amplifiers are implemented according to the RS422 standard.
- The differential outputs are inactive during power on, until they are controlled by the drive firmware and the user parameters.

Bi-directional Differential I/Os

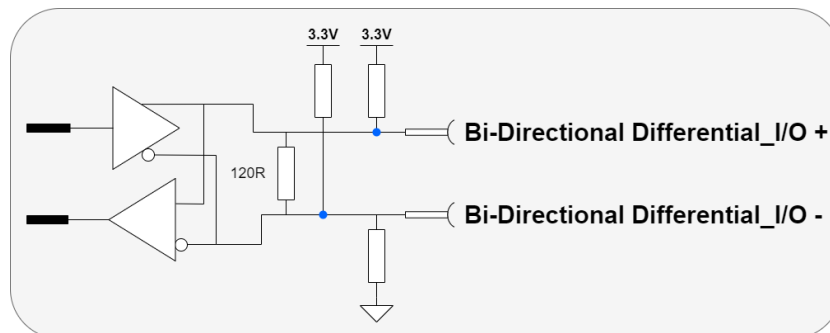


Figure 29. Bi-directional differential I/Os

- The bi-directional differential output is configurable by software to be a differential output or differential input.
- Both + and - pins are pulled up to 3.3V.
- There is a 120Ω termination resistor between the + and - pins.

3.4.15 DIP Switches

The AGD301 includes 8 DIP switches to define CAN or Ethernet address offset, to connect a 120Ω CAN terminator resistor, to activate firmware download mode, and set other functions. These are hardware configurations that are typically done only once, during product installation.

The value of the DIP switches, as read by the controller during power on (or reset), can be queried using ADebugData[4] in Agito PCSuite terminal.

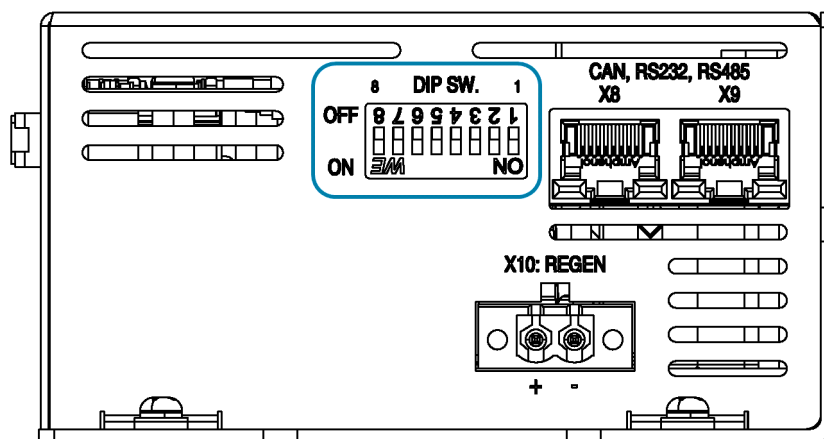


Figure 30 DIP Switches

DIP Switches

DIP Switch #	Function	Description
1	CAN Bus Terminator	Set to ON to connect 120Ω terminator resistor. Only the last unit in the CAN network needs to have this set to ON.
2	Force Download Firmware	Set to ON and power cycle to force the product into firmware download mode. Otherwise, always keep in OFF state.
3	Force Communication to Default	Forces the controller to default communication parameters (bypassing other software parameters in the controller): Ethernet IP: 172.1.1.101 Ethernet Port: 50000 CAN Address: 64 CAN and RS232/USB baud rates are not affected by this DIP switch. Requires power cycle or reset.
4-6	CAN/Ethernet Address Offset DIP Switch 4 – Most significant bit DIP Switch 6 – Least significant bit	DIP switches 4-5-6 create a three-bit value. For example, if DIP switch 4 is set to ON (value of 1), and 5 and 6 are set to OFF (value of 0), the result is: 100 (binary), meaning a value of 4. This value (referred to as <i>offset</i>) is used to define the drive's CAN bus address and Ethernet IP address as follows: Ethernet IP: the actual fourth number of the IP address is equal to: EthernetIP [4] + <i>offset</i> CAN address: the actual CAN address of the unit is equal to: CANAddr + <i>offset</i> * 16 Note: Requires power cycle or reset.
7	Reserved for Future Use	Always keep at OFF state.
8	Reserved for Future Use	Always keep at OFF state.

3.4.16 Status LED

A bi-colored LED, marked **ST**, shows the operational status of the AGD301.

