INSTALLATION AND STARTUP

SINGLE AXIS DIGITAL SERVO SYSTEM

DS2020 TECHNOLOGY

THIS DOCUMENT DESCRIBES THE INSTALLATION
AND STARTUP FOR THE DS2020 SYSTEM

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Table Of Contents

List of Figures

Foreword

The DS2020 drives meet the Low Voltage Directive (2014/35/EU) and EMC Directive (2014/30/EU). The safety function "Safe Torque Off" (STO) integrated in the drive complies with the Machinery Directive (2006/42 / EC).

To comply with the European Directives, the drive meets the requirements of the relevant harmonized installation standards EN 50178 (LVD), EN61800-3 (EMC) and EN 61800-5-2 (Safety of machinery).

The DS2020 drives are CE certified; certain models are also UL certified. Contact Moog for details.

The manual was written and checked by technical experts at Moog.

About Moog

The Moog Industrial Group designs and manufactures high performance motion control solutions combining electric, hydraulic, and hybrid technologies with expert consultative support in a range of applications including test, simulation, plastics, metal forming, and power generation.

Customers of Moog include leading automotive manufacturers, aerospace manufacturers, testing labs and global automotive racing teams.

We help performance-driven companies design and develop their next-generation machines.

The Moog Industrial Group is part of Moog Inc.

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Document Version

The following table shows the version of this document and all other possible versions:

ES	DA	DE	EL	EN	FR	IT	NL	PT	FL	SV	CS	ET	LV	HU	MT	PL	SK	SL	BG	RO	GA
				X																	

The language of documents and drawings are subject to contractual negotiations with the Customer.

In case of "Translation of the Original Instructions", the manufacturer of the machinery must also supply the "Original Instructions".

Revision Record

The following table shows the revision record:

Revision	Description	Date
A	First release	January 2020
Aa2	Second release	February 2022

Reader Instructions

The following table shows the symbols adopted in Moog documents:

⚠ DANGER
DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING
WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION
CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE
NOTE indicates possible property damage.

The following table shows the structure of a warning:

⚠ **SIGNAL WORD**
Type and source of hazard
Possible consequences of not avoiding the potential hazard
➢ How to avoid the hazardous situation

The following table shows other typographic elements:

Symbol	Explanation
	Electrical hazard alert symbol.

Symbol	Explanation
	Thermal hazard alert symbol.
	Mechanical hazard alert symbol.
	General hazard alert symbol.
	Notes about important operations and other useful information.
➢	This is an action to be carried out.
• / -	This is a bullet list.
1., 2., ...	These are steps in a procedure that must be performed in consecutive order.

1 Introduction

This chapter provides introductory information about this guide and the DS2020 system.

1.1 Contents

The *DS2020 Installation and Startup Guide*, the document you are currently reading, provides information to ensure proper installation and startup of the DS2020 series digital servo drive system. See the Table Of Contents on page 3 for a list of all the topics covered in this guide.

All information contained herein, including methods, techniques and concepts are the exclusive property of Moog and may be neither copied nor used without specific authorization. Moog reserves the right to modify products, and related documentation, at any time, without notice.

1.2 Related Documents

The following related documents are also available:

- DS2020 *Safety Guide* (shipped in the box with the DS2020 and also available on the Moog website)

- Moog motor installation guides (available on the Moog website)

- Moog motor installation drawing - provides information on motor mounting and wiring schematics for electrical installation (shipped in the box with the motor)

- Dx2020 GUI online help (available within the Dx2020 software)

1.3 Package Contents

The complete DS2020 system includes:

- One DS2020 drive

- Anchoring support for the shields

- Interconnect cables

> An optional connector kit must be ordered individually and is supplied separately.

1.4 Required Qualifications of Personnel

⚠ WARNING
⚠ WARNING: Personal injury and property damage risk. **Failure to follow all safety precautions when the drive is installed, operated or maintained may pose a risk of death or serious injury to personnel, or serious damage to property.** ➢ The system builder and end-use company are required to ensure that the safety instructions detailed in this manual and in the DS2020 *Safety Guide* are available to, read, understood and observed by all personnel responsible for the installation, operation and maintenance of the DS2020 system.

In addition to the following information, also follow the instructions in Safety and Usage Guidelines on page 18.

This manual and the equipment described in it are intended only for qualified personnel who have proper training and expertise in the following:

- **Transport:** All personnel must have knowledge and experience handling components that are sensitive to mechanical shock and electrostatic discharge (ESD).

- **Unpacking:** All personnel must have knowledge and experience handling components that are sensitive to mechanical shock and electrostatic discharge (ESD).

- **Installation and Maintenance:** All personnel must have extensive technical knowledge and experience with the installation and maintenance of AC- and DC-powered electrical and electro-mechanical equipment.

- **Startup:** All personnel must have extensive technical knowledge and experience with electrical drives, motors and their technology.

The qualified personnel must know and observe the following standards: IEC 60364, IEC 60664, and all relevant national accident prevention regulations.

1.5 Applicable Laws

The DS2020 drives meet the Low Voltage Directive (2014/35/EU) and EMC Directive (2014/30/EU). The safety function "Safe Torque Off" (STO) integrated in the drive complies with the Machinery Directive (2006/42 / EC).

To comply with the European Directives, the drive meets the requirements of the relevant harmonized installation standards EN 50178 (LVD), EN61800-3 (EMC) and EN 61800-5-2 (Safety of machinery).

The DS2020 drives are CE certified; certain models are also UL certified. Contact Moog for details.

1.6 Getting Started

The process for getting the DS2020 system installed, configured and operational looks like this:

1. Read this guide.

2. Read the related documents that are supplied with the DS2020 system, see Related Documents on page 14.

3. Install the DS2020 drive, see Mechanical Installation on page 69.

4. Install the supplied Moog motor, see the motor installation guide for your motor.

5. Install the cables and connect power, see Electrical Installation and Thermal Rating on page 71.

6. Provide a PC in the work area for the Dx2020 software.

7. Commission the system with the Dx2020 software, see Commissioning with Dx2020 Software on page 91.

2 Safety Information

This chapter provides safety information for the DS2020 system.

2.1 Safety and Usage Guidelines

Do not attempt to install, operate, maintain or inspect the DS2020 system until you have carefully read this guide and the other supplied documents, and you are properly trained in the correct use of the equipment. The DS2020 system may only be set up and operated in conjunction with this manual and the supplied documentation.

SAFETY FIRST Human safety and equipment safety must be the first considerations when performing the installation, operation or maintenance procedures for the drive system. When it comes to electronics in your factory or workplace, you want to make sure both your facility and its employees are safe. The following gives safety instructions that must be followed when you are working on the DS2020 system.

⚠ WARNING
WARNING: Risk of death or serious injury to personnel or damage to equipment. Failure to follow the safety and usage guidelines in this chapter can result in death or serious injury to personnel, or damage to equipment. ➢ In addition to the *DS2020 Installation and Startup Guide* (the guide you are currently reading), you must read the guides listed in Related Documents on page 14.

➢ Observe and adhere to the technical data and, in particular, the information given on the system component nameplates. ➢ The installation must comply with the local regulations and use of equipment and installation practices that promote electromagnetic compatibility and safety. ➢ Safety equipment - To protect yourself against personal injury, always wear suitable safety equipment, such as safety glasses, work shoes, and other safety equipment required by the operation.

2.2 Qualified Personnel

⚠ WARNING
WARNING: Risk of death or serious injury to personnel or damage to equipment. Only qualified, properly trained and certified personnel are permitted to operate and interact with the system.

This manual and the equipment described in it are intended only for qualified personnel who have proper training and expertise.

Qualified personnel are those who are specialized with required knowledge and experience, who have been trained to perform such work and are authorized to commission, systems and circuits in accordance with established safety practices and standards. The qualified personnel must know and observe the following standards and regulations:

- IEC 60364

- IEC 60664

- Accident prevention national, regional and local regulations for the site where the system or machine will be operated

2.3 Electrical Hazards

⚠ WARNING
WARNING: Electrical hazard. **High voltage may be present, which can result in death or serious injury to personnel, or damage to equipment.** ➢ Follow these safety instructions.

Certain electrical systems have to be maintained and cleaned by staff. Before they can be accessed, the systems have to be disconnected from the mains supply to eliminate electrical hazards to operating staff. According to the state of technology, this is accomplished with the five safety rules of DIN VDE 0105-100.

1. Disconnect the mains.

2. Secure against reconnection.

3. Verify that the system is dead.

4. Carry out earthing and short circuiting.

5. Provide protection from adjacent live parts.

2.3.1 Voltage Arcs and High Voltage

Voltage arcs may occur and/or high voltage may be present that can fatally or seriously harm personnel or damage equipment. Additionally, the drive's capacitors can have dangerous voltages present up to eight minutes after the removal of the mains voltage.

- Never attempt to remove safety covers, or loosen or disconnect the electrical connections when the DS2020 system is powered up,

- Never attempt to perform any cleaning or maintenance operations when the DS2020 system is powered up.

- Always ensure that the mains power supply is disconnected and locked out before attempting any work on the system.

- Always wait at least eight minutes after disconnecting and locking out the AC mains power before attempting to work on the DS2020 system equipment. The DS2020 capacitors can still have dangerous voltages present up to eight minutes after power is switched off.

- Always measure the voltage of the direct current circuit (BUS) and wait until the voltage drops below 40V.

- Always measure the voltage of any other contact point(s) to ensure the power is off and there is no voltage present.

- Never attempt to remove safety covers, or loosen or disconnect the electrical connections when the DS2020 system is powered up,

- Never attempt to perform any cleaning or maintenance operations when the DS2020 system is powered up.

2.3.2 General Hazards and Safeguards

The power from the drive to the motor can be removed in "a safe manner". In this way, when the safe power stage is disabled, the motor is not able to produce torque.

During normal operation, the equipment should not be accessible (i.e., protected as described in the Risk Assessment by covers, guards, barriers, and safety interlocked gates/doors, etc.), all covers/guards must be installed, and cabinet doors must be kept closed/locked.

During the operation of the drives, there may be uncovered live parts in the control cabinet installation, depending on the degree of mechanical protection required by regulations governing the site where the equipment is operated.

At the drive and/or motor, the power and control connections may be live, even when the motor is stopped.

2.4 Thermal Hazards

⚠ CAUTION
CAUTION: Burn hazard. The surface temperature of the drive may reach a temperature of 80 °C, and the motor may reach up to 100 °C (212 °F), and may become very hot in operation, according to their protection category.   ➢ Do not touch hot surfaces, measure the temperature, and wait until the drive and motor has cooled down below 40 °C (104 °F) before touching it.   ➢ It is recommended to always wear gloves when attempting to handle DS2020 system components that have been recently operating.

2.5 Mechanical Hazards

⚠ WARNING
WARNING: Mechanical hazard. Large motors can generate very high torque and impact or trapping hazards, which can result in death or serious injury to personnel, or damage to equipment.   ➢ Follow these safety instructions.

The motor must be properly mounted and anchored as specified in the Moog motor installation guide supplied with the DS2020 system motor. For details, consult the Moog motor installation guide.

2.6 STO Safety Feature

2.6.1 Description

The DS2020 drives include the STO (Safe Torque Off) function as a standard feature to ensure protection for personnel and equipment against accidental restart and re-enabling of the drive.

The STO function acts as an interlock against accidental motor rotations.

The STO function can be used as a power turn-off command to prevent accidental starts.

The function disables the power control voltage of the semiconductors of the converter output stage, preventing the drive from generating the voltage required to rotate the motor.

Using this feature, you can perform short-term operations and/or maintenance work only on non-electrical parts of the machine without switching off the mains. This function must be enabled from a safe external control (mechanical or semiconductor) or by a specific external security board.

2.6.2 Directives on Safety

⚠ WARNING
WARNING: Electrical hazard. High voltage may be present, which can result in death or serious injury to personnel, or damage to equipment. ➢ Follow these safety instructions.

⚠ WARNING
WARNING: Mechanical hazard. Large motors can generate very high torque and impact or trapping hazards, which can result in death or serious injury to personnel, or damage to equipment. ➢ Follow these safety instructions.

Suspended loads must always be securely mechanically locked. The STO function, if activated, does not ensure against movement of suspended loads.

The interruption of the 24 VDC supply of the STO circuit causes an uncontrolled arrest of the motor.

The STO function does not guarantee an electrical disconnection from the power output to the motor. If the motor power cable requires service, always disconnect and lock out the mains power supply, wait for eight minutes for the complete discharge of the intermediate circuit, and then check for residual voltages at any contact point.

When using the STO function, it is necessary to perform the following sequence of operations.

1. Stop the movement in a controlled manner, placing the nominal speed value to zero.

2. Upon reaching the zero speed, and in the case of suspended loads, mechanically lock the load.

3. Disable the drive and at this point turn on the STO function via supply command

Input voltage	24 V +/- 10 %
Max input current	50 mA +/- 10 %
Voltage Feedback	30 V max
Current Feedback	200 mA max

2.7 Safe Use of the DS2020 System

The technical data (nameplate) and documentation for the DS2020 system and how to install its components must be available to and observed by all personnel.

The drives contain electrostatically sensitive components, which can be damaged by electrostatic discharge (ESD) through improper handling. It is recommended to follow proper ESD procedures to discharge any electrostatic charge before handling the DS2020 system components (e.g., using ESD straps, ESD mats or other protective surfaces, etc).

2.7.1 Risk Assessment

The drives are safe industrial devices that are placed in electrical systems or machines and can only be operated as integrated parts of those systems or machines. The builder/manufacturer of the system or machine must generate a risk assessment, and take appropriate measures to avoid unexpected movements that could cause death or injury to personnel and/or damage to equipment or other property. The risk assessment must comply with all national, regional and local regulations for the site where the system or machine will be operated. For more details, see Risk Assessment on page 24.

2.7.2 Electrical Connections

The drives must operate only inside an enclosed control cabinet. Additional ventilation or cooling may be necessary based on the external environmental conditions.

Use only copper conductors for wiring all connections. The conductor cross sections must comply with IEC 60204.

2.7.3 Motor Selection

The DS2020 drives have been designed to control brushless asynchronous and synchronous motors with torque control, speed and/or position. The rated voltage of the motors must be at least the same level as:

$$V_{DCbus}/\sqrt{2}$$

produced by the drive. For more details on selecting the proper motor, see Motors on page 53.

2.7.4 Power Supply

The drives of the DS2020 series (overvoltage category III according to EN 61800-5-1) can be powered by three-phase industrial AC supply, earthing systems (TN system, TT with grounded neutral and symmetrical rated current of not more than 10KA 120V to 480V ± 10%).

Overvoltage between phases and the drive housing must not be greater than 1000 V peak.

According to EN61800-3 transient voltage spikes (<50ms) between the phases must not exceed 1000 V. Transient voltage surge (<50μs) between a phase and the housing must not exceed 2000V.

2.7.5 Prohibited Use

⚠ WARNING
⚠ **WARNING: Risk of death or serious injury to personnel, or damage to equipment.** **Uses other than those described above (safe use) can lead to death or serious injury to personnel, or damage to equipment.**   ➢ Avoid the prohibited use cases described below.

The use of the DS2020 system is normally prohibited in the following environments:

- Hazardous areas

- Areas subject to corrosive and/or electrically conductive acids, alkaline solutions, vapors, oils

- Directly on electrical supplies/circuits not connected to the ground, or on asymmetrically grounded power supplies with a voltage exceeding 240 VAC

- On ships or offshore installations

The installation and start-up of the drive are prohibited in cases where the machine on which it is installed:

- Does not comply with the requirements of the EC Machinery Directive

- Does not comply with the Directives on EMC or Low Voltage Directives

- Does not conform to national, regional and local regulations for the site where the system or machine will be operated

- Does not conform to the machine's Risk Assessment.

The control of the brake by the DS2020 drive alone is prohibited in applications where the safety of personnel must be ensured through the brake.

2.8 Risk Assessment

In order to protect personnel from any safety hazards in the machine or system, the machine/system builder must perform a "Risk Assessment", which is often based on ISO standards. The design/implementation of barriers, emergency stop (E-stop) mechanisms and other safeguards will be driven by the Risk Assessment and the safety standards specified by the governing authority (for example, ISO, OSHA, UL, etc.) for the site where the machine is being installed and operated. The methodology and details of such an assessment are beyond the scope of this manual. However, there are various sources of Risk Assessment information available in print and on the internet.

> The following list is an example of items that would be evaluated when performing the Risk Assessment. Additional items may be required. The safeguards must ensure the safety of all personnel who may come in contact with or be in the vicinity of the machine.

2.8.1 Installation Risk Assessment

The safety functional requirements of a DS2020 system depend on the application and should be considered during the evaluation of the overall risk of the installation. The designer of the installation is responsible for the risk assessment, and the specification of requirements for levels of functional integrity and safety integrity levels (SIL) of the drive according to CEI EN 62061: 2005 +A1:2013 +A2:2015 and/or performance levels (PL) according to UNI EN ISO 13849-1: 2016.

The following table, which is identical to Table 4 of the UNI EN ISO 13849-1: 2016, shows the relationship between performance levels (PL) and safety integrity levels (SIL).

PL	SIL (IEC 61508-1) operational mode high/continuous
a	No match
b	1
c	1
d	2
e	3

> Because SIL 4 level refers to catastrophic events, it does not cover the risks relating to machinery. The risk assessment presented by the machine must be carried out in accordance with Directive 2006/42 / EC, referring to UNI EN ISO 12100: 2010 and must contain the safety circuit configuration relating to the entire machine by taking into account all components of the integrated safety system, including the drive.

2.8.2 General Machine/System Safeguards Information

In general, the machine/system safeguards must:

- Provide a barrier to prevent unauthorized entry or access to the machine or system. The barrier must be designed so that personnel cannot reach into any identified danger zones.

- Position the control panel so that it is outside the barrier area but located for an unrestricted view of the moving mechanism. The control panel must include an E-stop mechanism. Buttons that start the machine must be protected from accidental activation.

- Provide E-stop mechanisms located at the control panel and at other points around the perimeter of the barrier that will stop all machine movement when tripped.

- Provide appropriate sensors and interlocks on gates or other points of entry into the protected zone that will stop all machine movement when tripped.

- Ensure that if a portable control/programming device is supplied (for example, a hand-held operator/programmer pendant), the device is equipped with an E-stop mechanism.

> A portable operation/programming device requires *many* additional system design considerations and safeguards beyond those listed in this section. For details, see the safety standards specified by the governing authority (for example, ISO, OSHA, UL, etc.) for the site where the machine is being installed and operated.

- Prevent contact with moving mechanisms (for example, arms, gears, belts, pulleys, tooling, etc.).

- Prevent contact with a part that is thrown from the machine tooling or other part-handling equipment.

- Prevent contact with any electrical, hydraulic, pneumatic, thermal, chemical or other hazards that may be present at the machine.

- Prevent unauthorized access to wiring and power-supply cabinets, electrical boxes, etc.

- Provide a proper control system, program logic and error checking to ensure the safety of all personnel and equipment (for example, to prevent a run-away condition). The control system must be designed so that it does not automatically restart the machine/system after a power failure. Refer to the next section.

- Prevent unauthorized access or changes to the control system or software.

2.8.3 Safeguards Related to SCRF

The manufacturer of the machine and/or final apparatus must perform, maintain and make available a Risk Assessment (risk analysis) of the machine in accordance with the ISO12100 and ISO14121 standards, and implement all necessary measures to avoid unforeseen movements that can cause damage to persons or objects. In particular, the manufacturer of the machine and/or final apparatus has to comply with the relevant product standards. Where it has been chosen to perform safety functions by means of electrical/electronic devices (SCRF), the safety integrity levels (SIL) and the functional requirements of each device must be specified clearly. According to TECHNICAL STANDARD IEC EN CEI EN 62061: 2005 +A1:2013 +A2:2015, this specification must include all information likely to influence the design of the electrical/electronic device, including, where applicable:

- The machine operating conditions

- Prioritization of functions that can be active simultaneously and cause conflicting actions

- The frequency of operation of each SCRF

- Requested response time of each SCRF

- Description of each SCRF

- SCRF interface with other functions of the machine

- Description of the reactions related to machine reboot failures and constraints, when the reaction to the fault results in the interruption of the reboot

- The operating environment description

- Tests and associated equipment (e.g., access doors, safety gates)

- Frequency of cycles of operation and utilization factor within the working cycles

3 System Overview

This chapter provides an overview of the DS2020 system.