ST - Status LED indicator

Color	LED	Meaning
–	Off	Powered off
Red	On steady	Fault
Green	On steady	Normal operation
Green	Blinking fast	In Boot mode
Green	Blinking slow	Firmware download in progress

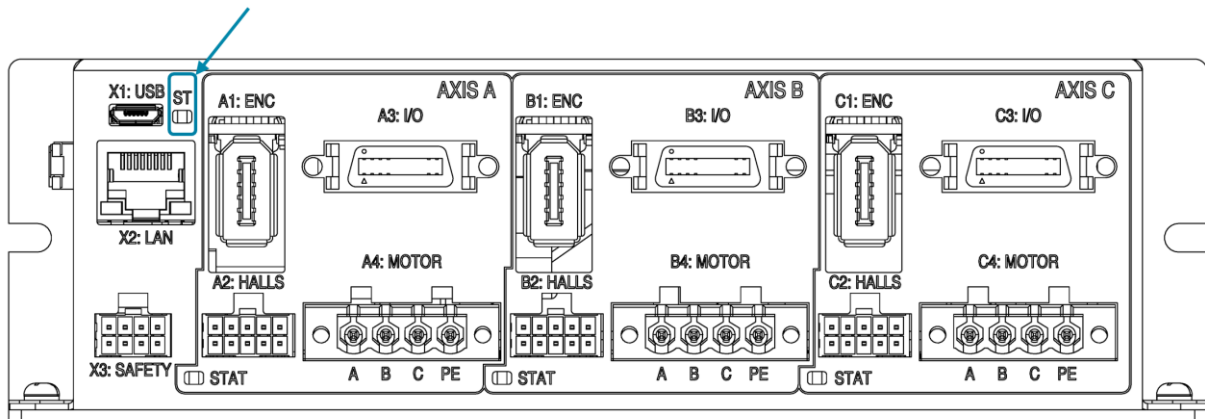


Figure 31: Status (ST)

4 Operation

4.1 Motor Configuration

This manual uses the product with a linear DC brushless motor as an example for illustration of the configuration and operation. For advanced configuration and operation, refer to the respective software manuals.

1. Connect the product to power supply, motor, encoder, and other I/Os according to the descriptions in the section *Electrical Interfaces*.

Make sure the safety port is connected before any operation.

2. Open Agito PCSuite software. Select CFG in CONFIG below and setup the parameters as follows:

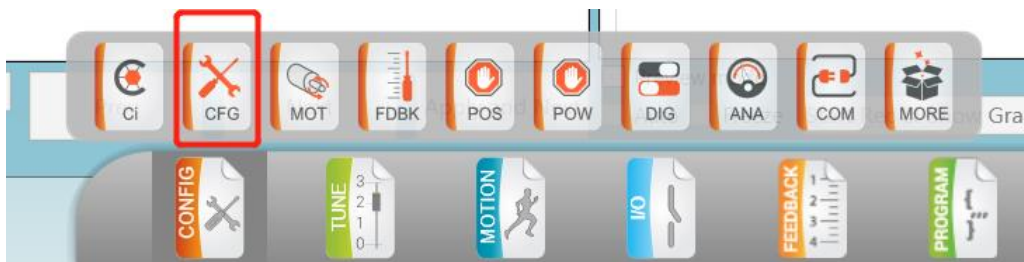


Figure 32. Configuration

Basic Configuration	
System	
Operation mode:	3 - Position control
<small>The controller supports multiple methods for on-the-fly mode switching. Please refer to the most updated User's Manual.</small>	
Amplifier type:	0 - Built In PWM amplifier (DRV product
Power supply:	1 - Single phase
Static brake	<input type="checkbox"/> Use
Static brake mode:	2 - Manual Release Command – without Protec
Brake lock time:	100 msec
Brake release time:	100 msec
Dynamic brake	<input checked="" type="checkbox"/> Use
Speed threshold:	2,000 user-units/sec
Regeneration	<input type="checkbox"/> Use
Activate at:	360,000 mV
Deactivate at:	340,000 mV

Figure 33. Operation Mode Configuration

3. Click **Next** and set the motor type and number of pole pairs according to the test motor.

Motor	
Motor Parameters	
Type:	3 - Linear DC Brushless
Number of pole pairs:	1

Figure 34. Select Motor Type

4. Click **Next** to setup the position feedback parameters. The definition of **Resolution** depends on the motor and encoder type. For rotary motor and rotary encoder, it is the number of encoder counts per mechanical revolution. For linear motor, it is the number of encoder counts per magnetic pitch (one pole-pair).

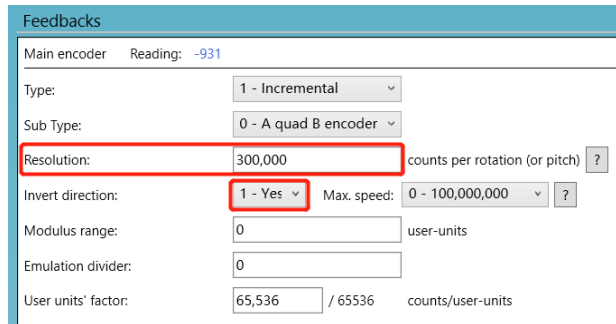


Figure 35. Feedback Parameters

The value of **Invert direction** affects commutation of the motor. The encoder must be moving in the positive direction during auto-phasing process.

5. Click **Next** to setup position, velocity, and motor stuck protection. Fill in the limits according to the application requirements.

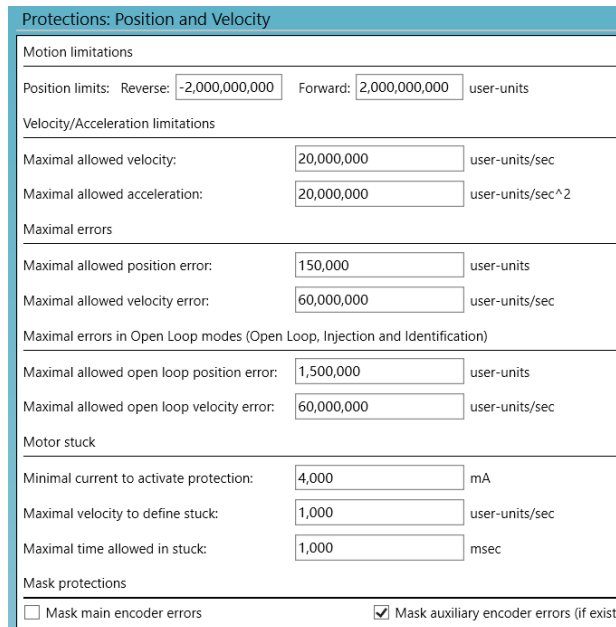


Figure 36. Position and Velocity Protection

6. Click **Next** to configure current and voltage limits. It is important to refer to motor’s specifications. The limits entered here must be within the motor operating limits to avoid damaging the motor.

Protections: Power and Current	
Current limitations and protections Current units ?	
Continuous limitation:	1,000 mA
Peak limitation:	5,000 mA
Peak maximum time:	1,000 msec
Maximal phase current:	4,750 mA
Maximal allowed motor current:	4,750 mA
<i>Current protections should be higher than Peak limitation</i>	
Maximal allowed power unit temperature:	65 °C
Motor temperature sensor (PT100):	<input type="checkbox"/> Connected
Maximal allowed motor temperature: 80 °C	
Bus voltage protections	
Minimal allowed bus voltage:	150,000 mV
Maximal timed bus voltage:	360,000 mV
Maximal time for over voltage:	0 ms
Absolute maximal allowed bus voltage:	360,000 mV
PWM limitations	
PWM limitations:	90 %

Figure 37. Current and Voltage Protection

4.2 Drive/Motor Overload Protection

The following methods are used to protect the AGD301 from overload:

- I2T
- Motor stuck

4.2.1 I2T

In a transient condition, the motor can sustain a certain amount of energy that exceeds the continuous limit. However, the more the current value exceeds the continuous current, the less time the current value can be sustained, and vice versa.

If the maximal energy level is surpassed, the maximal current is limited to the continuous current, instead of being limited to the peak current as usual.

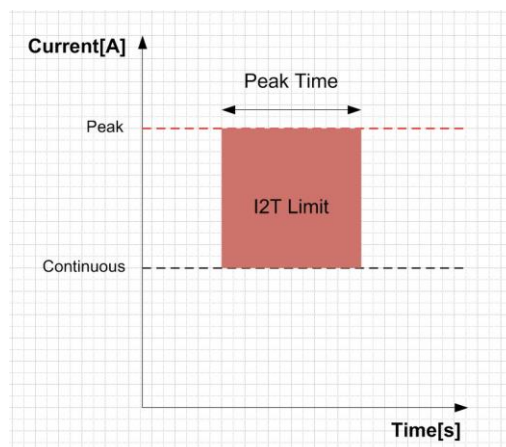


Figure 38. I2T

Drive/Motor Overload Protection

In Agito PCSuite, the following parameters define the I^2T characteristics:

- Peak current
- Continuous current
- Peak time

Protections: Power and Current		
Current limitations and protections		Current units ?
Continuous limitation:	<input type="text" value="2,000"/>	mA
Peak limitation:	<input type="text" value="4,000"/>	mA
Peak maximum time:	<input type="text" value="1,000"/>	msec

Figure 39. I2T Settings



Note – The I2T algorithm does not support thermal memory protection or thermal memory during power loss.

On drive power-up, the algorithm does not consider the amount of energy supplied to the motor prior to power-up.



Note – The I2T algorithm does not consider motor speed. Therefore, the product does not support thermal speed sensitivity.

4.2.2 Motor Stuck

Motor stuck indicates whether or not the motor is in fact stuck. The condition is strongly dependent on the application.