3.1 Product Structure

3.1.1 Product Description

The DS2020 system represents the new generation of Moog digital servo drives for the control of brushless synchronous or asynchronous motors. It is comprised of a single stand-alone drive powered directly by a 3-phase AC mains supply and by a separate +24 VDC control power supply.

The digital control system of the motors and the diagnostic functions of the DS2020 system are made possible through microprocessor technology.
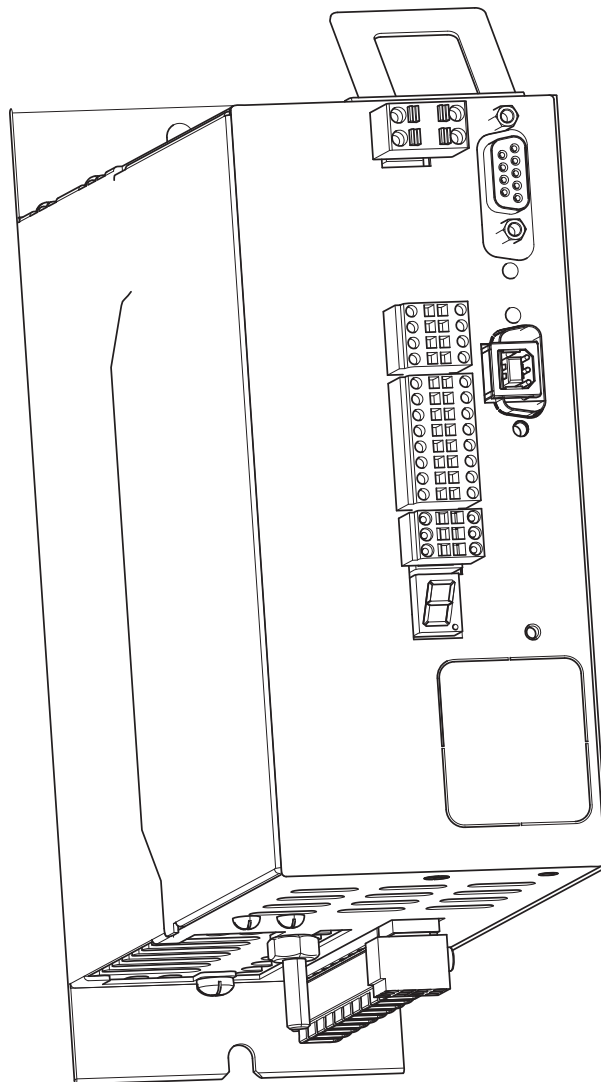
Figure 1: DS2020 Front View
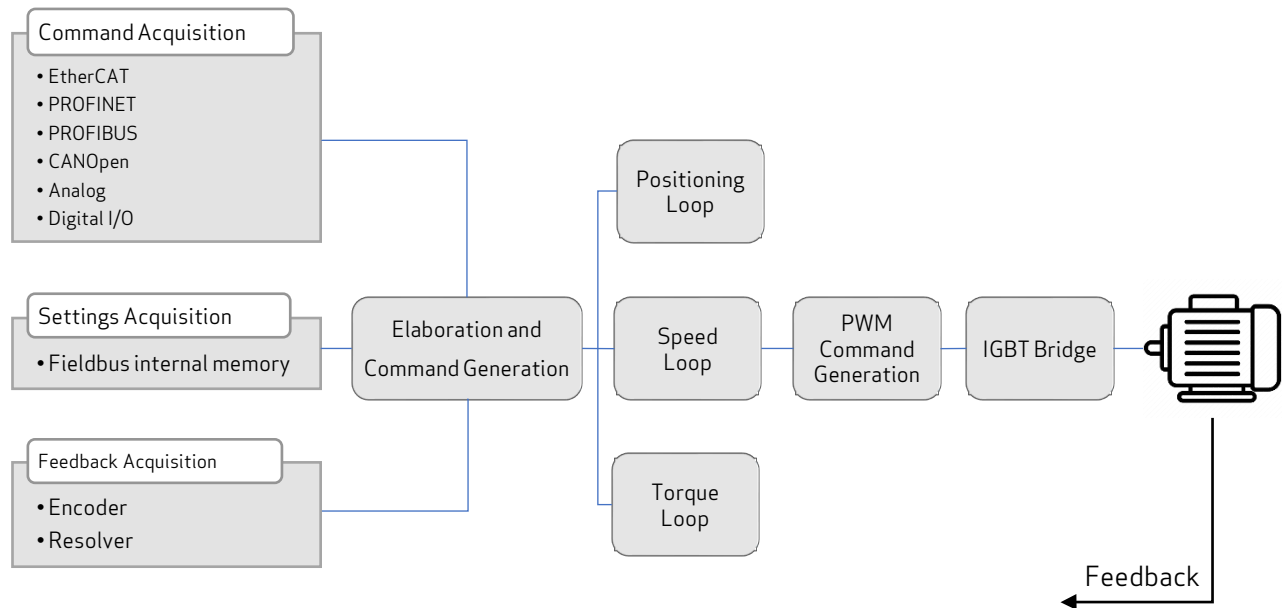
Figure 2: DS2020 System Theory of Operation Flow Chart

Feature/Function	Implementation
Control functions	Implementation of the Torque, Speed and Position loops
Command protocols	EtherCAT, PROFINET, PROFIBUS, CANopen and "Analog"
Configuration/Commissioning	Through GUI : Dx2020 software allows to configure, calibrate and control the drive.
Diagnostic	Through Dx2020 software GUI
Positioning transducers	• Resolver (standard) • Encoder Incremental TTL • Encoder, Stegmann Sinusoidal Absolute Single/Multi-Turn with Hiperface communication • Encoder, Heidenhain Sinusoidal Absolute Single/Multi-Turn with ENDAT communication • BISS Absolute Encoder • Sensorless mode
User Interface	Dx2020 software
Data logging	Through GUI
AC/DC conversion	Three-phase input bridge with soft start
Power range	From 120 VAC to 480 VAC +/- 10 %
PWM frequency	8 kHz (from 2 to 16 kHz configurable by Software)
Encoder simulation	Simulated encoder output with programmable number of pulses
Control Power supply voltage	+ 24 VDC +/- 10 %

Feature/Function	Implementation
Rated current	From 2 to 192 Arms
Peak current	From 4 to 384 Arms
Analog inputs	2 inputs, +/- 10 volt differential
Analog outputs	2 output, +/- 10 volt single ended
Digital inputs	2 digital inputs, opto isolated
Digital outputs	1 Digital output, opto isolated
Communication interface for set-up	• RS-422 PC • USB PC • Ethernet or CANopen PC (option)
Motor brake control	Integrated
Braking resistor	Integrated (external optional)
Electromagnetic com-patibility	External EMC filter is required
Cooling	Forced air with integrated fans in each DS2020 system

3.1.2 Storage and Working Conditions

Item	Description
Operating environment temperature	from 0 °C to 40 °C up to 55 °C with current derating
Storage temperature	from -25 °C to 55 °C
Transport tem-perature	from -25 °C to 70 °C
Motor overheating protection	PTC, NTC or PT1000
Relative humidity	5...95 % without condensation
Mounting altitude	Up to 1000 m, up to 2000 m with output current derating
Certification	CE, some sizes are UL certified (contact Moog for details)
Protection	IP20
Pollution rating	2 or less (only non-conductive pollution is normally allowed; however, there may be occasional, temporary conductivity caused by condensation only when the drive is idle or powered)
Mechanical resistance according to EN 60721-3-3	Vibration: 3 mm for frequencies between 2 and 9 Hz Vibration: 1 g for frequencies between 9 and 200 Hz Shock: 98 m/s^2 (10 g) for 11 ms
Machine safety	STO (Safe Torque Off) SIL3 PL e

3.1.3 DS2020 Standard Models

The following table shows the standard drive models. For details on each model, see Features and Component Details on page 34.

	L50	L75	L85	L125	L165	L355
Dimension [width, mm]	50	75	85	125	165	355

The DS2020 drive code is found on an identification (ID) plate on the side of the drive. To request information about a specific DS2020 drive, it is essential to communicate to Moog Casella all the data indicated on the drive ID plate, refer to the following figure.

The year and week of assembly are identified by the 'Date' field. The first two digits of the number are for the year, and the second two indicate the week (example DATE 1907: year 2019, week 7).

Figure 3: Example Drive Plate

3.1.4 Model Codes

To identify the available models, refer to the following codes.

The first two characters are "CH" and are used to identify the DS2020 family

Version

1	Standard model
E	Special mode
X	X (Experimental model)

Drive Type & Mechanical Hardware Configuration

Value	Type/Width	Rated Current (Arms)	Peak Current (Arms)
02	SINGLE / 50 mm	2	4
04	SINGLE / 50 mm	4	8
06	SINGLE / 75 mm	6	12
08	SINGLE / 75 mm	8	16
12	SINGLE / 75 mm	12	22
16	SINGLE / 85 mm	16	32
24	SINGLE / 85 mm	24	48
32	SINGLE / 125 mm	32	64
48	SINGLE / 125 mm	48	96
70	SINGLE / 165 mm	64	128
86	SINGLE / 355 mm	144	288
88	SINGLE / 355 mm	192	384

X2 / X3
Transducer type & RS422/485 Serial link type

Value	Type	
R	RESOLVER	SERIAL
T	RESOLVER	USB
E	ENCODER Sincos	SERIAL
U	ENCODER Sincos	USB
G	TTL Single Ended	SERIAL
H	TTL Full Differential	SERIAL
L	TTL Single Ended	USB
M	TTL Full Differential	USB
B	ENCODER Biss	SERIAL
D	ENCODER Biss	USB
C	RES / ENC Config. board with 2 Voltage An. Ref.	
F	RES / ENC Config. board with 2 Current An. Ref.	

Special variation

Value – Internal coding (2)

Special configurations

Value – internal coding (2)	
00	Standard

Hardware Revision

Value – internal coding (2)

Fieldbus configuration

Value	Type
0	Analog references (1)
1	CanBus configuration (option)
2	EtherCAT configuration (option)
3	Analog References P/q control (option)
4	(Reserved)
5	Profinet Anybus (option)
6	Profibus Anybus (option)

(1) Standard version
(2) Values attributed by Moog

Figure 4: Drive Model Codes

3.1.5 Connector Kits

To order a connector kit, refer to the following table. For cable information, see Cables on page 54.

Drive size	Connector kit code	Type of transducer
L50/L75	BC8901-R	RESOLVER
	BC8902-R	ENCODER SINCOS
		TTL SINGLE ENDED
		TTL FULL DIFFERENTIAL
L85/L125	BC8921-R	RESOLVER
	BC8922-R	ENCODER SINCOS
		TTL SINGLE ENDED
		TTL FULL DIFFERENTIAL
L165 - MP	BC8913-R	RESOLVER
	BC8914-R	ENCODER SINCOS
		TTL SINGLE ENDED
		TTL FULL DIFFERENTIAL
L355 - VHP	BC8911-R	RESOLVER
	BC8912-R	ENCODER SINCOS
		TTL SINGLE ENDED
		TTL FULL DIFFERENTIAL
The drive can be equipped with a USB or RS-422 port in the X3 port position.		

3.2 Features and Component Details

This section provides details on the features and components of the DS2020 system.

3.2.1 Electrical Data

Electrical data	L50	L75	L85	L125	L165	L355
AC supply voltage	From 120 VAC to 480 VAC +/- 10 %					
Control Power voltage	24 VDC +/- 10 %					
Rated current Arms	From 2 to 4	From 6 to 12	From 16 to 24	From 32 to 48	From 64	From 144 to 192
Peak current Arms	From 4 to 8	From 12 to 22	From 32 to 48	From 64 to 96	From 128	From 288 to 384
Protections	Protection with thermal reading of the heat sink temperature, and estimated temperature of the power module junction; insufficient voltage (under voltage) or excessive voltage (over voltage) detection					
Cooling	Forced air from internal fans					

3.2.2 Mechanical Data

Mechanical data	L50	L75	L85	L125	L165	L355	
Rated Current (Arms)	2-4	6-8-12	16-24	32-48	32	144	192
Weight [Kg]	1.493	2.344	5.633	8.000	20	45	50
Height [mm]	215		355		371.5	707	
Width [mm]	50	75	85	125	165	355	
Depth [mm]	199.4		243.2			330	

> ⓘ The following figures are provided to show external dimensions only. The front panel shown may not represent the particular option(s) ordered on your drive.

Module 50 mm (1.97 inch)
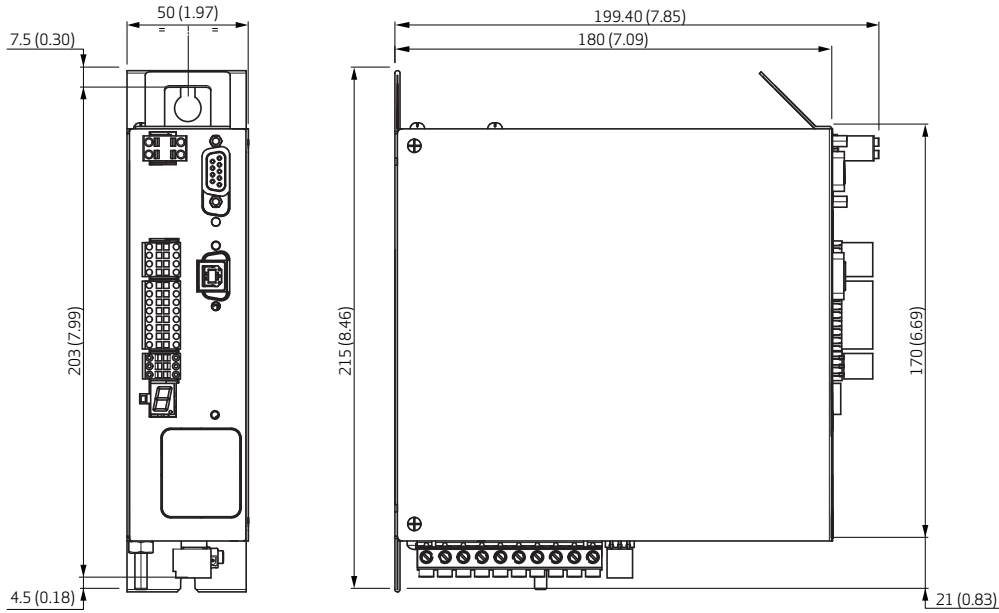
Module 75 mm (2.95 inch)
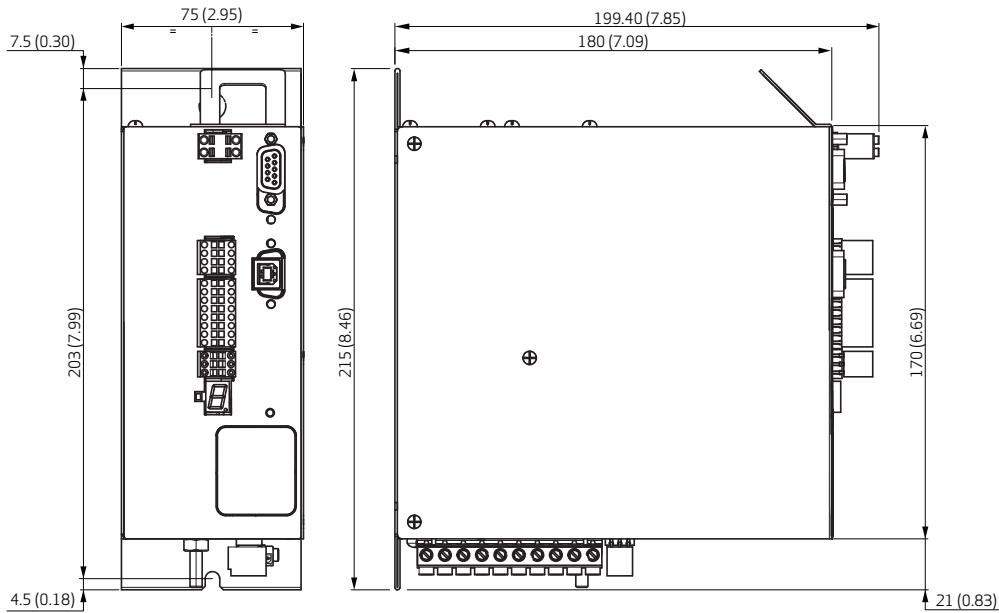
Figure 5: Drive Chassis Dimensions (L50 and L75)

Module 85 mm (3.35 inch)
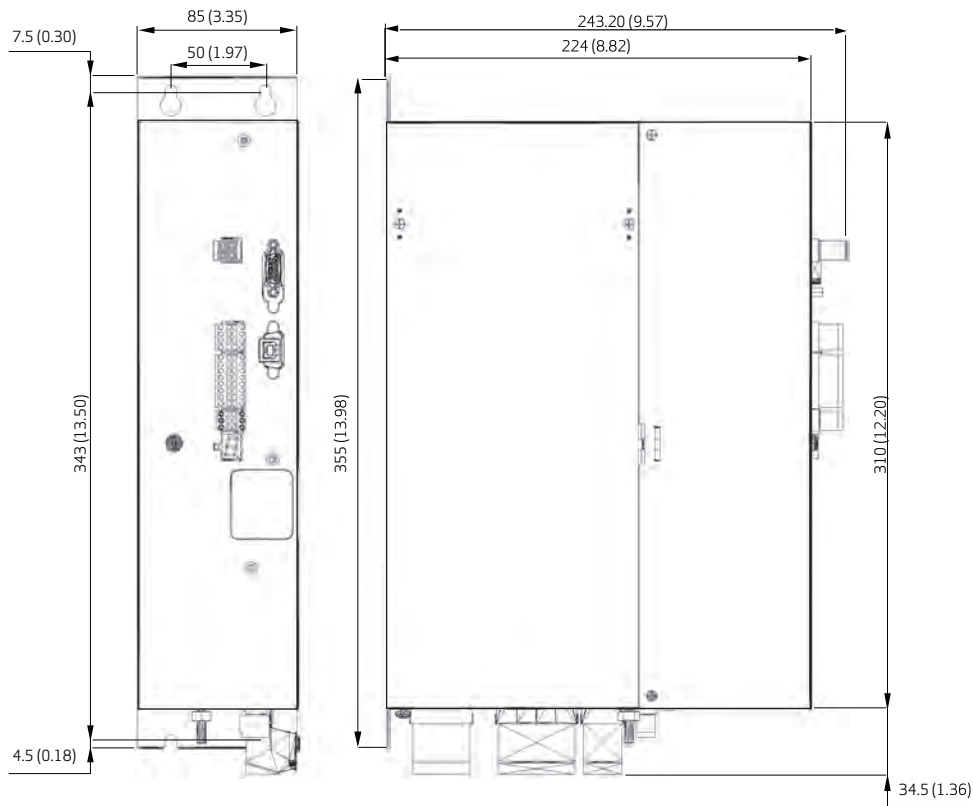
Module 125 mm (4.92 inch)
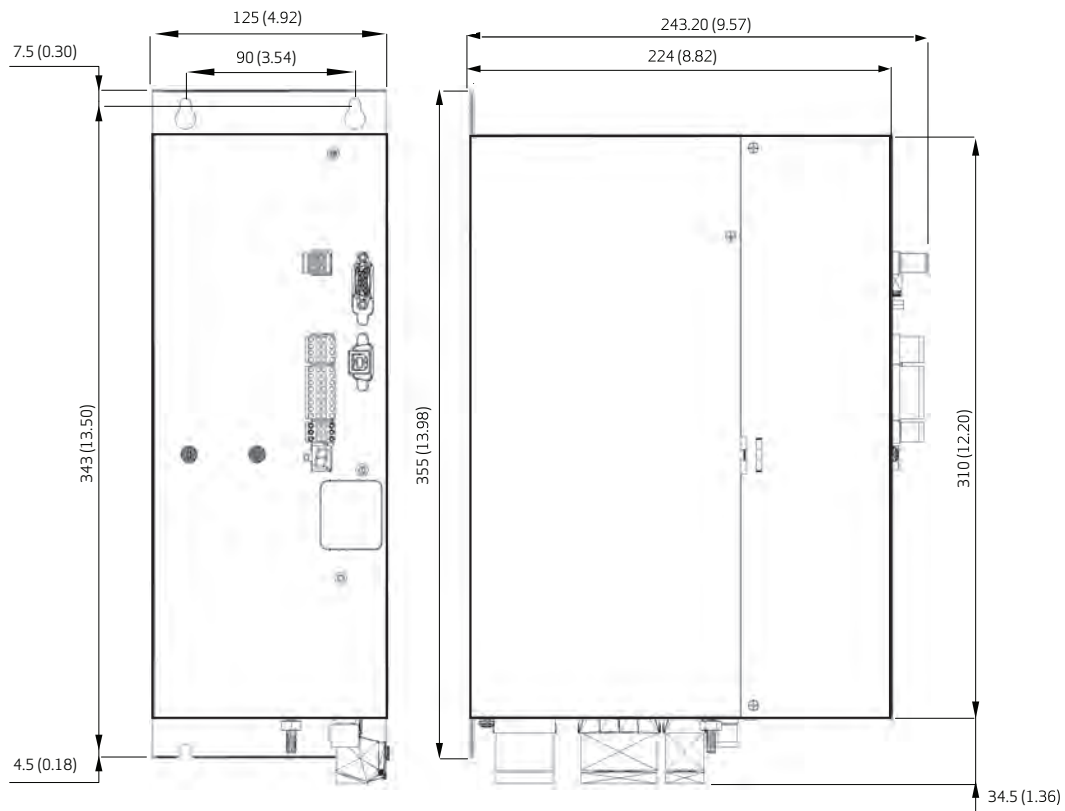
Figure 6: Drive Chassis Dimensions (L85 and L125)