Protections: Position and Velocity		
Motion limitations		
Position limits: Reverse:	<input type="text" value="-80,000,000"/>	Forward: <input type="text" value="80,000,000"/> user-units
Velocity/Acceleration limitations		
Maximal allowed velocity:	<input type="text" value="20,000,000"/>	user-units/sec
Maximal allowed acceleration:	<input type="text" value="20,000,000"/>	user-units/sec^2
Maximal errors		
Maximal allowed position error:	<input type="text" value="15,000"/>	user-units
Maximal allowed velocity error:	<input type="text" value="20,000,000"/>	user-units/sec
Maximal errors in Open Loop modes (Open Loop, Injection and Identification)		
Maximal allowed open loop position error:	<input type="text" value="1,500"/>	user-units
Maximal allowed open loop velocity error:	<input type="text" value="20,000,000"/>	user-units/sec
Motor stuck		
Minimal current to activate protection:	<input type="text" value="3,000"/>	mA
Maximal velocity to define stuck:	<input type="text" value="40,000"/>	user-units/sec
Maximal time allowed in stuck:	<input type="text" value="1,000"/>	msec

Figure 40. Motor Stuck Settings

The protection feature monitors and responds to a condition in which the amplifier is providing a certain amount of minimal current (StuckCurr), but the motor does not move at the minimal expected speed (StuckVel) for a certain amount of time (StuckTime). If this condition occurs, the motor will be shut off.

4.3 Tuning

4.3.1 Commissioning



This step is required only for brushless motor.

Select TUNE > PHAS. in the tune option.

Configure the main encoder resolution. For Auto-Phasing mode, select **Automatic upon power on** if the application allows “shake and wake” upon power up. If not, select **Automatic upon MotorOn (if needed)** to “shake and wake” only when the motor is ready for motor on.

Use **Jump to zero phase** for Auto-Phasing method for most reliable result. This method requires the longest search distance.

If the stroke does not allow such search distance, select **Minimal Motion** method.

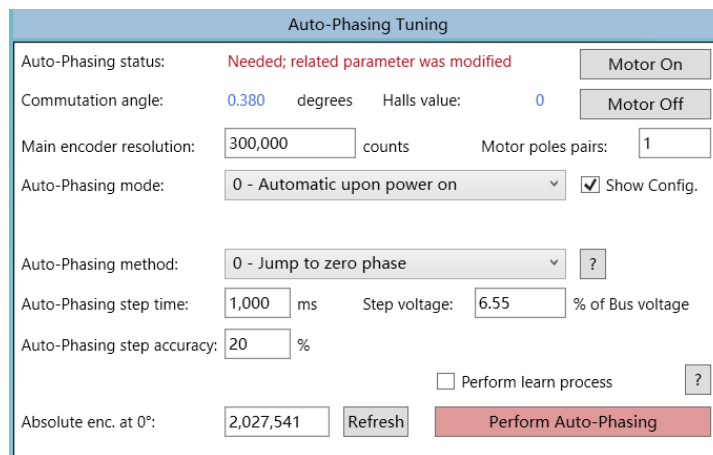


Figure 41. Auto-Phasing for Brushless motor

If the system does not allow any motion during power-on or motor-on, use Hall sensors for commutation phasing.

1. Connect Hall sensors to HALLS port and configure the first of the three inputs in the digital I/O page as **Hall A**.
2. Use the **Jump to zero phase** method to establish the motor and Hall phases; select **Perform learn process** and click **Perform Auto-Phasing**.
3. After the auto-phasing is completed successfully, change the Auto-Phasing method to **Encoder with Halls/Encoder switching** and save all parameters to flash. After reset or power cycle of the controller, auto-phasing will be done by Hall sensors.

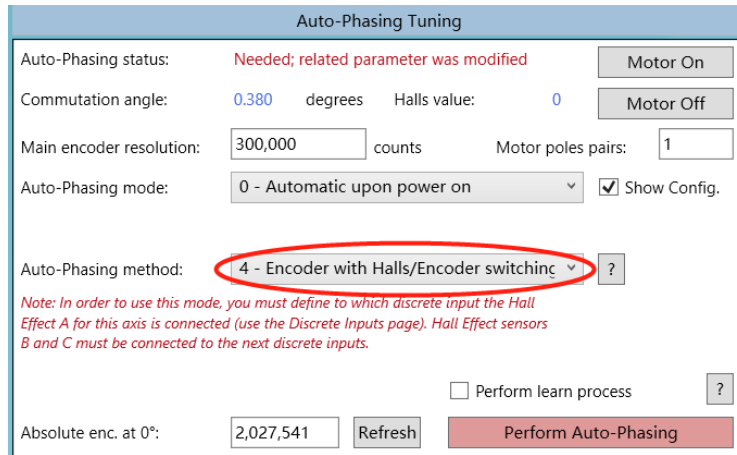
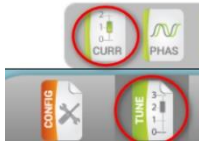


Figure 42. Using Hall Sensors to Avoid "Shake and Wake"

4.3.2 Current Loop Tuning



Select TUNE > CURR.

Enter motor’s phase resistance and phase inductance according to the motor’s datasheet and enter the desired current loop bandwidth for this axis. Typically, 1000 Hz is suitable for most applications.

Click **Calculate PI** to calculate the current loop gains.

Check both checkboxes for auto data recording and user predefined data recording.

Click **Apply Current Command** to test the current loop performance.

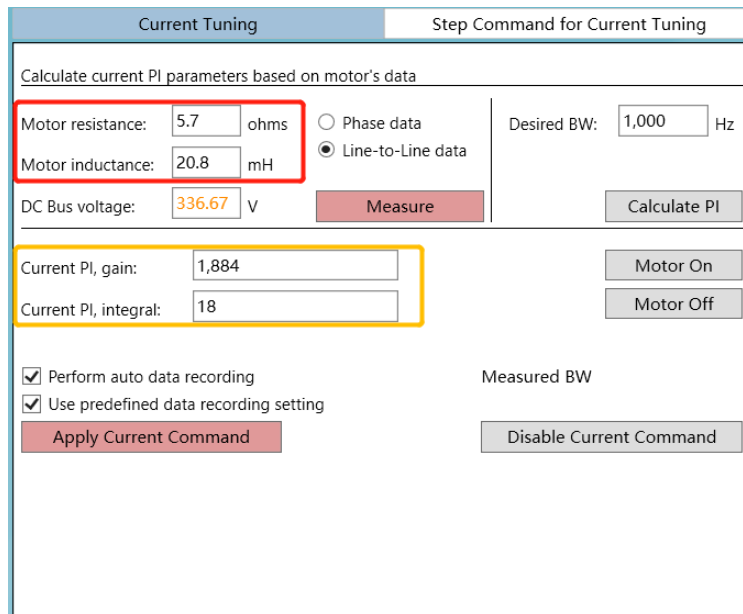


Figure 43. Current Loop Tuning

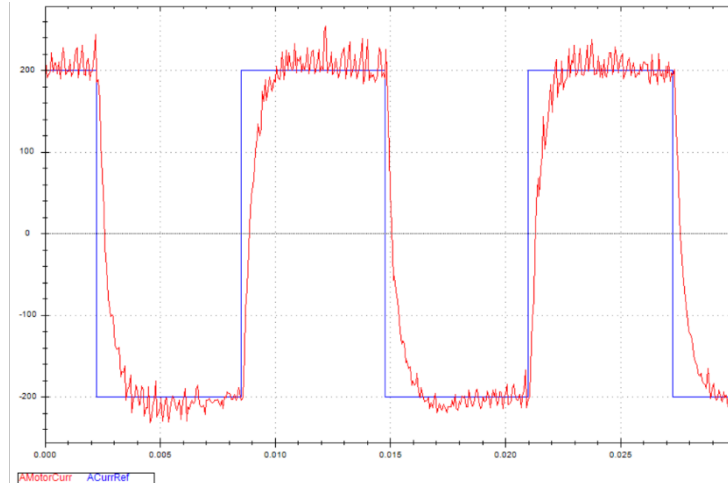


Figure 44 Typical Current Loop Performance

4.3.3 Auto Velocity and Position Loop Tuning

1. System Identification.

Select TUNE > IDEN.

Click **Begin Identification** to perform system identification.

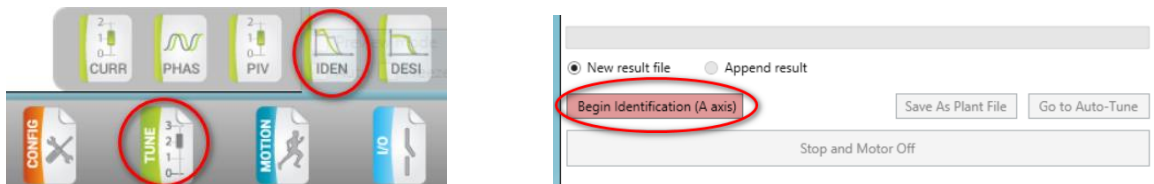


Figure 45. Begin System Identification

When the identification is completed successfully, the plant's transfer function will be displayed, as shown in the following figure.

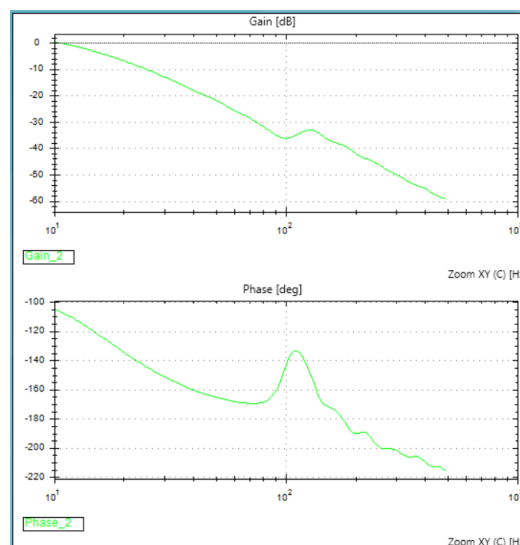


Figure 46. Typical Plant Transfer Function

Tuning

- Click **Go to Auto-Tune**. Alternatively, select TUNE-> DESI to open the Auto-Tuning (controller design) page.