Module 165 mm (6.49 inch)
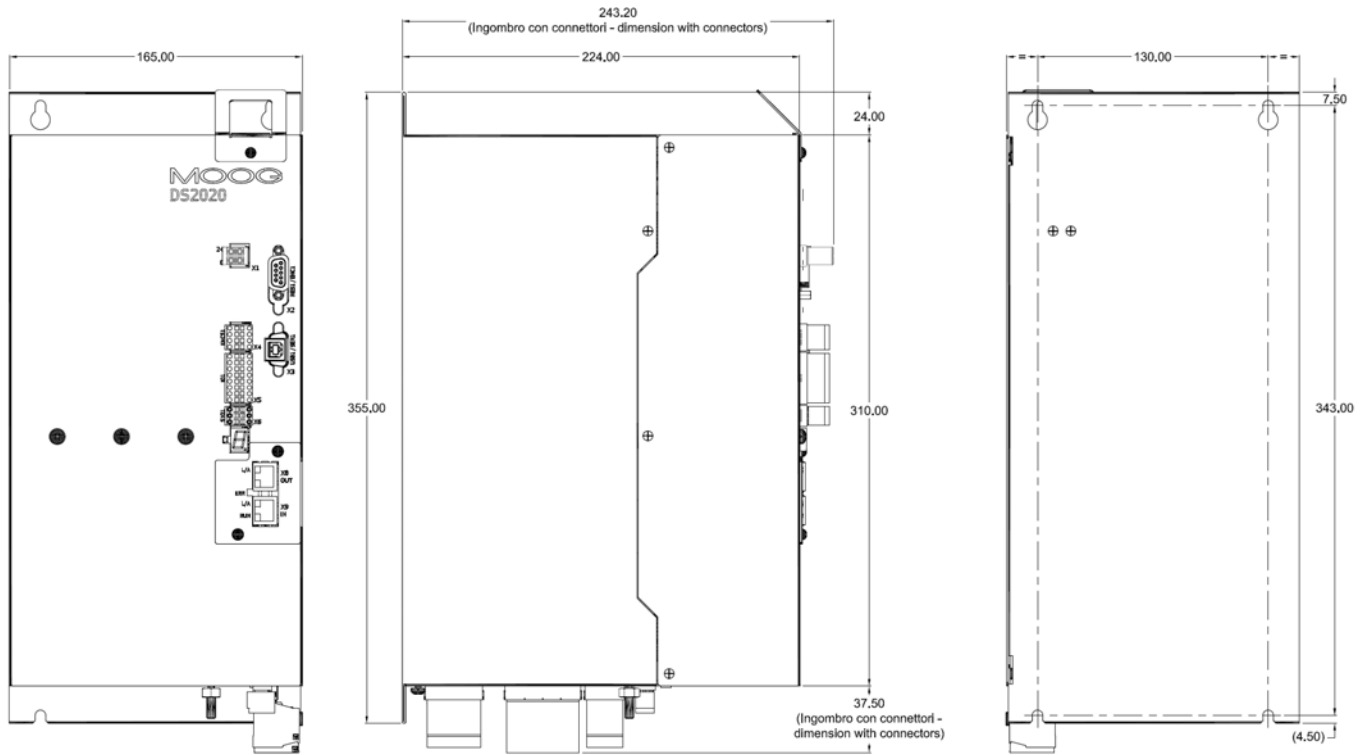
Module 355 mm (13.97 inch)
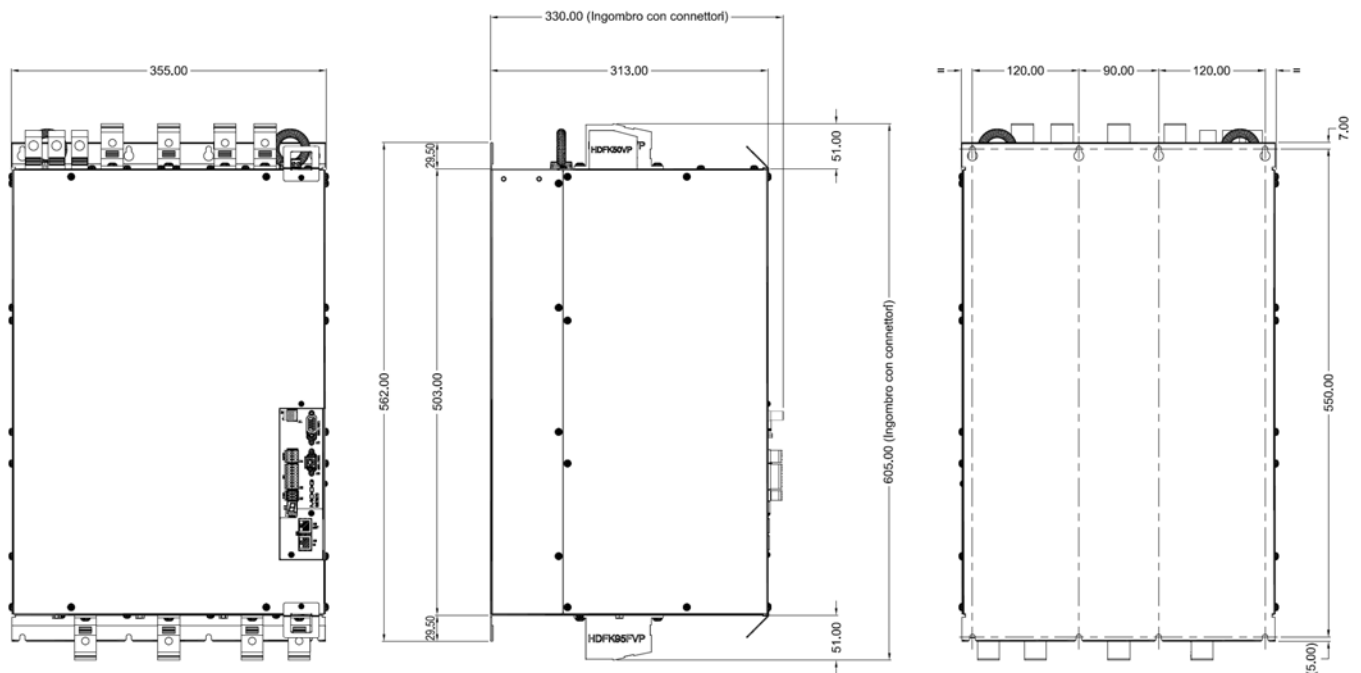
Figure 7: Drive Chassis Dimensions (L165 and L355)

Figure 6: Drive Chassis Dimensions (L85 and L125)

3.2.3 Transducers

The DS2020 system can manage the following transducers:

• Resolver (standard)

• Encoder Incremental TTL

• Encoder, Stegmann Sinusoidal Absolute Single/Multi-Turn with Hiperface communication

• Encoder, Heidenhain Sinusoidal Absolute Single/Multi-Turn with ENDAT communication

• BISS Absolute Encoder

• Sensorless mode

3.2.4 Connectors

X1:+24V Control power

X2: Resolver or Encoder interface

X3: Serial link or USB interface

X4: Simulated Encoder or RS-232 interface

X5: Input/Output Analog I/O Digital I/O Drive OK Restart

X6: STO interface

LED Display

Space for options

Front view
(connector layout for all sizes)

Bottom view (connector layout for sizes L85 - L125 and L165)

X13 AC supply power in

X12 Motor power out

X11 Brake resistor

X10 Motor brake (Power and command)

Bottom view (connector layout for sizes L50 and L75)

X11
- AC supply power in
- Motor power out
- Brake resistor

Figure 8: Drive Front Panel and Bottom Connectors

Front view (connector layout for sizes L355)
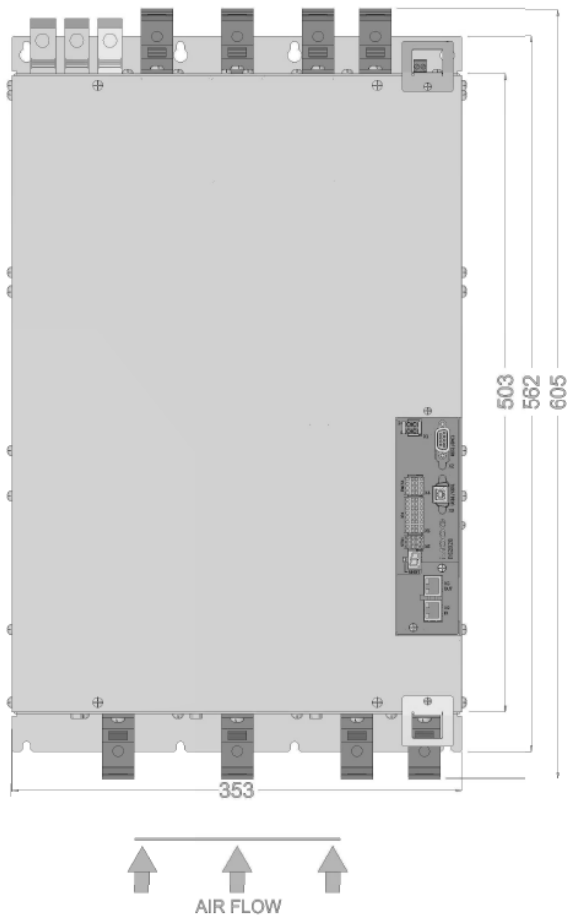
Top view (connector layout for sizes L355)
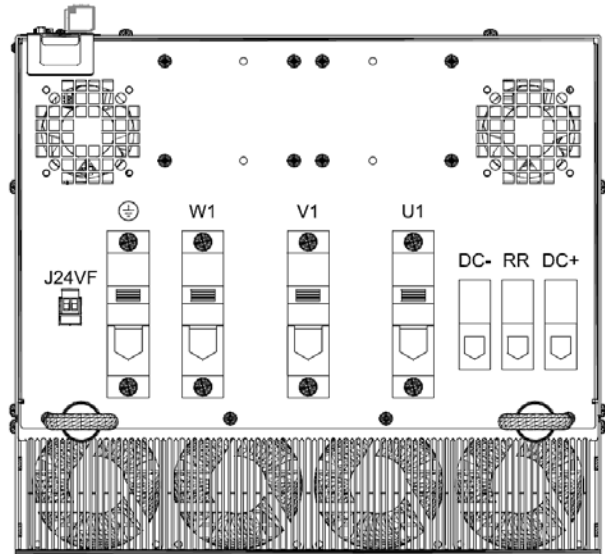
W1 - V1 - U1   = AC Power Supply IN
⊕   = Connection to earthing system
J24VF   = 24V Power Fan
DC -   = DC BUS -
RR   = Brake Resistor
DC +   = DC BUS +

Bottom view (connector layout for sizes L355)
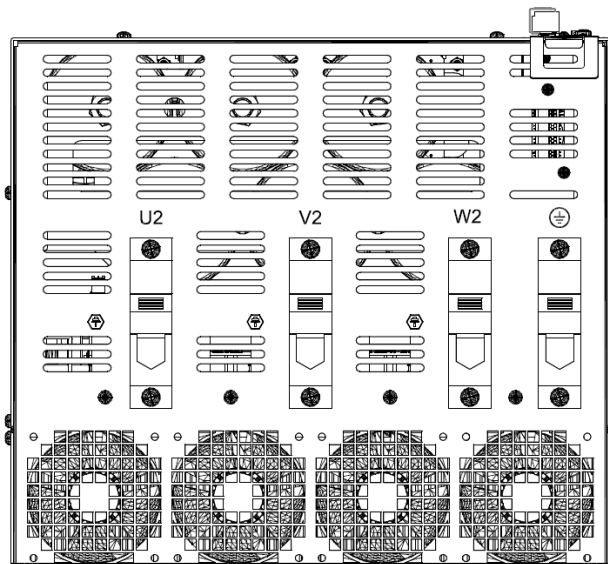
W2 - V2 - U2   = Motor Power OUT

⊕   = Connection to earthing system

⊕   = Connection to earthing system

Figure 9: Top and Bottom Connectors L355

Below is the list of connectors.

Size	Connector	Function
All sizes	X1	+24 VDC Control Power In
	X2	Resolver or Encoder motor feedback
	X3	USB or RS-422 interface
	X4	Programmable digital connector
	X5	Analog and digital I/O
	X6	Interface STO
	X7	CANopen Fieldbus (Optional)
	X8	EtherCAT Out Fieldbus (Optional)
	X9	EtherCAT In Fieldbus (Optional)
	X10	Motor brake connector (Power and Command)
L50/L75 only	X11	Power In, Motor power Out, Brake resistor
L85/L125/L165 only	X11	Brake resistor
	X12	Motor power Out
	X13	Power In
L355 only	RR, DC+	Brake resistor
	U2 – V2 - W2	Motor power Out
	U1 – V1 – W1	Power In
	J24VF	Fan cooling connector

ⓘ It is possible to have the X7 connector (connection via CANopen) or, depending on the configuration of the drive code, the X8-X9 connectors (connection via EtherCAT)

3.2.4.1 Connector Layout

The connector pin tables are shown in the following figures.

X1 Control Power Input
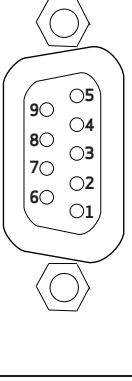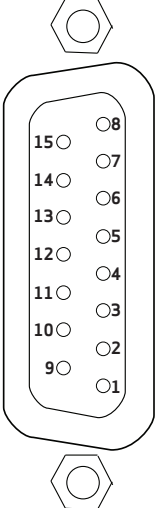
The drive requires a 24 VDC power supply connected to X1. The drive cannot operate without this low voltage supply. Note that the drive can be turned on with only the 24 VDC power supply to check the communication interfaces, set the configuration, etc.

Pin	Function
1	+ 24 Volt
2	0 Volt
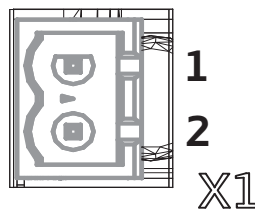
ⓘ If the +24 VDC on X1 is not supplied or is removed, the drive is fully powered off.

X2 Motor Feedback

X2 – Resolver	
Pin	**Function**
1	COS-
2	COS+
3	GND
4	SIN-
5	SIN+
6	TERM A
7	8 kHz-
8	TERM B
9	8 kHz+
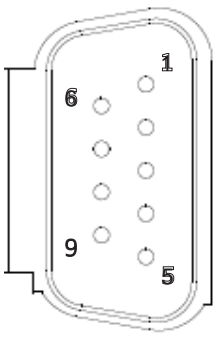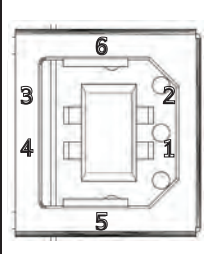
Pin	X2 - Encoder TTL Function	X2 - Encoder Stegmann Function	X2 - Encoder ENDAT Heidenhain Function
1	+ 5V (max 100 mA)	REFSIN	B-
2	GND	GND	0 V
3	W-	REFCOS	A-
4	W+	US	UP
5	V+	DATA+	DATA+
6	V-	N.C.	N.C.
7	A+	PTC	PTC
8	A-	N.C.	CLOCK+
9	C+	+SIN	B+
10	C-	N.C.	0 V SENSE
11	U+	+COS	A+
12	U-	N.C.	UP SENSE
13	B-	DATA-	DATA-
14	B+	PTC	PTC
15	PTC	N.C.	CLOCK-

Motor Thermal Sensor Inputs

The X2 and X10 connectors provide inputs for a motor thermal (temperature) sensor. Both connectors behave exactly the same with regard to the thermal sensor signals. Motors with a thermal sensor on the position feedback connector, such as the Moog Fastact G Servomotors, can be conveniently connected on the X2 inputs. Motors with a thermal sensor on the power connector can use the inputs on the X10 connector.

X3 Serial (RS-422) or USB Interface

The X3 connector can be either a 9-pin RS-422 or a USB type B.

Pin	Definition	Function
1	RX+	Data+ reception
2	N.C.	Not connected
3	TX+	Data+ transmission
4	N.C.	Not connected
5	N.C.	Not connected
6	RX-	Data- reception
7	0V	0V reference
8	TX-	Data- transmission
9	N.C.	Not connected

9-pole RS422 communication interface

Pin	Definition	Function
1	USB_ +5V	Power
2	USBDM	USB- data channel
3	USBDP	USB+ data channel
4	0V	0V Reference
5	Shield	Shield
6	Shield	Shield

USB-B communication interface

X4 Programmable Digital I/O

The digital inputs on X4 connector are not "single ended". Their input stage meets the RS-485 (3.3V) standard. Therefore, a simple RS-485 transceiver must be used to convert a single ended signal into a differential signal.

Different configurations are available; the one shown is configured as "Simulated Encoder".

Pin	Definition	Function
1	+24V_EXT	Output voltage 24 VDC 200 mA
2	A+	Channel A
3	A-	Channel A inverted
4	B+	Channel B
5	B-	Channel B inverted
6	C+	Channel C
7	C-	Channel C inverted
8	0V	0V reference
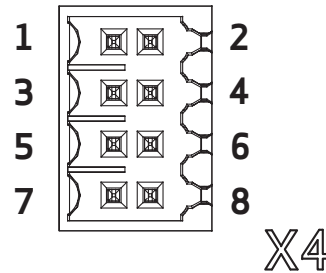
> The 24 Volt power supply provided on the connector can be used to power external devices.

For a sample RS-485 driver for the X4 connector, see Example RS-485 Driver on X4 on page 164.