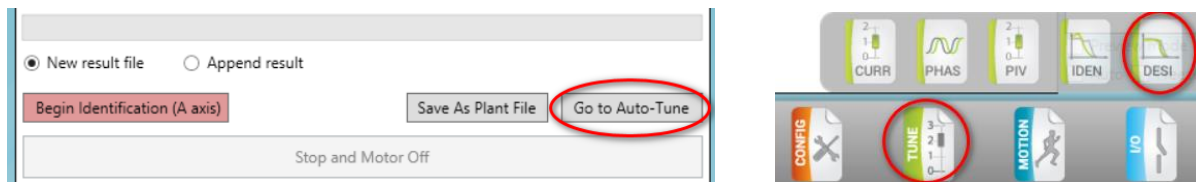


Figure 47. Go to Auto-Tuning page

- Click Run Auto-Tune to start Auto-Tuning. It will take a few seconds, or longer for more complex systems, to calculate the optimum PIV gains for this plant.

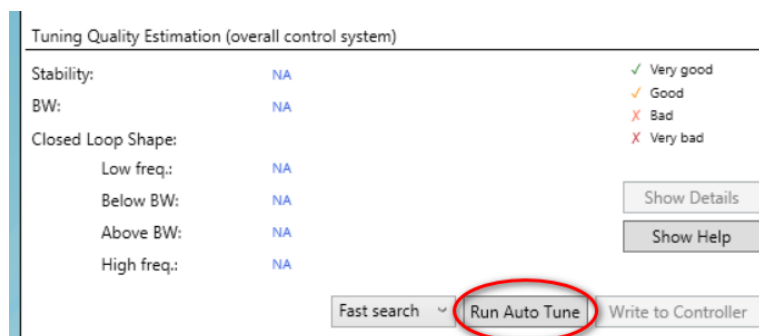


Figure 48. Start Auto-Tuning calculation

- Once Auto-Tuning is completed, click **Write to Controller** to download the calculated gains into the controller.

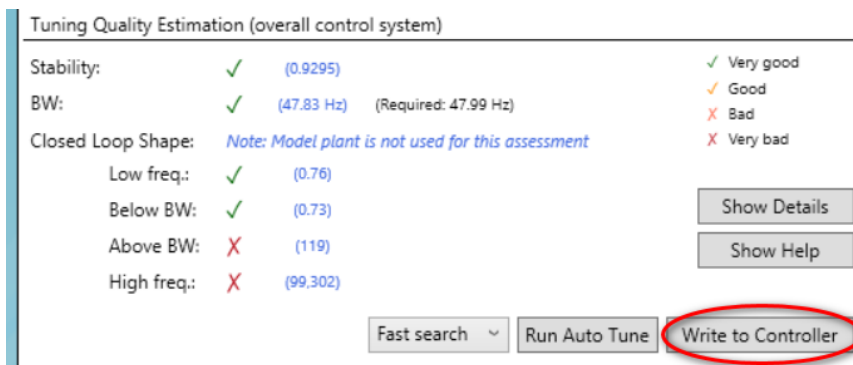
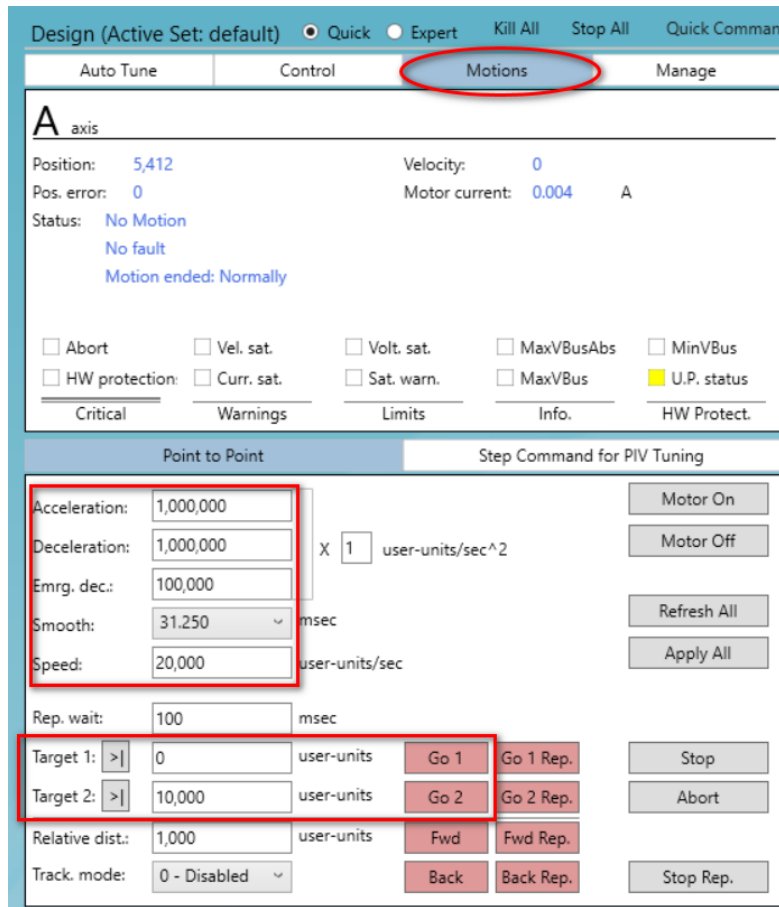