X20 PROFIBUS Option

Pin	Name	Function	
1	NC	Not connected	
2	NC	Not connected	
3	B	Data receiver and transmit (+)	
4	CNTR_P	Control signal to repeater (+)	
5	0V_ISO	Reference potential for +5V_ISO	
6	+5V_ISO	+5V_ISO for terminating resistors (active termination)	
7	NC	Not connected	
8	A	Data receiver and transmit (-)	
9	CNTR_N	Control signal to repeater (-)	
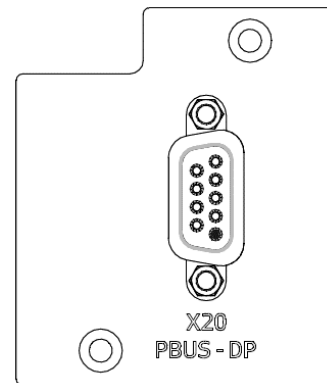
X5 Analog and Digital I/O Connector

Pin	Definition	Function
1	Analog IN1+	Programmable Analog Inputs
2	Analog IN1-	Programmable Analog Inputs
3	Analog IN2+	Programmable Analog Inputs
4	Analog IN2-	Programmable Analog Inputs
5	Analog OUT1	Programmable Analog Inputs
6	Analog OUT2	Programmable Analog Inputs
7	+24 Volt IN	24 volts input for the power supply of the digital output
8	0V Digital	Common ground for digital I / O
9	Digital OUT1	Digital output 1, optoisolated
10	NA	Not Available
11	Drive OK	Drive ok contact
12	Drive OK	Drive ok contact
13	Digital IN1	Digital input 1, fast, optoisolated
14	Digital IN2	Digital input 2, fast, optoisolated
15	Restart	Reset of the module
16	0V Analog	Analog GND
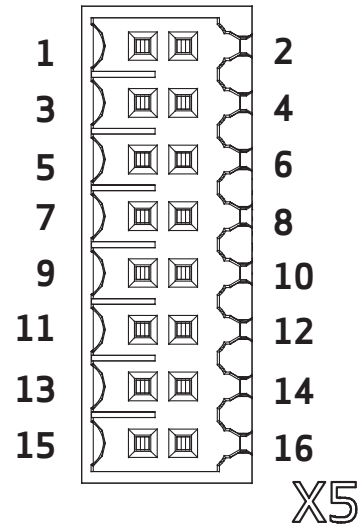
- Digital OUT1, Digital IN1 and Digital IN2 are isolated from the rest of the system and are referenced to 0V Digital (pin 8).

- Digital I/O ground on pin 8 is isolated from other system grounds.

- Drive OK (pins 11 and 12) are a relay contact in the DS2020 drive; its contacts are closed when the drive is ready to move the motor. This is the same information shown in Status Word 0, bit 0.

Programming the X5 analog and digital I/O connector:

Analog Input 1 and 2 options:

- Torque reference
- Speed reference
- Position reference
- Current limitation (maximum output torque)

Analog Out 1 and 2 options:

- Measured voltage DC BUS
- Current measured Iq
- Current reference Iq
- Measured phase current U
- Measured phase current V
- Motor speed measured
- Internal test variable

The digital inputs on the X5 connector are "standard" ones. For example, for positive and negative limit inputs, simply connect the input signal to pin 13 (for input 1) or pin 14 (for input 2) and 0 reference to pin 8.

For some sample I/O connections, see Example I/O Connections on X5 on page 155.

X6 STO Interface Connector

Pin	Definition	Function
1	+24 V S1	STO power input
2	0 V S1	0 Volt
3	+24 V S2	STO power input
4	0 V S2	0 Volt
5	FEEDBACK	Contact S1
6	FEEDBACK	Contact S2
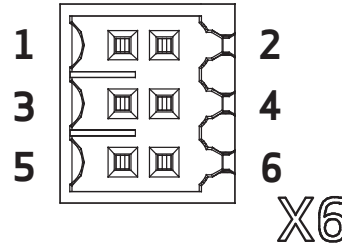
Reset button

When pressed, causes the initialization of the drive control section.

A long press (> 3 seconds) accesses the boot routine of the drive, which provides the ability to install a different version of firmware. For assistance with these operations, contact Applications Engineering.

LED 7-segment display

Indicates the axis state after the insertion of the +24 VDC control power. The meanings of the different messages are reported in the following table:

Display Symbol	Status	Note
I	Initialization	The drive has completed the initialization phase
S	Ready	The drive is ready to be enabled
E	Enabled	The drive is controlling the motor
F	Fault	The drive is in alarm
8 (blinking)	Boot	The drive is being programmed via serial line RS-422 or USB
b (fixed light)	Boot	The drive is being programmed via EtherCAT

If the operation mode is Analog, in the event of fault, the letter F would follow a 2-digit code that identifies the alarm. The details can be found in section 9.3 Alarm Display in Analog Operating Mode on page 134.

X7 CAN Option

Pin	Name	Function
1	Reserved	Not associated with a function in the drive
2	CANL	Negative terminal CAN line
3	CAN_GND	Logic 0 CAN line
4	Reserved	Not associated with a function
5	CAN_shield (optional)	Shield (optional)
6	GND (optional)	Logic 0 CAN line (optional)
7	CAN_H	Positive terminal CAN line
8	Reserved	Not associated with a function
9	CAN_V+	Power supply line CAN (supplied by power adapter)
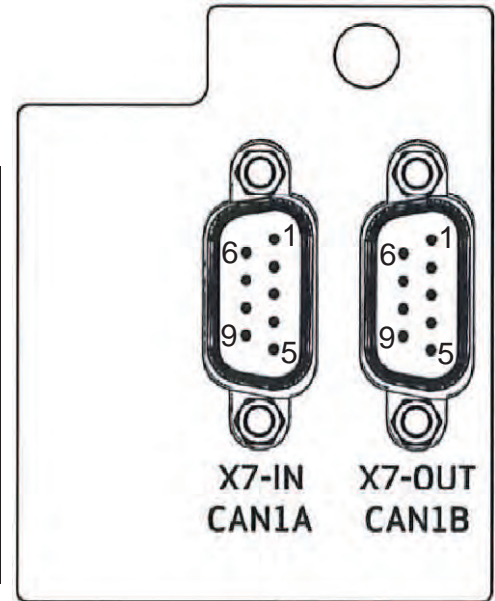
The PC connection via CAN Drive is currently performed using a USB adapter: CAN IXXAT Automation (www.ixxat.com) VCI V3 model; other models or devices can be added to the GUI on request.

X8 – X9 - PROFINET Option

Pin	Name - X9 IN	Name - X8 OUT	Function
1	A_1P	B_1P	First pair, positive signal
2	A_1N	B_1N	First pair, negative signal
3	A_1CEN	B_1CEN	Center tap voltage for first pair
4	SHIELD	SHIELD	Profinet cable Shield
5	SHIELD	SHIELD	Profinet cable Shield
6	A_2CEN	B_2CEN	Center tap voltage for second pair
7	A_2P	B_2P	Second pair, positive signal
8	A_2N	B_2N	Second pair, negative signal
9	+3.3V_D	+3.3V_D	+3.3V_D Power Led
10	LED_LINK_ACT0	LED_LINK_ACT1	Link/Act for the network port
11	LED_COL_ACT0	LED_COL_ACT1	NOT USED
12	+3.3V_D	+3.3V_D	+3.3V_D Power Led
13	SHIELD	SHIELD	Profinet cable Shield
14	SHIELD	SHIELD	Profinet cable Shield
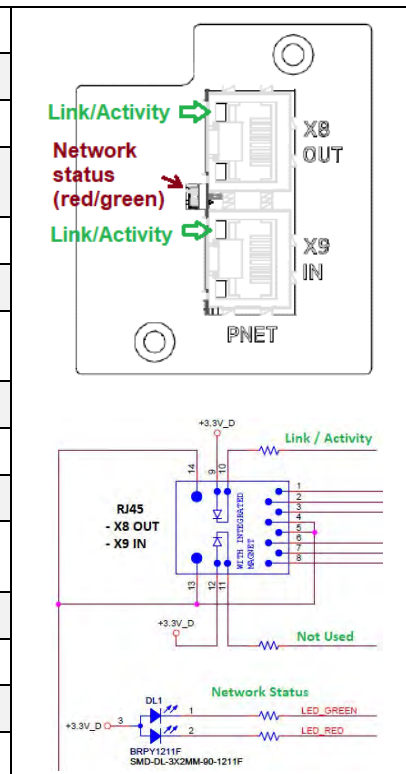
X8 - X9 EtherCAT Option

The cable used is standard EtherCAT, the connector is RJ45
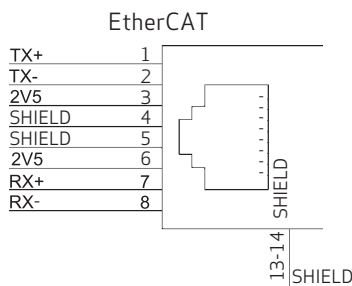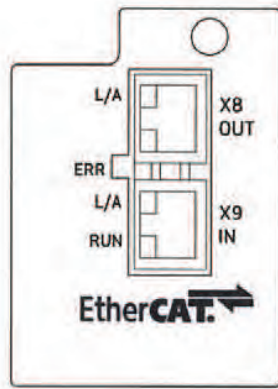
LED	Name	Description	
X9 - RUN	EtherCAT RUN Indicator	OFF	- The drive is in the state INIT
		BLINKING	- The drive is in the state PRE-OPERATIONAL
		SINGLE FLASH	- The drive is in the state SAFE-OPERATIONAL
		ON	- The drive is in the state OPERATIONAL
		FLICKERING	- The drive is in the state BOOTSTRAP
X9 - L/A	EtherCAT Link/Activity	OFF	- The input Ethernet port is closed
		ON	- The input Ethernet port is open
		FLICKERING	- The input Ethernet port is open and there is network activity
X8 – L/A	EtherCAT Link/Activity	OFF	- The output Ethernet port is closed
		ON	- The output Ethernet port is open
		FLICKERING	- The output Ethernet port is open and there is network activity

X10 Integrated Motor Brake

Pin	Function
1	0 Volt
2	+ 24 Volt
3	0 Volt
4	Brake output
5	Thermal protection
6	Thermal protection
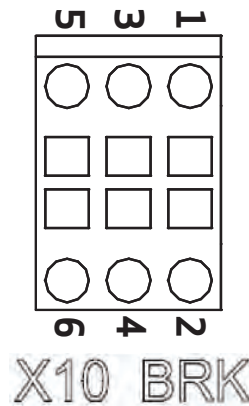
The brake control circuit must be externally powered through X10.

> ⚠ **WARNING**
>
> **WARNING: Mechanical hazard.**
> **Large motors can generate very high torque and impact or trapping hazards, which can result in death or serious injury to personnel, or damage to equipment.**
>
> ➢ Follow these safety instructions.

- **The connection to the motor's brake alone does not guarantee the safety of personnel or equipment.**

- **In particular, vertical loads require an additional mechanical brake to operate in a certifiably safe manner.**

> The brake cannot be autonomously monitored if there is an insufficient voltage level. Consequently, it is necessary to measure the voltage on the input of the brake, and always verify the functionality when releasing and braking. In particular, examine connections with long cables or cables with reduced cross section, which are subject to significant voltage drops.

The brake can be enabled in different ways:

- According to logic defined by the user condition (disable/enable the axis)

- With a command through fieldbus

- With a suitably programmed digital input

- With a special command through the GUI software

X11 - 13 Power Connections
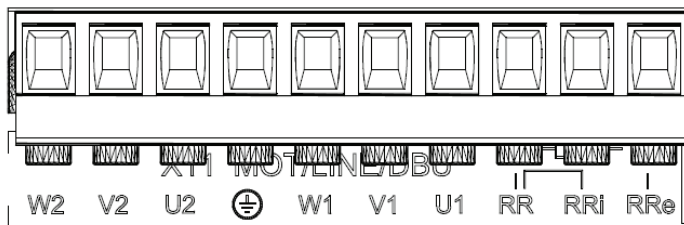
X11 connection - sizes L50 and L75

Definition	Function
U2, V2, W2 , ⏚	Motor connection
GND	Connection to earthing system through M5 stud
U1, V1, W1	Connection to the three-phase AC supply
RRe, RR	Connection to the external brake resistor (L50/L75 only)
RRi, RR	Bridge to use the internal brake resistor (L50/L75 only)

Ground stud (M5)
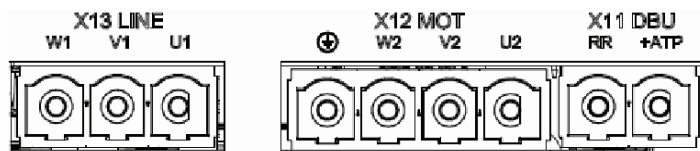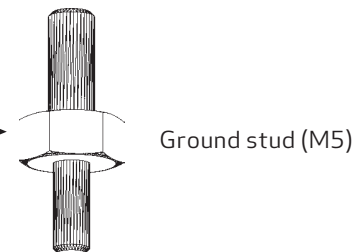
X11-X12-X13 connections - size L85 - L125 - L165

The cable must be shielded. The shield connection to ground can be closed with a conductive strap, which is used to connect the cable to the metal bracket fixed under the drive.

Definition	Function
U2, V2, W2 ,	Motor connection
⏚	Connection to earthing system
U1, V1, W1	Connection to the three-phase AC supply
DC-	DC BUS – (Optional L355)
RR, DC+	Connection to the external brake resistor (L355)
J24VF	Connection to the 24Vdc power supply
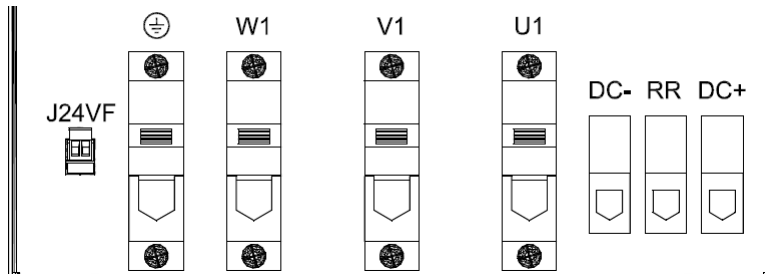
Top view (connector layout for sizes L355)
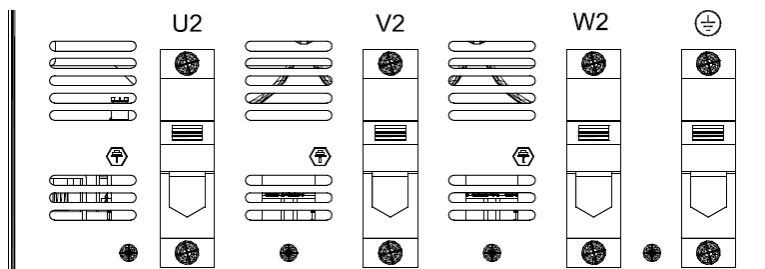
Botton view (connector layout for sizes L355)

3.2.5 Power Line Filters

To ensure proper compatibility with the EMC standards, insert a power line EMC filter, code AT6009 or AT6010 (or equivalent), between the AC supply and drive.

Item	Description
Code	AT6050 / AT6055 / AT6065 / AT6074 / AT6051 / AT6056 / AT6066 / AT6075 / AT6052 / AT6057 / AT6067 / AT6076 / AT6047 / AT6058 / AT6068 / AT6049 / AT6059 / AT6069 / AT6077 / AT6060 / AT6063 / AT6070 / AT6078 / AT6060 / AT6072 / AT6080 / AT6045 / AT6073 / AT6081
Rated current	3 x (400/480 V), 50/60 Hz, to 50 °C
Overcharge	4 x on startup 1.5 x for 60 s, repeatable every 60 min.
Environmental temperature	From -25 °C to +100 °C, with current reduction from 60 °C (1,3 % / °C)
Mounting altitude	1000 m, with current reduction from 4000 m (6 % / 1000 m)
Relative air humidity	From 15% to 85%, non-condensing
Storage temperature	From -25 °C to +70 °C
Protection	IP20
Acceptance test	CE Compliant
Non-industrial environment EN61800-3 complies with radio shielding	Allowable length of the cable between the drive and motor up to 50 m
Non-industrial environment EN61800-3 complies with radio shielding	Allowable length of the cable between the drive and motor up to 100 m

Code	Mfr	Mfr. No	Drive Model / Current
AT6050 AT6055 AT6065 AT6074	Schaffner Schaffner FINMOTOR FINMOTOR	FN3288-10-44-C34-R65 FN3258-7-44 FIN538S1.007.M FIN1500.10.V	Dimension L50 Current 2/4A 4/8A
AT6051 AT6056 AT6066 AT6075	Schaffner Schaffner FINMOTOR FINMOTOR	FN3288-16-44-C35-R65 FN3258-16-44 FIN538S1.016.M FIN1500.16.V	Dimension L75 Current 6/12 8/16
AT6052 AT6057 AT6067 AT6076	Schaffner Schaffner FINMOTOR FINMOTOR	FN3288-25-33-C35-R65 FN3258-30-33 FIN538S1.030.M FIN1500.30.V	Dimension L85 Current 16/32 24/48
AT6047 AT6058 AT6068	Schaffner Schaffner FINMOTOR	FN3288-40-33-C35-R65 FN3258-42-33 FIN538S1.042.M	Dimension L125 Current 32/64
AT6049 AT6059 AT6069 AT6077	Schaffner Schaffner FINMOTOR FINMOTOR	FN3288-50-53-C35-R65 FN3258-55-34 FIN538S1.055.M FIN1500.50.V	Dimension L125 Current 48/96
AT6060 AT6063 AT6070 AT6078	Schaffner Schaffner FINMOTOR FINMOTOR	FN3258-75-34 FN3288-10-44-C17-R65 FIN538S1.075.M FIN1500.80.V	Dimension L165 Current 64/128
AT6062 AT6072 AT6080	Schaffner FINMOTOR FINMOTOR	FN3258-130-35 FIN538S1.130.M FIN1500.150.V	Dimension L355 Current 144/288
AT6045 AT6073 AT6081	Schaffner FINMOTOR FINMOTOR	FN3359-180-28 FIN538S1.180.M FIN1500.200.V	Dimension L355 Current 192/384

3.2.6 Braking Resistor

When the motor accelerates, the energy is dissipated as heat in the braking resistor (or recovery resistor). The table shows the values of the brake resistors listed by size.

Size	Rated Current (Arms)	Peak Current (Arms)	Power [Watts]	Ohms	Position
L50	2-4	4-8	100	75	Internal
L75	6-8-12	12-16-22	100	51	Internal
L85	16	32	200	51	External
L85	24	48	240	22	External
L125	32	64	370	22	External
L125	48	96	370	12	External
L165	64	128	750	8.2	External
L355	144	288	1500	3.9	External
L355	192	384	1500	3	External

> ⓘ The supplied brake resistor ensures adequate power dissipated for a typical light work cycle where the braking current is lower than the nominal value. In applications where a heavy braking cycle is required, contact Applications Engineering.

NOTICE

The braking resistor must always be connected, as it also performs the soft-start function. Failure to do so would prevent the system from starting. Additionally, it would prevent making a controlled stop of the motor.

3.2.7 Line Inductors

For normal operation, it is not necessary to use inductors inserted between the AC power supply and the drive input.

3.3 Motors

The DS2020 drives have been designed to control speed and position of brushless synchronous motors.

> ⓘ   Torque control is always active (directly achieved by current control), because the velocity loop always produces current references, but it is not directly available to the user.

3.3.1 Selecting a Moog Motor

To make the motor selection process easy, Moog has identified a variety of its motors that are fully compatible with each drive model. Both low voltage and high voltage Moog motors are available to satisfy a wide range of applications. For details, see the *DS2020 Drive Systems Guide.*

3.3.2 Selecting a Non-Moog Motor

Moog offers a wide variety of compatible motors for use in the DS2020 system. However, if you wish to use a non-Moog motor with the drive, please contact Applications Engineering for assistance.

NOTICE
It is critical to select a compatible motor-drive combination. Pairing a motor and drive that are not properly matched can result in underperformance of the system and/or damage to system components. For further assistance, contact Applications Engineering.

3.4 Cables

Part Number	Description	Motor
CVM-Pxx-2020-21	CD Motor Series Power cable, flex rated, 1.5 mm^2 (Size 1 connector)	G1-G3
CVM-Pxx-2030-31	CD Motor Series Power cable, flex rated, 2.5 mm^2 (Size 1 connector)	G3-G4
CVM-Pxx-2030-41	CD Motor Series Power cable, flex rated, 4.0 mm^2 (Size 1 connector)	G4-G5
CVM-Pxx-3030-51	CD Motor Series Power cable, flex rated, 6.0 mm^2 (Size 1.5 connector)	G5-G6
CVM-Pxx-3030-61	CD Motor Series Power cable, flex rated, 10.0 mm^2 (Size 1.5 connector)	G6
CVM-Sxx-4040-03	CD Motor Series Feedback cable, Resolver, flex rated (9 pin D-sub connector)	CD with Resolver
CVM-Sxx-5030-03	CD Motor Series Feedback cable, Encoder, flex rated (15 pin D-sub connector)	N/A

If you are building your own cables or using motors from other manufacturers, please consult the following table for recommended cable specifications.

Feature	DS2020							
	L50/L75	L85		L125		L165	L355	
	2A - 4A - 6A - 8A - 12A	16A	24A	32A	48A	64A	144A	192A
Section of the motor cable	2.1 mm^2 14 AWG	3.3 mm^2 12 AWG	5.3 mm^2 10 AWG	8.4 mm^2 8 AWG	13 mm^2 6 AWG	16 mm^2 5 AWG	35 mm^2 2 AWG	50 mm^2 0 AWG
Section of the brake cable	1 mm^2 16 AWG							
Maximum motor cable length	100 m							
Maximum cable capacitance	< 150 pF/m							
Section of I/O	0,22-1 mm^2 16 AWG							
Section of AC power supply cable	2.1 mm^2 14 AWG	3.3 mm^2 12 AWG	5.3 mm^2 10 AWG	8.4 mm^2 8 AWG	13 mm^2 6 AWG	16 mm^2 5 AWG	35 mm^2 2 AWG	50 mm^2 0 AWG
Section of brake resistor cable	2.1 mm^2 14 AWG	3.3 mm^2 12 AWG	5.3 mm^2 10 AWG	8.4 mm^2 8 AWG	13 mm^2 6 AWG	16 mm^2 5 AWG	35 mm^2 2 AWG	50 mm^2 0 AWG
Section of 24 VDC cable	0.8 mm^2 18 AWG							
Section of ground cable	2.1 mm^2 14 AWG	3.3 mm^2 12 AWG	5.3 mm^2 10 AWG	8.4 mm^2 8 AWG	13 mm^2 6 AWG	16 mm^2 5 AWG	35 mm^2 2 AWG	50 mm^2 0 AWG
For the Metric/AWG conversion table, see Metric/AWG Conversion Table on page 169.								
For the list of connector see Table on page 41.								

> The power and control cables (except those that go from the AC power supply to the filter) must be shielded. To minimize noise, it is recommended that they are separated from each other at a distance greater than 200 mm.

> Shielded power cables can be grounded with a copper bar using a clamp that ensures an efficient electrical contact area with larger cross-section of the ground wire.

Particular attention should be given to the use of appropriate cables.

The cables and the motor winding may interact with the drive output stage to create an oscillating circuit that increases the maximum voltage of the system. The parameters that contribute to determining this maximum voltage are: the capacity and the length of the cables, the motor inductance, and the frequency and rising edges of the PWM modulation. An analysis of these parameters is recommended to prevent excessive voltages for the application. For applications assistance, contact Applications Engineering.

ⓘ	The power and control cables (except those that go from the AC power supply to the filter) must be shielded. To minimize noise, it is recommended that they are separated from each other at a distance greater than 200 mm.
ⓘ	Shielded power cables can be grounded with a copper bar using a clamp that ensures an efficient electrical contact area with larger cross-section of the ground wire.

Particular attention should be given to the use of appropriate cables.

The cables and the motor winding may interact with the drive output stage to create an oscillating circuit that increases the maximum voltage of the system. The parameters that contribute to determining this maximum voltage are: the capacity and the length of the cables, the motor inductance, and the frequency and rising edges of the PWM modulation. An analysis of these parameters is recommended to prevent excessive voltages for the application. For applications assistance, contact Applications Engineering.

4 Certifications

This chapter provides information about the DS2020 system certifications.

4.1 CE Certificate

According to the European Community Directives, drives must conform to:

- EMC 2014/30/EU directive

- Low Voltage Directive 2014/35/EU

The DS2020 system has been tested in a laboratory for the verification of the parameters of compliance with the above Directives.

Regarding electromagnetic compatibility, the DS2020 system refers to C3 industrial environments.

> The DS2020 system can emit radio frequency that might interfere with non-industrial electric and electronic devices.

> The machine manufacturer MUST NOT use the DS2020 system or its components if there is no documentation that ensures the fulfillment of the requirements of Directive 2006/42/EC.

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MOOG

CENELEC

Memorandum N°3

DICHIARAZIONE CE DI CONFORMITA'/ *EC DECLARATION OF CONFORMITY*

Il sottoscritto, rappresentante il seguente costruttore / *The undersigned, representing the following manufacturer*

| MOOG ITALIANA S.r.l., Sede di Casella / *Casella Site* |
| Via Avosso 94, Casella (Genova), Italy |

dichiara qui di seguito che i prodotti / *herewith declares that the products*

| Marchio / Brand : MOOG |
| Azionamenti Serie / *Drives Series*: DS2020 |

risultano in conformità' a quanto previsto dalle seguenti direttive comunitarie / *are in conformity with the provisions of the following EC directives*
(comprese tutte le modifiche applicabili / *including all applicable amendments*)

rif./ ref nr	titolo / *title*
2014/30/EC	Direttiva Compatibilità Elettromagnetica/ *EMC Directive*
2014/35/EC	Direttiva Bassa Tensione/ *Low Voltage Directive*

e che sono state applicate le norme armonizzate, o parti di esse, indicate di seguito / *and that the following harmonized standards, or parts thereof, have been applied*

nr	issue	titolo / *title*
EN 50178	1997	*Electronic equipment for use in power installations*
EN 61800-3	2004	*Adjustable speed electrical power drive systems. Part 3: EMC product standard including specific test methods*
EN 61800-3: 2004 A1	2012	*Adjustable speed electrical power drive systems. Amendment 1*
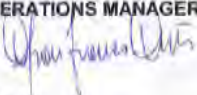
Altri riferimenti o informazioni richiesti dalle direttive comunitarie applicabili / *Other references or information required by the applicable EC directives*: La conformità dei prodotti è subordinata al rispetto delle procedure contenute nei rispettivi "Manuale di installazione". L'utilizzatore ha la responsabilità primaria nel seguire le raccomandazioni del costruttore riguardo alle problematiche EMC./ *The conformity of products is subjected to observation of the procedures included in the proper "Installation Manual". The user has the primary EMC responsibility in following the recommendations of the manufacturer.*

Ultime due cifre dell'anno in cui e' stata affissa la marcatura CE / *Last two digits of the year in which the CE marking was affixed*: 14

Casella, 20 Aprile , 2016

Gianfranco Costa

OPERATIONS MANAGER

CENELEC

Memorandum N°3

Figure 10: CE Declaration of Conformity

4.2 Safe Torque Off (STO)

The DS2020 integrates the Safe Torque Off (STO) function according to standards EN 61800-5-2; UNI EN ISO 13849-1:2016. SILCL 3 PL "e" (as per certificate). The function also corresponds to an uncontrolled stop in accordance with stop category 0 of IEC/EN 60204-1 standard.

The validation of the function is based on:

- A guarantee that a single fault does not lead to loss of the safety function

- Some, but not all, possible faults may be identified

- The addition of more undetected failures can lead to loss of the safety function

In case of the occurrence of two simultaneous faults in the power section, the residual risk is for the motor to rotate by an angle dependent on the number of its pole pairs. So, for example, a 6-pole motor can result in a maximum rotation of 60°.

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MOOG

EC DECLARATION OF CONFORMITY
(TRANSLATION OF THE ORIGINAL DECLARATION)
according to Annex II A of Directive 2006/42/EC

We,

MOOG ITALIANA S.r.l., Casella Site
Via Avosso 94, Casella (Genova), Italy

herewith declare that the logic unit to ensure the safety function "**Safe Torque Off**" integrated in the drives series **DS2020**

is in conformity with the provisions of the Machinery Directive 2006/42/EC

and is in conformity with the model submitted to EC type-examination, which achieved the EC certificate n. n. 14CMAC0030 rev.1 dated January 02nd 2020 issued by the following notified body:

I.C.E.P.I. S.p.A. (Istituto Certificazione Europea Prodotti Industriali)
Via Paolo Belizzi, 29/31/33 - 29122 Piacenza - Italy
Identification number: 0066

and that the Technical File has been compiled by:

MOOG ITALIANA S.r.l., Casella Site
Via Avosso 94, Casella (Genova), Italy

and that the following standards have been applied:

harmonized standards

EN 61800-5-2:2017, UNI EN ISO 13849-1:2016

Casella, January 14th 2020

Gianfranco Costa

OPERATIONS MANAGER

Sede Legale: **MOOG ITALIANA S.r.l.** – Società a Socio Unico soggetta a direzione e coordinamento da parte di **MOOG Gmbh & Co.KG**
Via G.Pastore, 4 - 21046 Malnate (VA) - Telefono (39) 0332.421111 Fax (39) 0332.429233 –
R.E.A. Varese 138918 – Cod. Fisc. , Partita IVA, Nr. Reg. Imp.Varese: IT00531090124 – Cap. Soc. Euro 520.000 i.v.

Figure 11: CE "Safe Torque Off" Certificate of Conformity

Figure 12: EC-Type Examination Certificate

4.3 Certification Compliant System Installation Requirements

4.3.1 Environmental Ratings

- Environmental designation: "Open Type drive – Suitable for Pollution degree 2 Installation Environment"

  "(Eng. Note: Provided by end use installation enclosure)"

- Operating Temperature: "Maximum Surrounding Air Temperature 40 °C"

- Altitude end use installation: "Maximum 3000 m above sea level"

- Water Cooling System (when provided):
  - Liquid Cooling Type: Water (80%) – Glycol (20%)
  - Inlet Max Liquid Cooling Temperature: 40 °C
  - Outlet Max Liquid Cooling Temperature: 70 °C
  - Rated Liquid Cooling Operating Pressure: 0.8 bars
  - Max Liquid Cooling Operating Pressure: 1 bar
  - Rated Liquid Cooling Flow rate:
    - 2 l/min (Model L75W)
    - 5 l/min (Models L85W-L125W)
- Wiring Ratings: "Only for Factory Wiring"

- System Voltage - "Overvoltage Category III"

4.3.2 Short Circuit Protection

The "Short Circuit Protections" are provided by both:

- Internal "Solid State Short Circuit Protection"

- External "Branch Circuit Protection (BCP) – Fuses (R/C Special Purpose Fuses (JFHR2/8)"

A1   Internal Solid State Short Circuit Protection (provided) - All Drive models are equipped with Solid State Short Circuit Protection. The same type of circuitry is used throughout the series.

A2   External Branch Circuit Protection (BCP) (required in the end use installation) - R/C Special Purpose Fuses (JFHR2/8), Type: Semiconductor Fuse. See the following table for the manufacturers, model number and electrical ratings of the Fuses.

External (required) Type Semiconductor Fuses						
Drive Models	R/C Special Purpose Fuses (JFHR2/8) manufactured by Cooper Bussmann LLC (200 kArms Symmetrical A.I.C.)					
	Mod. No.	CurrentArms	Peak let-through Current Arms	I^2t @480 V A^2sec	Vac	Qty
L50-2 L50-4	25 ET	25	700	213	700	3
L75-6 / L75-W6 L75-8 / L75-W8 L75-12 / L75-	50 FE	50	900	553		
L85-16 / L85-W16	50 FE	50	900	553		
L85-24 / L85-W24	71 FE	71	1150	923		
L125-32 / L125-W32	71 FE	71	1150	923		
L125-48 / L125-W48	100 FE	100	1600	2570		
L165-64	*	*	*	*		
L355-144	*	*	*	*		
L355-192	*	*	*	*		

* UL Certifications Test in progress

4.3.3 Primary Circuit Overvoltage Protection

The "Open Type, Servo Drives – DS2020 Series" are protected from Transient-Overvoltage in the Power Supply Primary Circuit of the end-use applications by:

- R/C Surge-Protective Device (VZCA2, VZCA8 or CSA certified), Internally provided and Externally required in the "Main Line Supply".

B1   Internal (provided) devices - According to the United States Standard UL61800 5 1 (Eng. Note: employed eventually only to reduce the spacings (clearances) required for "Functional Insulation")

B2   External (required in the end use installation) Surge Protection devices - According to the Canadian Standard C22.2-No.274-17. (Eng. Note: necessary to reduce the spacings (clearances) also, as required by the Standard UL61800 5 1 for "Basic Insulation")

Suppressive Device/Component: R/C Surge Protective Device (VZCA2, VZCA8 or CSA certified). Refer to the following Table for the Models and Ratings of these or equivalent suppressive devices.

Drive Models	Manufacturer	SPD Mod. No.	Ratings			Qty
			Max Continuous Op. Voltage (Vac)	Voltage Protection Rating (VPR)(Vpk)	Type SPD Appl. / Nom.Dis Current (In, kA)	
All Drives	ABB France (E322885)	OVR T2 3L 40 550PTSU	L-G 550 Vrms Max L-L 110 Vrms Max	L-G 1800 V Max L-L 4000 V Max	1 10 kA	3
	Phoenix Contact (E330181)	VAL-CP-3C-350	L-G 350 Vrms Max L-L 700 Vrms Max	L-G 1200 V Max L-L 2000 V Max	2 10 kA	

4.3.4 Dynamic Brake Unit Ratings

For the "Open Type, Servo Drives – DS2020 Series" the "Dynamic Brake Unit – Chopper (IGBT)" transistor is connected to the following "Internal / External Resistors" (suitable also as "Soft start resistors").

1. Internal (provided) Dynamic Brake Unit Resistor

Drive Models	Max Current (Amps)		Max Duty Cycle* (%)	Internal D.B.U. Resistor Ratings (Ohms)
	Peak	rms		
L50xx	10.7 A	0.13 A	1.17 %	75 Ω (100 W)
L75xx	15.7 A	0.13 A	0.81 %	51 Ω (100 W)

2. External DBU Ratings (Optionally mounted DBU External Resistors)

    The following table also shows the ratings of the external DBU Resistors required or provided (as optional accessories) by the manufacturer.

Drive Models	Max Current (Amps)		Max Duty Cycle* (%)	External D.B.U. Resistor Ratings (Ohms)
	Peak	rms		
L50xx	10.7 A	0.25 A	2.35 %	75 Ω (200 W)
L75xx	15.7 A	0.25 A	1.61 %	51 Ω (200 W)
L85xx	15.7 A	0.30 A	1.93 %	51 Ω (240 W)
L125-32	36.4 A	0.46 A	1.27 %	22 Ω (370 W)
L125-48	66.7 A	0.94 A	1.41 %	12 Ω (750 W)
L165-64	*	*	*	*
L355-144	*	*	*	*
L355-192	*	*	*	*

*The Duty Cycle (D.C.) is referred to as % of Total Time = 5 sec.

* UL Certifications Test in progress

5 Electrical and Mechanical Installation

This chapter provides information about the electrical and mechanical installation of the DS2020 system.

5.1 Tools and Equipment

This section lists the special tools and equipment needed to install the DS2020 system components. Note that other tools may be needed, for example, to work in the control panel, terminate cables, mount safety and/or mechanical components at the machine, etc.

5.1.1 Tools

Have the following tools available for the installation of the DS2020 system:

- Screwdriver, M2 (inserting connectors)
- Screwdriver, M3 (mounting screws and connectors on the front panel)
- Screwdriver, M4 (mounting power connectors)
- Box wrench, Ø8
- Box wrench, Ø10

5.1.2 Electronic Equipment

Have the following electronic equipment available:

- Digital multimeter (measurement/verification of voltage, amperage, continuity, etc.)

There is no need for any other specialized electronic equipment.

5.2 Mechanical Installation

This section provides information about the mechanical installation of the DS2020 system.

5.2.1 Assembly of System Components

> ⓘ The DS2020 drives have been designed and built for vertical installation. They require a free space of at least 100 mm above and below to ensure sufficient air circulation.

5.2.1.1 Drive Installation

Standard vertical mounting.

Mounting fasteners: 2 or 4 (depending on drive size) M5 socket head screws.

For horizontal mounting applications, contact Applications Engineering for verification.

5.2.1.2 Power Line Filter Installation

For the installation of the power line EMC filter, follow the same requirements described in the previous section for the installation of the drive.

5.2.1.3 Braking Resistor Positioning

⚠ WARNING
⚡ WARNING: Electrical hazard. **High voltage may be present, which can result in death or serious injury to personnel, or damage to equipment.** ➢ The external resistor must be properly guarded to prevent accidental contact.

The DS2020 L50 and L75 sizes are equipped with internal braking resistors (or recovery resistors); the L85, L125, L165 and L355 sizes have external braking resistors. If the application requires it, external braking resistors are available for all sizes; they must be placed at the top of the electrical panel and mounted to a heat sink to facilitate the dissipation of the generated heat.

The following figure shows an example of an external braking resistor.

Figure 13: External Braking Resistor (with brackets)

5.3 Electrical Installation and Thermal Rating

This section provides information on the electrical installation and thermal rating of the DS2020 system.

5.3.1 Safety and General Instructions

⚠ WARNING
WARNING: Electrical hazard.
The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.
➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

⚠ WARNING
WARNING: Mechanical hazard.
The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.
➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

5.3.2 Electrical Installation

Control power input
+24 VDC

Three-phase AC
power supply

Contactor

Fuse protection
'Thermal' 0

EMC grid
filter
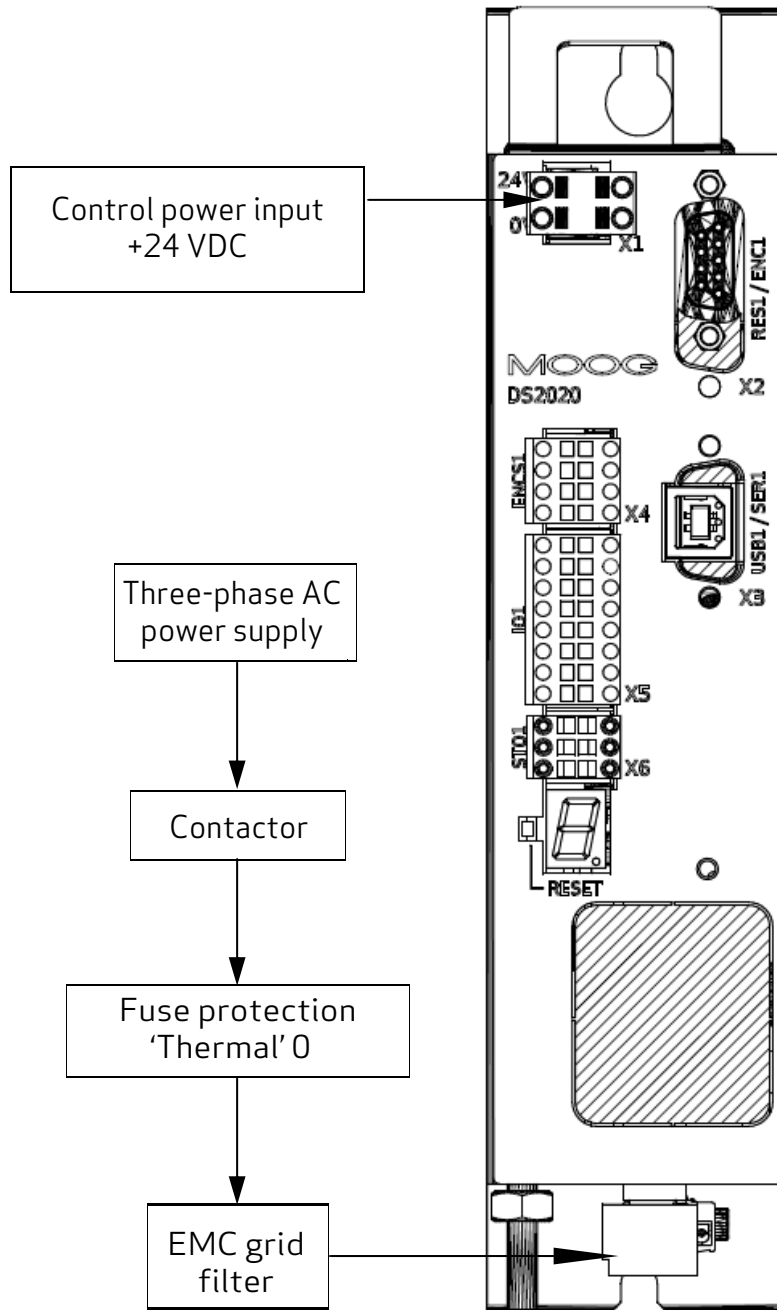
Figure 14: Structure of the Electrical Panel with the Components of a Servo System

Particular attention should be given to grounding, shielding and the use of the filter to reduce or suppress particularly steep voltage surges (derived by PWM modulation), which are capable of generating significant unwanted currents through capacitive couplings and grounded systems. These voltage surges can also generate high-frequency radiation mainly through the motor cable. Filters can be installed to reduce conducted disturbances; see Power Line Filters on page 50 for the recommended models.