Figure 49. Download the parameters to the controller

Tuning

5. Check the motion performance in the Motions Tab, set the required motion profile, and click **Go 1** or **Go 2** to move to Target 1 or Target 2. Record the motion data to analyze the motion performance in detail.



The screenshot shows the 'Motions' tab for 'A axis'. The status section displays: Position: 5,412, Velocity: 0, Pos. error: 0, Motor current: 0.004 A, Status: No Motion, No fault, Motion ended: Normally. Below the status are checkboxes for Abort, Vel. sat., Volt. sat., MaxVBusAbs, MinVBus, HW protection, Curr. sat., Sat. warn., MaxVBus, and U.P. status. The main configuration area is divided into 'Point to Point' and 'Step Command for PIV Tuning'. The 'Point to Point' section has a red box around the following settings: Acceleration: 1,000,000, Deceleration: 1,000,000, Emrg. dec.: 100,000, Smooth: 31.250 msec, Speed: 20,000 user-units/sec, Rep. wait: 100 msec. The 'Step Command for PIV Tuning' section has a red box around the following settings: Target 1: >| 0 user-units, Target 2: >| 10,000 user-units, Relative dist.: 1,000 user-units, Track. mode: 0 - Disabled. Buttons for Motor On, Motor Off, Refresh All, Apply All, Stop, and Abort are visible on the right side.

Figure 50. Testing Motion

4.3.4 Manual Velocity and Position Loop Tuning



Select TUNE > PIV.

Adjust the proportional (PI, gain) and integral (PI, integral) gains of velocity loop.

Click **Apply Vel Command** to check the performance.

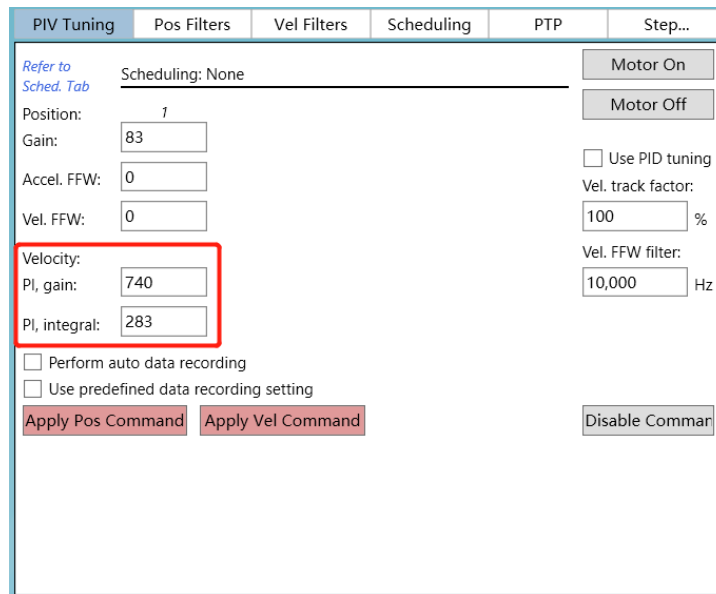


Figure 51. Manual Velocity Loop Tuning

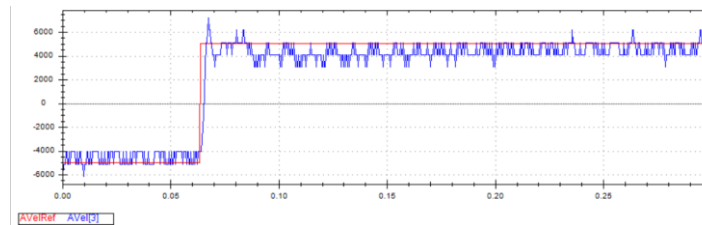


Figure 52. Typical Velocity Loop Performance

Similarly, adjust proportional gain of position loop.