Regarding the grounding in the panels, there are typically two types of problems:

- EMC Ground (high frequency) using unpainted areas of the metal panel, where the drives and the filters are positioned, to create an adequate electrical contact for the mitigation of high frequency noise.

- Safety Ground (PE = protective earth) according to standard EN 60204-1, to be performed with a minimum wire cross section of 10 mm^2.

Regarding the shielding, all power and control cables must be shielded except those from the mains to the EMC filter, as its separate shielding is connected to the body of the electrical panel and consequently does not require further protection.

Generally, the shield must be connected at each end. In some cases, however, the control cable shield can only be connected at one end to clear the noise that might interfere with the control signal.

Requirements for laying the connecting cables:

- Avoid crossing power cables with signal cables

- Use a shielding cover that is greater than 70%

- Avoid laying the power and signal cables side by side with each other, especially near the line filter — always maintain physical separation

- Avoid the formation of "loops" in the cables, keep the wiring as short as possible and close the common potential correctly

- Keep the power cables of the input power separate from those of the motor

- If the motor is equipped with a brake, keep the 24 V brake cables separated from the signal (feedback) cables
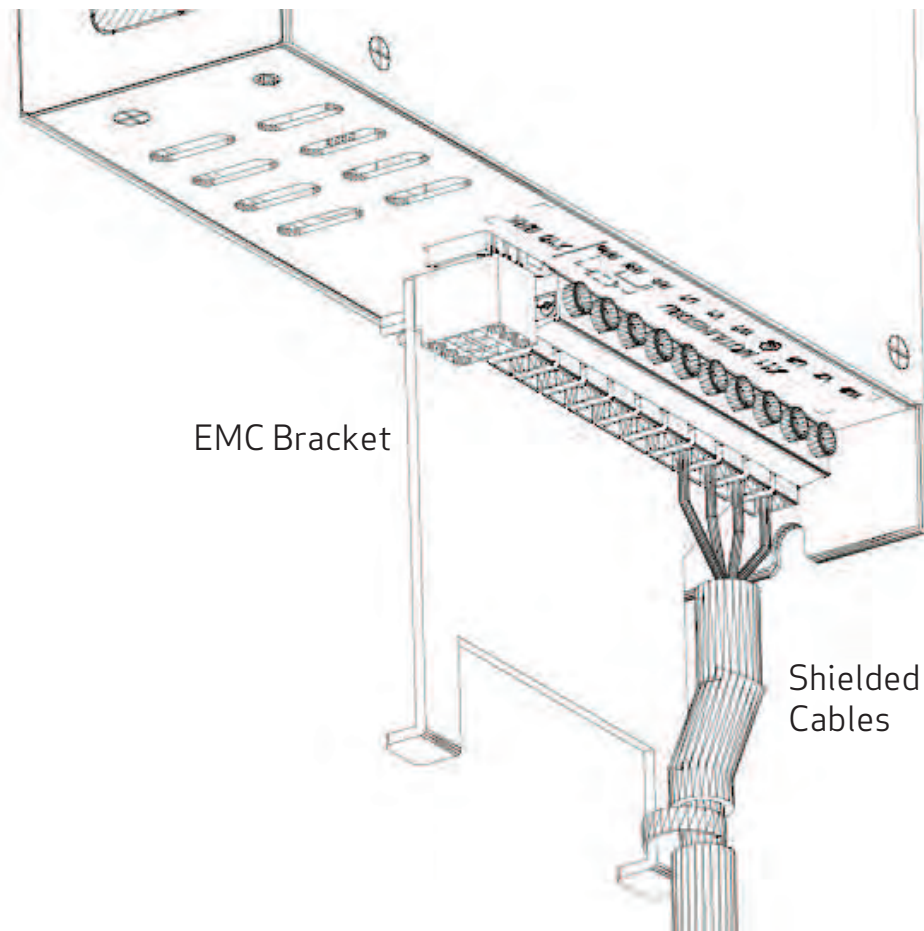
Figure 15: Connection Cables EMC Bracket on size 50 mm

5.3.3 Thermal Rating of the Electrical Panel

For a thermal rating of the electrical panel, refer to the following table. The first column indicates the value of the maximum power that can be dissipated from the radiator, The second column indicates the value of the power dissipated by the DS2020 system under nominal operating conditions. The value of maximum power that can be dissipated from the radiator is useful to estimate the power dissipated on the internal braking resistors.

In the application, if the dissipated power (W) values in the loop are higher than the values indicated in the following table, contact Applications Engineering.

5.3.3.1 Drive Axis Power Dissipation and PWM Frequency

Type	Rated size [Amps]	Dissipated power (W) for the DS2020 system	PWM frequency
L50	2	21	8 KHz
	4	42	
L75	6	63	
	8	82	
	12	122	
L85	16	195	
	24	293	
L125	32	400	
	48	567	
L165	64	900	4 KHz
L355	144	1800	8 KHz
L355	192	2300	

5.3.3.2 Thermal Dissipation of Accessories

Device	Dissipated power (W)
AC power supply filter	From 9 to 30
External braking resistor	From 100 to 370

ⓘ	If possible (i.e., permitted by the safety regulations and Risk Assessment), mount the braking resistors outside the control cabinet, suitably protected against accidental contact, to avoid having to remove the heat generated by them from the electrical panel.

5.3.4 Control Power Requirements

The control power supply must provide 24 VDC with a tolerance of +/- 10%, and "ripple" of less than 200 mV. The current consumption will depend on number and type of DS2020 drives in the system.

The maximum required current will be the sum of the currents required by all components. Refer to the following table.

DS2020	Rated Current consumption (Arms)
Size L50	1.0
Size L75	1.0
Size L85	1.2
Size L125	1.5
Size L165	2.5
Size L355	3.3
Motor brake	2.0

NOTICE
If a dedicated power supply for the motor brake is not used, the current requirements for the control power supply must be correctly calculated. Additionally, its tolerances must comply with those required by the motor brake.

5.3.5 AC Mains Power/Ground Connection

⚠ WARNING
⚡ WARNING: Electrical hazard. High voltage may be present, which can result in death or serious injury to personnel, or damage to equipment.   ➢ Follow these safety instructions.

- It is necessary to properly ground the DS2020 system to avoid risk of injury or death to personnel.

- In the case of AC power supply circuits that are ungrounded or asymmetrically grounded, you must insert an isolation transformer.

5.3.5.1 Types of Earthing (Grounding) Systems

TN-C system

The TN-C earthing system, shown in the following figure, is common to many industrial facilities and has the following characteristics:

a. Direct connection to ground (ground point)

b. The neutral and grounding of the whole system are wired in a single connector, i.e., the PEN

c. Connection to ground of all parts exposed to contact and all shields
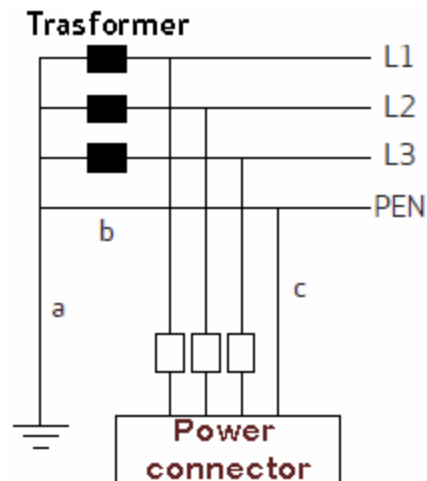
TN-S system

The TN-S earthing system, shown in the following figure, is the most widespread in Europe and has the following characteristics:

a. Direct connection to ground (ground point)

b. NA

c. Connection to the ground of all parts exposed to contact and all shields
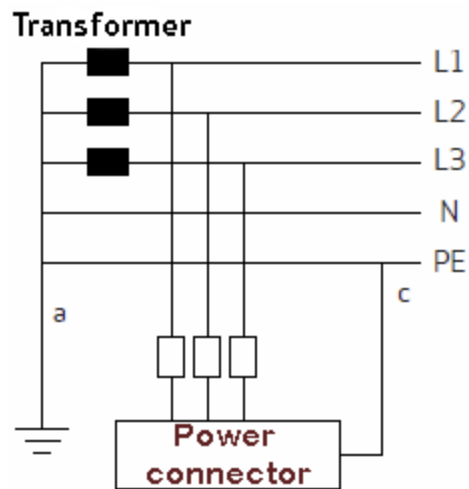
TT system

The TT earthing system, shown in the following figure, is NOT widespread and presents problems for the EMC requirements, which can only be fully met with precautions and measurements in the field. The following are the main features:

a. Direct connection to ground (ground point)

b. NA

c. Connection to the ground of all parts exposed to contact and all shields
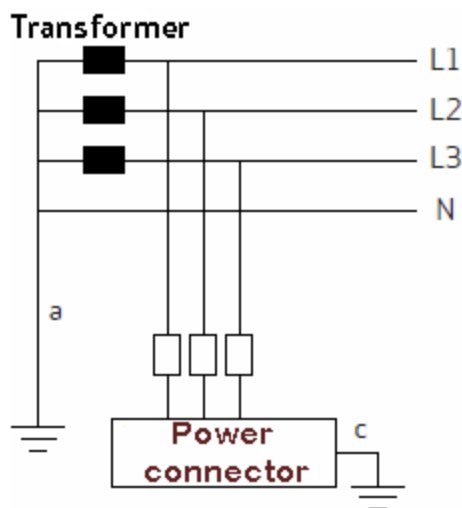
5.3.5.2 Protection Components

Fuses

It is recommended to implement protection against short circuit in the final application using external semiconductor type fuses, 660 VAC, 200 kA M.A.H., or other with the same characteristics.

The sizing of the mains fuses can be achieved using the next size larger than the single DS2020 system current.

To use a single protection with three fuses on the input line to a system consisting of several DS2020 systems, the size required will be the one that is the next size larger than the sum of the currents of the individual systems.

Example: in a system consisting of three DS2020 systems (one L50 4A, one L75 6A and one L75 12A), select a fuse sized immediately above: 4 + 6 + 12A = 22A, which results in a 25A fuse. That size is needed in case multiple axes are used simultaneously.

Safety switches for fault currents

According to the EN 60204-1 standard for electrical equipment of machinery, a safety switch for fault currents can be used provided it meets all applicable regulations and provisions. To protect against direct accidental contact, a fault currents (leakage) safety switch with 30 mA sensitivity needs to be installed on each power supply system/modules-axis.

5.3.5.3 Ground Connection

In the electrical panels, there are normally two types of grounds:

- EMC Ground (high frequency) using unpainted areas of the metal panel, where the drives and the filters are positioned, to create an adequate electrical contact for the mitigation of high frequency noise.

- Safety Ground (PE = protective earth) according to standard EN 60204-1, to be performed with a minimum wire cross section of 10 mm^2.

The length of the individual cables that connect to the ground should be minimal, so it is advisable to place a grounding bar as close as possible to the drives.

5.3.5.4 Ground Stud

The DS2020 drive (L50 - L75 - L85 - L125 - L165) provides a ground stud (M5) at the bottom of the chassis.
The DS2020 drive (size L355) provides a ground connector at the bottom and top of the chassis
Refer to the following figure.

Ground stud (M5)

Bottom view of DS2020 drive
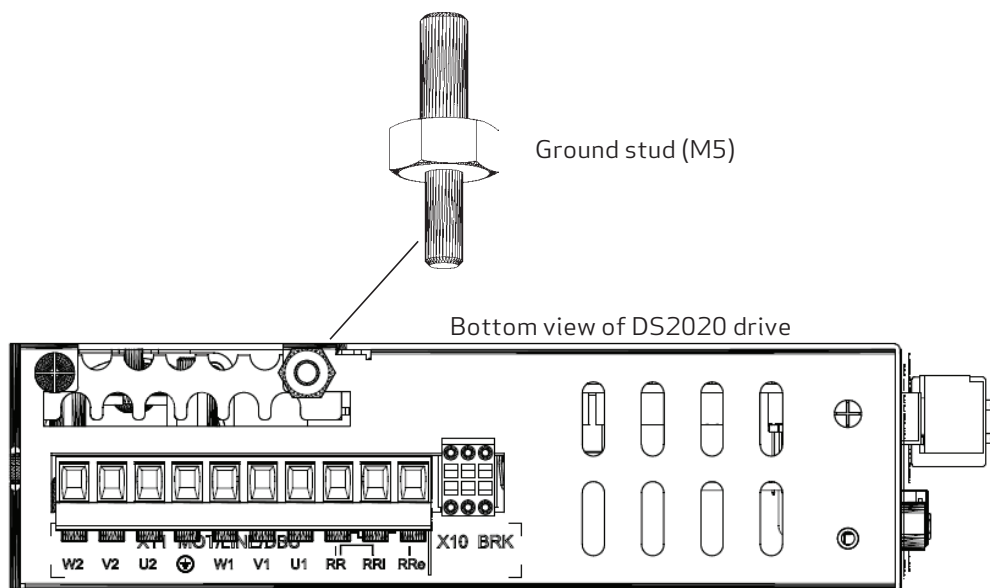
Figure 16: Location of the Ground Stud (M5)

- *Location of the Ground Connector size L355*

Top view (connector layout for sizes L355)

Botton view (connector layout for sizes L355)
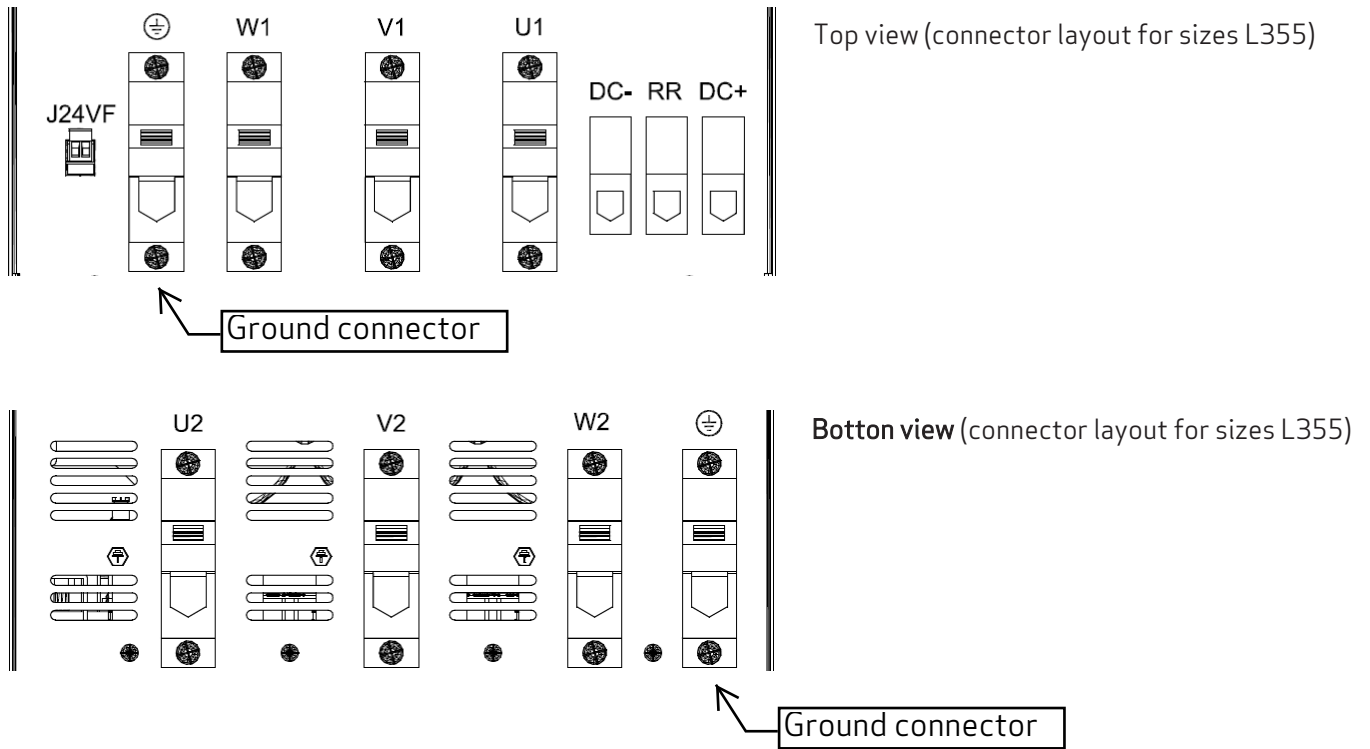
Figure 17: Location of the Ground Connector size L355

5.3.6 Drive Wiring

The steps for wiring the DS2020 drive are as follows:

1. Ground the drive mounting plate, the motor housing of the motor and the control unit ground.

2. Separately lay the power and the control signal cables.

3. Connect the control power on X1, see Control Power Connection on page 75.

4. Connect the transducer (feedback device) on X2, see Transducer Connection on page 81.

5. Connect the I/O signals on X4 and X5, see I/O Signal Connection on page 79.

6. Connect the communication interface: X3 for USB or RS-422; on X4 if RS-232, CANopen on X7 if, on X8, X9 if EtherCAT, see Electrical Installation and Thermal Rating on page 66.

7. Connect the "power" supply lines on X11, see Power Cord Connection on page 74.

8. Connect the motor on X11, see Motor Cable Connection Details on page 76,

9. Prepare the connections for the STO on X6, see STO Signals Connection on page 79.

10. If the motor has a brake, connect the motor brake on X10, see Brake Cable Connection on page 76.

11. For L85 or larger drives, or if the application requires it, connect the external braking resistor on X11, or connect a jumper if the internal braking resistor is used (L50/L75 sizes only), see Braking Resistor Connection on page 75.

12. Final check: inspect the accuracy of the wiring from the electrical panel to the drive/motor, to ensure it matches the System Diagram and design schematics for the electrical panel.

5.3.6.1 Grounding

Mount the DS2020 drive to the control cabinet's metal structure, ensuring that the contact surface is adequate and that the connection has low resistance and inductance. Do not mount the DS2020 drive on painted or insulated surfaces.