In addition, adjust acceleration and velocity feedforward to improve performance.

Click **Apply Pos Command** to check performance.

PIV Tuning	Pos Filters	Vel Filters	Scheduling	PTP	Step...
Refer to Sched. Tab					
Scheduling: None					
Position:	7				
Gain:	83				
Accel. FFW:	0				
Vel. FFW:	0				
Velocity:					
PI, gain:	740				
PI, integral:	283				
<input type="checkbox"/> Perform auto data recording <input type="checkbox"/> Use predefined data recording setting					
Apply Pos Command		Apply Vel Command		Disable Command	
Motor On Motor Off <input type="checkbox"/> Use PID tuning Vel. track factor: 100 % Vel. FFW filter: 10,000 Hz					

Figure 53. Position Loop Tuning

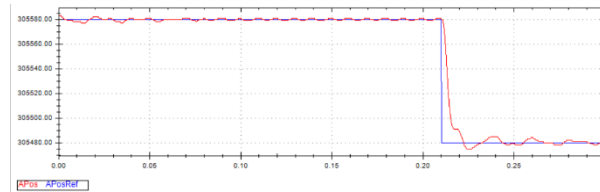


Figure 54. Typical Position Loop performance

Repeat the configuration and tuning steps for all the axes connected to the product.

Finally, test the motion according to the required motion profile, as shown in Figure 50. Testing Motion.

5 Maintenance and Servicing

5.1 Troubleshooting

Condition	Potential Cause	Possible Resolution
Power is On but no LED light	Power connector is loose	Check power connector, measure power supply voltage using a voltmeter.
	Firmware is corrupted	Turn on DIP switch #2, power cycle, and download firmware using Agito PCSuite.
Motor is oscillating or out of control (free wheel)	The position feedback sensor (encoder) is faulty or disconnected	Check wiring.
	Position feedback sensor is configured in wrong direction	Go to Agito PCSuite's CONFIG > FDBK page, toggle the Invert direction setting.
	Encoder signal is interfered by EMI noise in the system, resulting in lost counts or incorrect position feedback	Verify if the encoder signal is drifting even when the motor is physically locked or not moving. Check electrical grounding, shielding and PE in the system to ensure there are no ground-loop in the system. Set EncFilt from Agito PCSuite's CONFIG > FDBK page to a frequency setting that is just above the required motion speed.
	Control loops' gains are too high	Go to Agito PCSuite's Tune page, select CURR and/or PIV page to reduce the gains to half. If the situation improved, redo tuning for the axis.
	Velocity or Acceleration command is set too high	Reduce the acceleration, deceleration, smooth and speed setting.
	Noise introduced in calculation of velocity from position feedback	Add a software low pass filter from Agito PCSuite's TUNE > PIV, Velocity Filters tab.
	Mechanical resonance.	Add a software low pass filter from Agito PCSuite's TUNE > PIV, Velocity Filters tab. Do advanced auto tuning to allow Agito PCSuite identify and apply a suitable filter. Perform TUNE > IDEN and TUNE > DESI (Expert > Expert Tune mode for best result).
Cannot achieve the required speed	Acceleration and/or deceleration and/or speed is set too low, or smooth is set too high.	Adjust acceleration, deceleration, and smooth settings.
	Current and voltage limits are set too low	Check current limits are according to motor's datasheet and maxPWM, under CONFIG->POW page, is set to between 90% and 95%.
	Improper control loops gains	Re-tune the motor
	The load inertia or friction is too high for the motor	Check motor and driver sizing for this axis to ensure the motor force, current and voltage of power supply is sufficient to achieve the motion.

Condition	Potential Cause	Possible Resolution
	Auto-phasing is inaccurate	Check that hall sensors and encoder signal are functional and not interfered by EMI in the system. And redo auto-phasing.
Motor does not respond to a command	The axis is stopped by FLS/RLS position limit sensor or limited by software position and velocity limits.	Check if FLS and RLS of the motor is active. Or it could be a wrong setting where another sensor is configured wrongly as the FLS or RLS of this motor. Check software position limits and velocity limits at Agito PCSuite's CONFIG > POS page. If the FLS or RLS signal is active when the digital input is changed, the FLS or RLS status will remain ON. In this case, set the digital input to FLS or RLS, manually move the motor away from the sensor before change the digital input function. Alternatively, reset the controller or power cycle the controller.
	The axis is configured in a wrong operating mode or function, e.g. as a slave axis or another master.	Check all motion related configurations.
	Motor connector is loose.	Check motor power connection.
	The motor is faulty.	Measure motor's resistance and inductance at Agito PCSuite's TUNE > CURR page to check if the resistance and inductance values are close to the motor specification.
	If this is an actuator with ballscrew, timing belt or other transmission, the coupling or other mechanical part may be loose.	Check all mechanical transmission parts and mechanism.
	Motor brake is engaged	Check brake wiring and power supply.