A ground stud (M5 is located on the bottom of the DS2020 housing for connection to the earthing system. For grounding details, see AC Mains Power/Ground Connection on page 71.

5.3.6.2 Power Cord Connection

For selection information, see Cables on page 54.
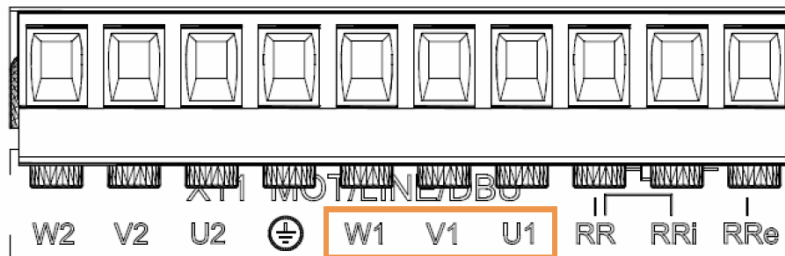
Figure 18: Connector X11 – [W1-V1-U1] sizes L50 and L75
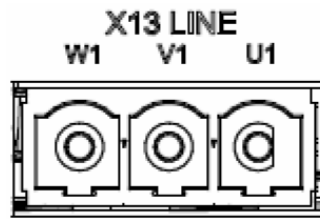
Figure 16: Connector X13 – [W1-V1-U1] sizes L85 L125 L165

Top view (connector layout for sizes L355)
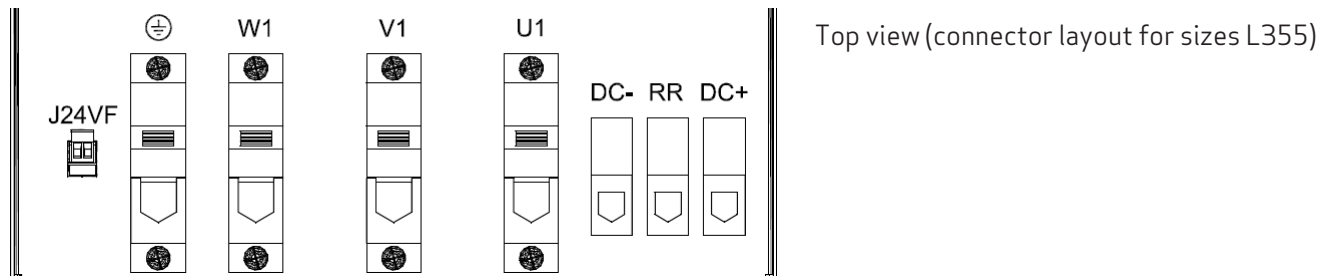
Figure 19: Connector – [W1-V1-U1] sizes L355

5.3.6.3 Braking Resistor Connection

The following figures show the braking resistor connection points.
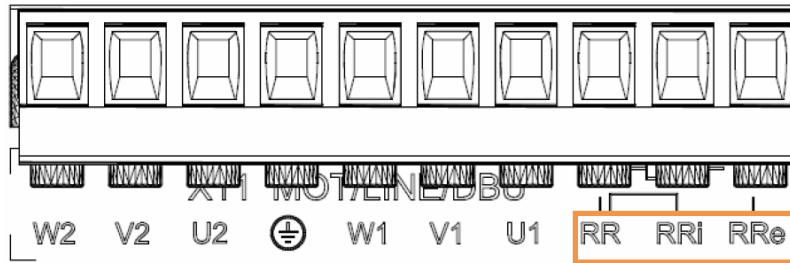
Figure 20: Connector X11 – [RRe – RRi - RR] size L50 and L75
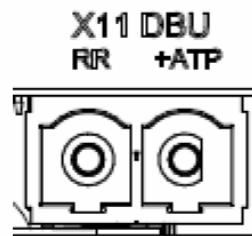
Figure 21: Connector X11 – [RRe-RRi-RR] sizes L85 L125 L165
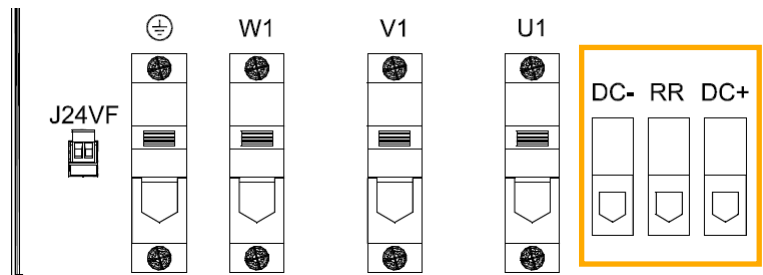
Figure 22: Connector [DC- RR DC+] sizes L355

For L50/L75 only, to use the internal resistor, insert a bridge between RRi, RR
For L50/L75 only, to use an external resistor, connect it between RRe and RR
For L85/L125/L165 only, the external resistor must be connected between RR and +ATP
For L355 only, the external resistor must be connected between RR and DC+

The cable must be shielded. The connection of the shield to ground can be closed with a conductive strap, which is used to connect the cable to the metal bracket under the drive.

For the preper resistance selection, see Braking Resistor on page 52

5.3.6.4 Control Power Connection

A control power of 24 VDC, must be externally provided to the +24 V and 0 V terminals on the X1 connector. For details, see Control Power Requirements on page 76.

5.3.6.5 Signal Connection

For connection of the control signals, transducer interface, linear communication, see Connectors on page 39.

5.3.6.6 Motor Cable Connection Details

The following figures show the motor cable connection points. For the motor cable specifications, see Cables on page 54.
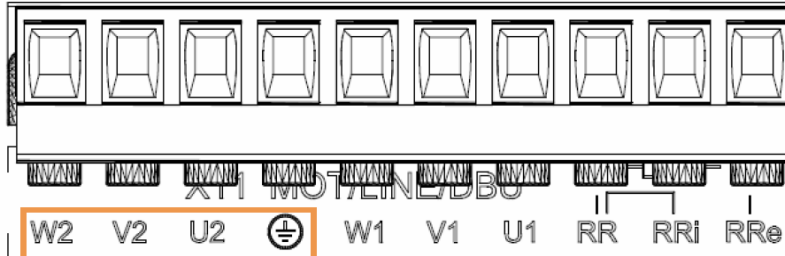
Figure 23: Connector X11 – [W2-V2-U2-] Sizes L50 and L75
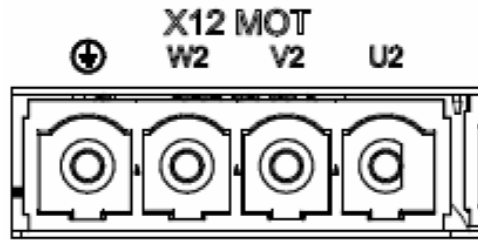
Figure 24: Connector X12– [W2-V2-U2-] Sizes L85 and L125
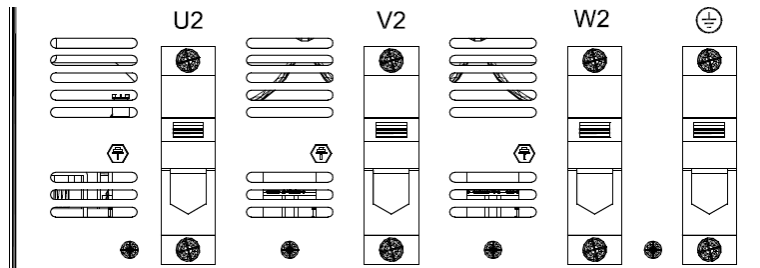
Figure 25: Connector [W2-V2-U2-] Sizes L355

ℹ	For motor power cables with capacity greater than 150 pF/m the leakage currents could cause false alarms, which can be overcome with an inductor in series to the power cable placed as close as possible to the drive.
ℹ	For cables longer than 50 meters and for the eventual sizing of the inductor, contact Applications Engineering.

5.3.6.7 Brake Cable Connection

This connection is required only when the motor is equipped with a brake.

> When specifying the brake connections, see the following figure, Take into account the possible voltage drop for any cable runs over 10 m long and select the proper cables to avoid that.
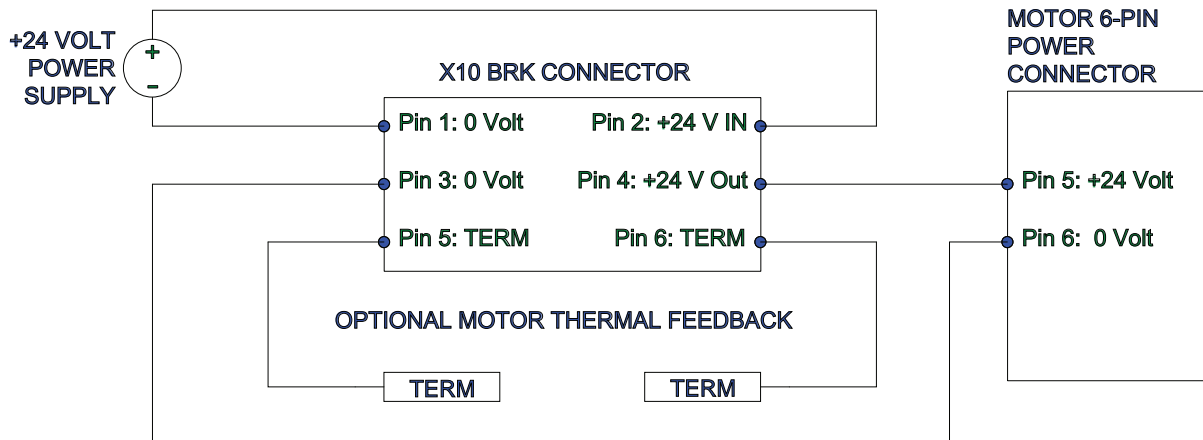
- Power must be supplied externally (pin 2 on the 24 Volt connection, while on pin 1, the return to 0 volts).

- Overload protection is provided with a fuse of 2 A maximum, delayed, to protect both the internal devices and the power supply; it is installed externally on the 24 Volt line if not protected in any other way.

- Internal devices are protected from short circuit between the terminals (3 and 4) and to ground. The drive detects the correct execution of the command; a possible short-circuit condition is indicated as the absence of output on terminal 4.

- An optional thermal sensor for motor protection can be connected; the inputs have the same characteristics as those on the X2 feedback position connector. For more detaisl, see Motor Thermal Sensor Inputs on page 40.

The following figure shows functional and timing relationships between the enabling signal, activation and speed command. The timing of the motor brake varies depending on the specific data of the motor itself. The external control of the brake activation must get to the drive when the motor speed is close to or equal to 0. The delay introduced by the drive between reception of the command and its transmission to the brake is less than 125 µs. The brake activation delay depends on the type of brake and is specified for each motor.

Motor speed

Stopped motor

Brake tension command

A

Brake activation

A: Deceleration time of the machine (variable)
B: Brake activation (300 ms)

B
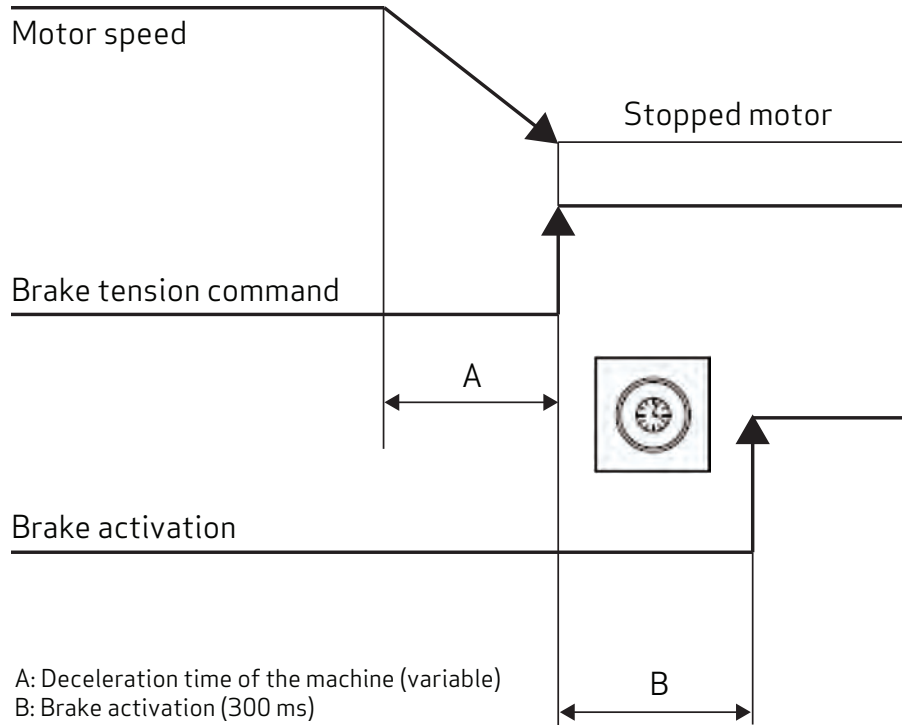
Figure 26: Brake Activation Timing Diagram

The same considerations relating to the motor cable also applies. Therefore, pay special attention to the use of shielding, even if the conductors are not already incorporated in the motor cable.

⚠ WARNING

WARNING: Mechanical hazard.
Relying on the motor brake alone does not guarantee the safety of personnel or equipment, and may result in death or serious injury to personnel or damage to equipment.

➢ It is the responsibility of the machine manufacturer to specify an appropriate braking mechanism for the application to ensure safe operation.
➢ In particular, vertical loads require an additional mechanical brake to operate in a certifiably safe manner.

The brake cannot be autonomously monitored if there is an insufficient voltage level. Consequently, it is necessary to measure the voltage on the input of the brake, and always verify the functionality when releasing and braking. In particular, examine connections with long cables or cables with reduced cross section, which are subject to significant voltage drops.

5.3.6.8 I/O Signal Connection

All I/Os on the X5 connector are isolated from the rest of the system. Digital I/Os are referenced to 0 V Digital (pin 8 of the X5 connector).

Notes for the digital inputs and outputs on the X5 connector:

- Digital IN1 and Digital IN2 can be used to connect positive and negative limit switches (see Example I/O Connections on X5 on page 155); their functions are enabled by the EILP and EILN commands. These inputs are referred to 0 V Digital (pin 8 of X5). For details on the EILP and EILN commands, see the *SmartMotor™ Developer's Guide*.

- Digital OUT1 (pin 9 of X5) is driven by OUT(5)=x command. It is referred to 0V Digital (pin 8 of X5) and needs to be supplied with 24 VDC on +24 Volt IN (pin 7 of X5).

Notes for the digital inputs on the X4 connector:

- Inputs A+ and A- on pins 2 and 3 of the X4 connector are used as a differential input for drive enable when configured with EISM(0). For details on the EISM command, see the *SmartMotor™ Developer's Guide*. For a sample RS-485 driver using the X4 connector, see Example RS-485 Driver on X4 on page 156.

5.3.6.9 STO Signals Connection

The X6 connector is used to connect the STO signals. Refer to the following figure.

```
          X6
+24 Volt CH 1 ——— 1      2 ——— 0 Volt CH 1
+24 Volt CH 2 ——— 3      4 ——— 0 Volt CH 2
   Feedback   ——— 5      6 ——— Feedback
          STO
```
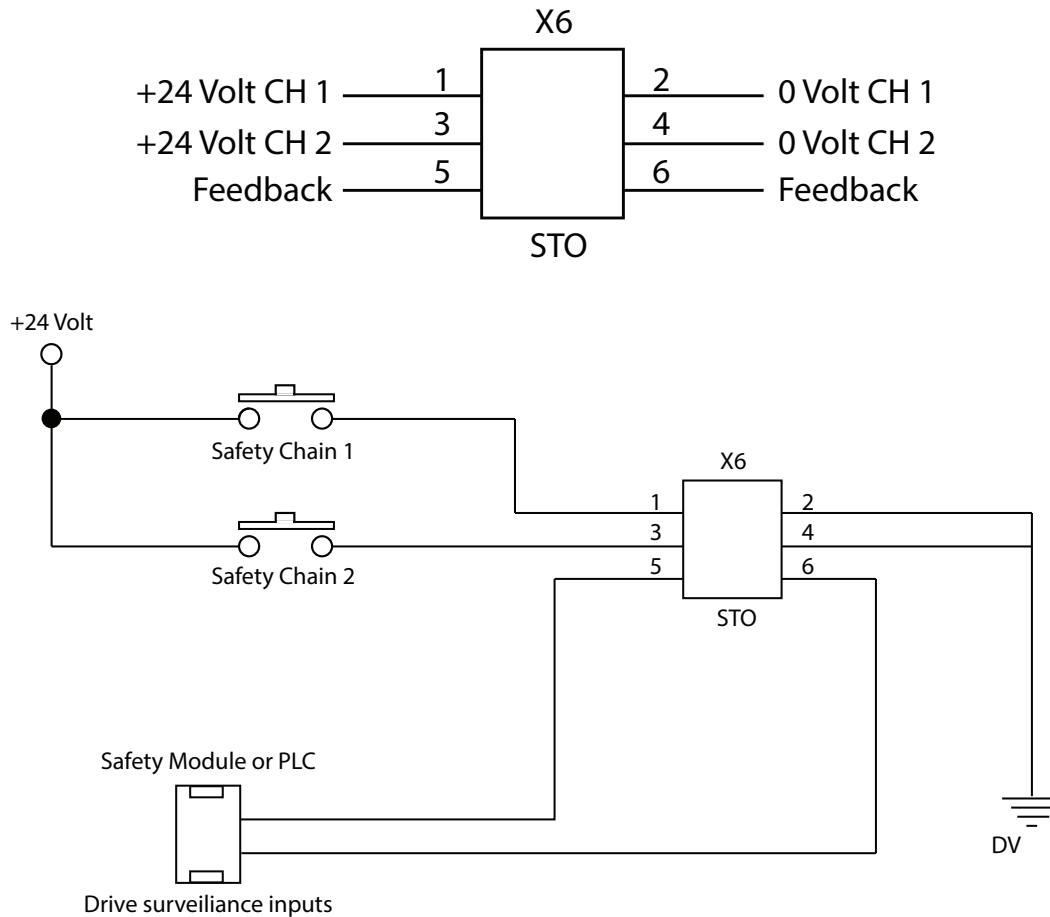

Figure 27: Detail of the Feedback Contact Circuit

By inserting the two commands in series to the circuit of the STO "safeties", the axis enable is controlled only when the master (e.g., PLC) controls both the S1 and S2 signals, and all the safeties of the machine are simultaneously closed.

⚠ **CAUTION**

CAUTION: Mechanical hazard.
Note that the opening of a "safety" contact may cause an axis to drop uncontrollably. which could cause damage to equipment.

➢ In situations where this behavior is not compatible with the machine movements (for example with interpolated axes or ones that interfere mechanically), it is recommended to use appropriate delayed safety contacts to release the axis only after full stopping of the movement in a position that will not cause any damage to the machine.

The dual channel consists of two separate, independent circuits; each control line is independent but acts on devices connected in series with each other. Both commands must be properly provided to enable motor movements.

- The absorption on the two inputs, S1 and S2, is less than 50 mA at 24 volts.

- As feedback of the two commands is given, the drive closes an electrical contact to the controller to verify the accuracy and consistency of the supplied commands, and then controls the movements with a proper sequence.

- The delay between the application of the command (S1 or S2) and the feedback, executed command signaling, is less than 50 ms. The delay between the removal of the command and its feedback signal is less than 20 ms.

- Always wait at least 50 ms before moving the axes after applying the controls, and wait 20 ms before detecting that the drive is in a "safe condition".

The STO function is certified according to SIL 3 (EN 62061) and PL e (ISO 13849-1:2016) and allows a simplification of the machine's safeties wiring.

⚠ WARNING
WARNING: Electrical hazard. **High voltage may be present, which can result in death or serious injury to personnel, or damage to equipment.** ➢ If the connection cables of the STO function are located beyond the area of the machine installation, the cables must be installed in a "fixed" manner and protected (for example through a raceway).

5.3.6.10 Transducer Connection

The DS2020 system is able to handle most common motor position transducers, as shown in the following list.

• Resolver (standard)

• Encoder Incremental TTL single ended and differential

• Encoder, Stegmann Sinusoidal Absolute Single/Multi-Turn with Hiperface communication

• Encoder, Heidenhain Sinusoidal Absolute Single/Multi-Turn with ENDAT communication

• BISS Absolute Encoder

• Sensorless mode (test purpose only)

The X2 connector is used for the transducer connection. For the connector layout and pin descriptions, see Connector Layout on page 39.

The cable for the incremental encoder must be at least 6 twisted pairs, possibly individually shielded, for incremental signals A, B, C and Hall signals U, V, W.

ⓘ	For long connection cables over 50 m, please contact Applications Engineering.

5.3.6.11 Connecting the Fieldbus - X8, X9, X10 Connectors

> **ⓘ** Depending on the type of fieldbus, you must install a different firmware. If the connection is via EtherCAT the file will have the suffix _ecat; if it is via CAN bus, the file will have the suffix _can.

- EtherCAT

  The X8 (X9) connector is used for the Ethernet interface. The installed software handles the communication with the network EtherCAT. For details on the connector, see Connector Layout on page 39.

- CAN bus

  The X7 connector is used for the CAN interface. For details on the connector, see Connector Layout on page 39.

  For the connection, the CAN bus must be terminated at BOTH ends of the bus, each termination requires a 120 ohm resistor.

- Note that the usable cable length for ensuring secure communications decreases with increasing transmission speed. Refer to the following table for details. FOR CABLE LENGTHS GREATER THAN 100 METERS, contact Applications Engineering for assistance.

Transmission speed (kBaud)	Max cable length (m)
1000	10
500	60
250	100

6 Commissioning with Dx2020 Software

The commissioning of the system is performed through the operator Dx2020 GUI. For a detailed description of the menus and procedures, please refer to the Dx2020 GUI online help in the GUI.

6.1 Safety

⚠ WARNING
WARNING: Electrical hazard. High voltage may be present, which can result in death or serious injury to personnel, or damage to equipment. ➢ Follow these safety instructions.

⚠ WARNING
WARNING: Mechanical hazard. Large motors can generate very high torque and impact or trapping hazards, which can result in death or serious injury to personnel, or damage to equipment. ➢ Follow these safety instructions.

Before attempting to commission the DS2020 system, you must review the Safety and Usage Guidelines on page 18. In addition, be aware that:

- Only qualified, properly trained and certified personnel are authorized to set the parameters of a running drive.

- Changing parameters without prior verification may result in unexpected, unsafe and/or incorrect machine movements.

- Before operating the drive, verify that the settings of all parameters are correct.

6.2 Dx2020 GUI

6.2.1 Overview

A graphic interface software called Dx2020 GUI is associated with each drive. It provides controls for setting and changing the parameters, and configuring the drives.

The main features are:

- System Configuration with access to the basic parameters of the system (sensors, digital and analog I/O, motor parameters, etc.

- Calibration of the loop speed and position to customize and optimize the drive response

- Drive direct control (jog mode, speed profile with internal generator)

- Commissioning

- Diagnostics

- Monitoring of the variables internal to the drive and I/O signals

- Data logging

- Display signals on a digital 4 tracks oscilloscope

- Firmware update

- Drive parameters management (save, restore, etc.)

> At minimum, the installer/programmer should have the Windows operating system "Power User" access rights. This is necessary because of a limitation related to the write access of the file from the Windows operating system.

6.2.2 Minimum PC Requirements

- Pentium® 1 GHz processor or higher

- 512 MB RAM

- 150 MB free hard drive (HD) space

- x86 and x64 supported

- Internet connection for software download and update

- Serial port onboard, PCI adapter or USB to serial converter, Ethernet port, CAN interface (IXXAT)

The GUI uses .NET Framework 4.0 libraries, needing the following:

- x86: 600 MB free HD space

- x64: 1,5 GB free HD space

  Supported OS:

- Windows 8

- Windows 8.1

- Windows 10

	Windows 8 and Windows 8.1, already have pre-installed the .NET Framework 4.5 libraries that are an update of the 4.0 ones.

	You must have administrative rights to install and run the program.

	If the software configuration of the system does not meet the requirements, you can upgrade using the Microsoft Update site through the utility included in the operating system.

6.2.3 Dx2020 GUI Installation

After downloading the installer, start by double clicking it. ,

The installation software may be obtained from Moog Casella.

If the software is installed for the first time on the PC, you are prompted for the desired language. By default, if available, the program will automatically select the operating system language as the first choice. This setting applies to both the Installer and for the application Dx2020 GUI. Available languages are English and Italian.

Note that you can also change the language through the GUI later.

The installer requires the installation of additional components, some are installed automatically, while others require user consent. During installation, you can view the steps performed by the installer, and any installation errors, in a LOG window.
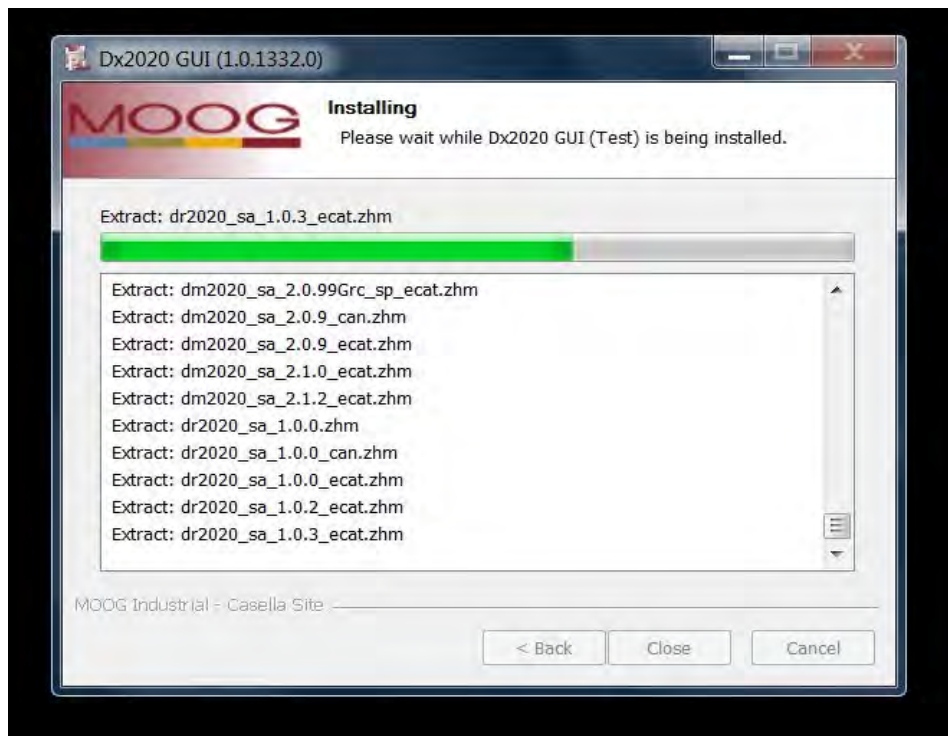
After installation, click Finish to close the installer.

If an error occurs during installation, report the error message to Applications Engineering. Once the program is installed, the Dx2020 GUI icon will be displayed on the desktop.

6.2.4 GUI Drive Connection

Run the executable Dx2020 GUI with the DS2020 system powered up.
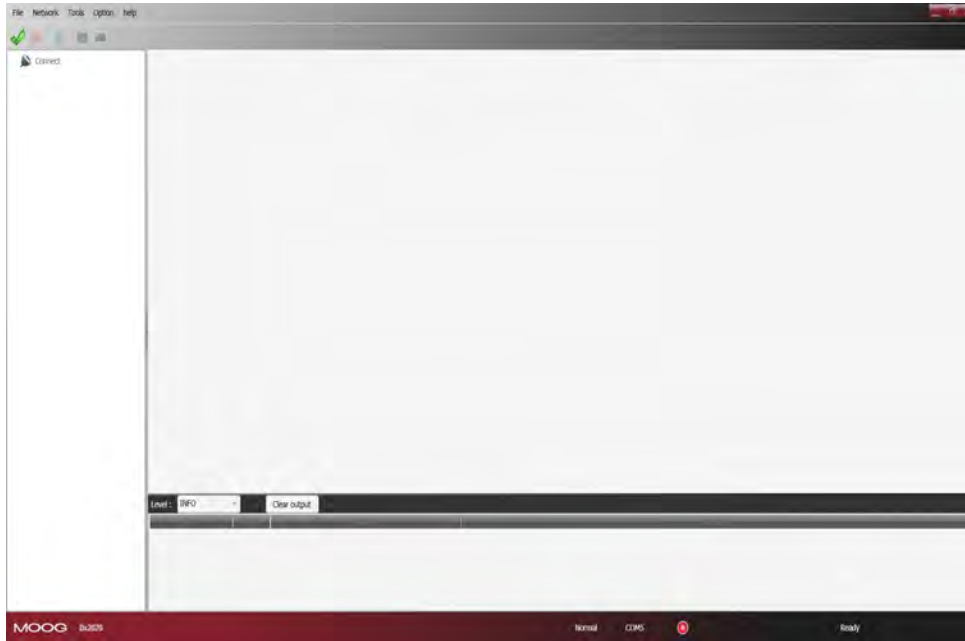
The GUI can connect to the drive through:

- Serial RS-422/RS-232 or USB (connector X3); the GUI automatically detects whether it is used on RS-422 or RS-232.

- EtherCAT* (X9-IN)

- CAN bus* (connector X7-IN)

  *The EtherCAT and CAN bus interfaces are optional.

For details on connectors see Connectors on page 38.

From the Network menu, click Select to choose the communication protocol.
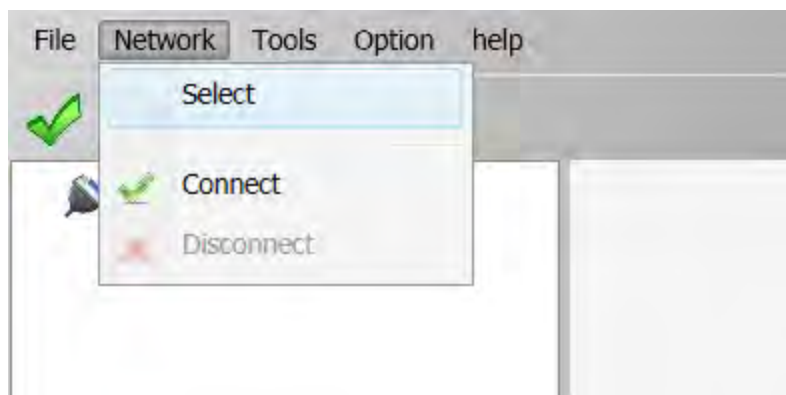
For more details, refer to the Dx2020 GUI online help (see Accessing the Dx2020 GUI online help on page 93).

Select the Connect command from the toolbar or through the drop-down menu Network. The LED in the Statusbar turns green if the connection is successful; otherwise, it is red. Depending on the type of connection:

- **RS422/RS232 or USB:** The GUI connects and loads the parameters automatically
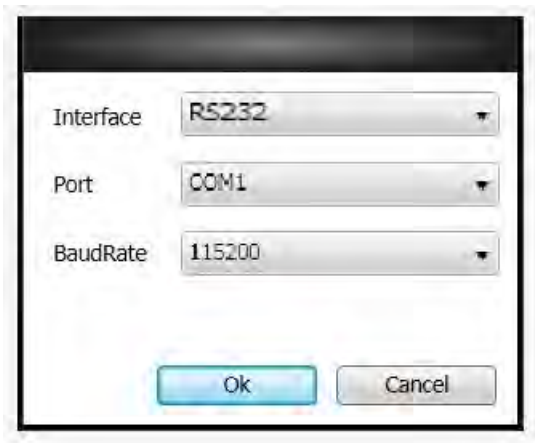
- **EtherCAT:** Click Auto Scan to detect available nodes. Then click OK. The GUI connects and uploads the parameters of all nodes.
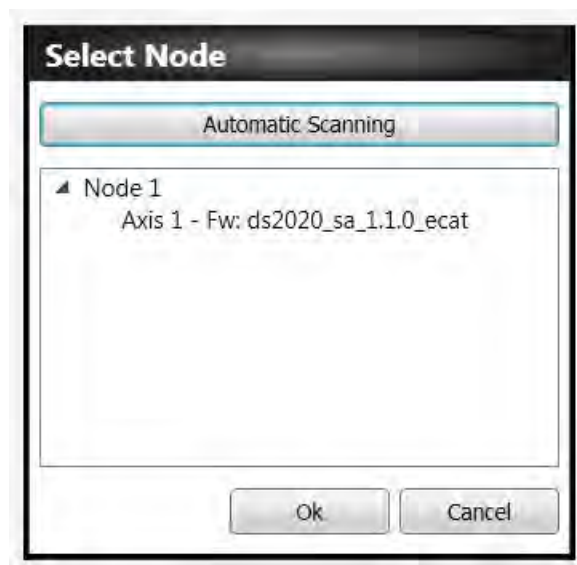
- **CAN Bus:** from the connection selection window, choose the Port and Baud Rate. Then click OK.
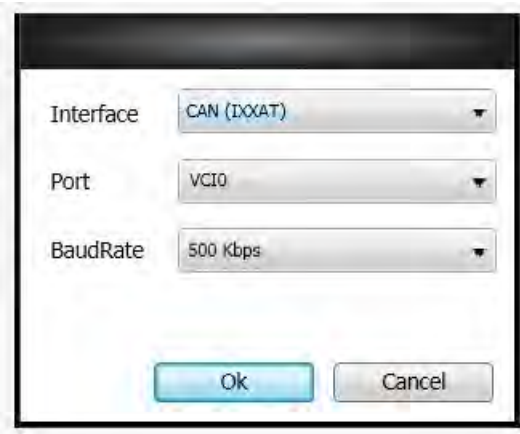
In the Select Node window, confirm the Node and ID values, then click OK

In case of failure during connection, refer to Troubleshooting on page 127 and follow the suggested actions.

6.2.5 Layout

After connecting, the following screen opens:
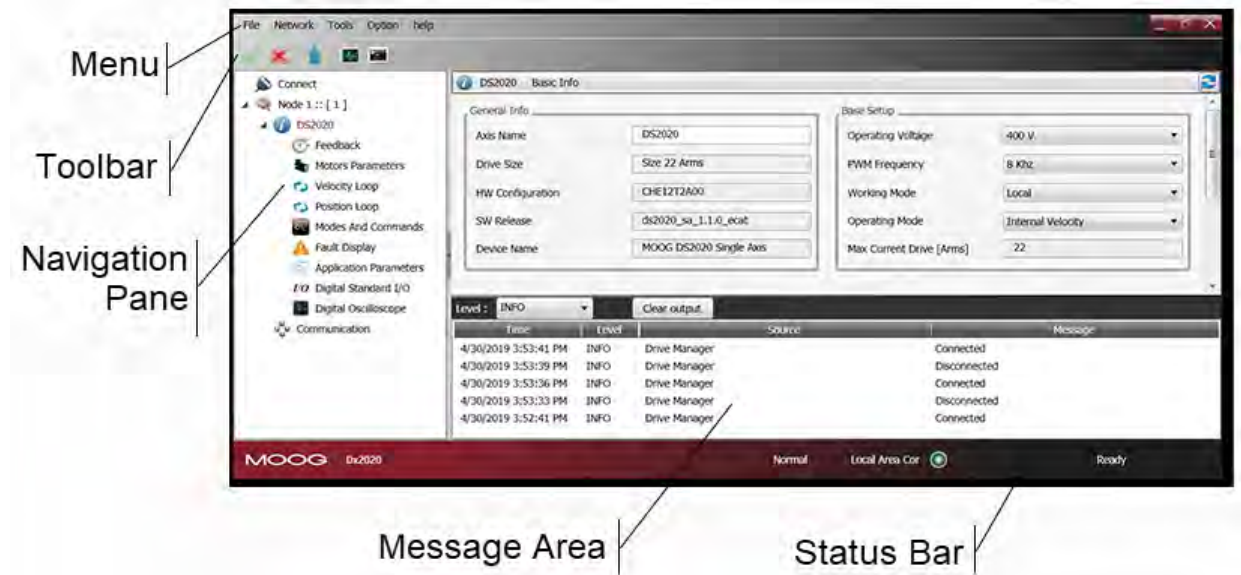
- **Menu:** Contains the following menus: File, Network, Tools, Options, ? For more information, refer to the Dx2020 GUI online help.

- **Toolbar:**
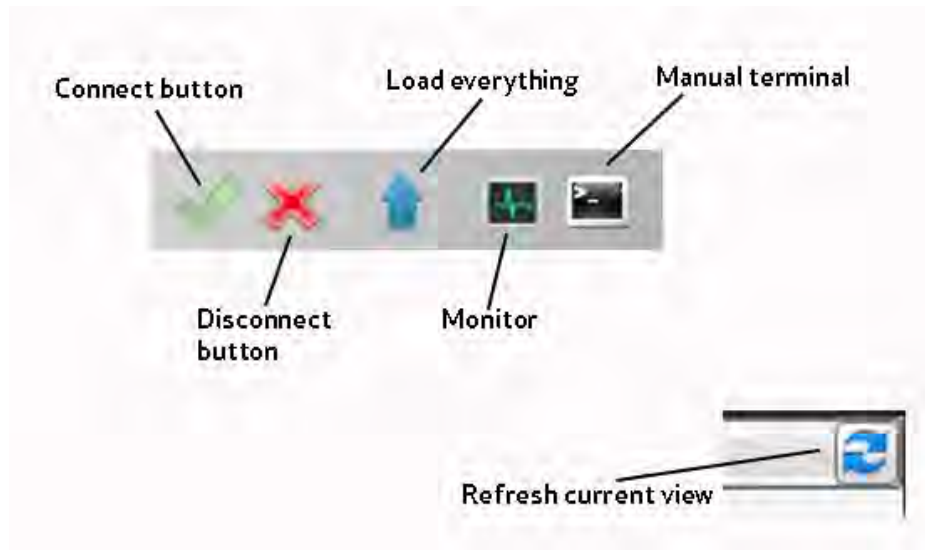
- **Navigation area:** This area provides access to all information organized into views. The axis has a submenu that lists the parameters by function (transducer, motor, speed loop, etc.) Clicking submenus in the main area displays the associated graphic window.

- **Communication parameters:** The last menu item is related to the EtherCAT or CAN communication parameters (one per DS2020 system).

- **Main area:** This area displays the information and the parameters associated with the selected view in the navigation area. This window is used to view and set the DS2020 drive parameters. For more information, refer to the Dx2020 GUI online help.

- **Notification window:** This area is dedicated to display messages that may have different meanings. A filter can be applied to display messages based on the type (ERROR, WARNING, INFO, DEBUG).

ERROR	Messages indicating an error sent by the device or related to the connection (e.g. transmission errors)
WARNING	Messages usually caused by an error when accessing parameters (eg "object not found") and require your attention
INFO	Messages relating to the data exchange between the device and the application and showing the progress of the operations
DEBUG	Messages with program control information

- **Statusbar:** The Status Bar displays information about the state of the application. It indicates which protocol you are using, if connected, and the progress of operations for all views

6.2.6 Firmware Update (BootLoader)

The firmware update can take place through serial RS-422, USB or EtherCAT. The download file extension is *.zhm.

The firmware update occurs through dedicated applications (BootLoader EtherCAT and BootLoader RS232), which simultaneously install with the Dx2020 GUI. The firmware download procedure is only possible if the GUI is disconnected from the drive.

- Access to the procedure from the Tools menu

- Follow the instructions present in the user interface Help

You can access the BootLoader tools from the PC, as a normal program from your Program menu or folder, or directly from the GUI using the Tools menu:
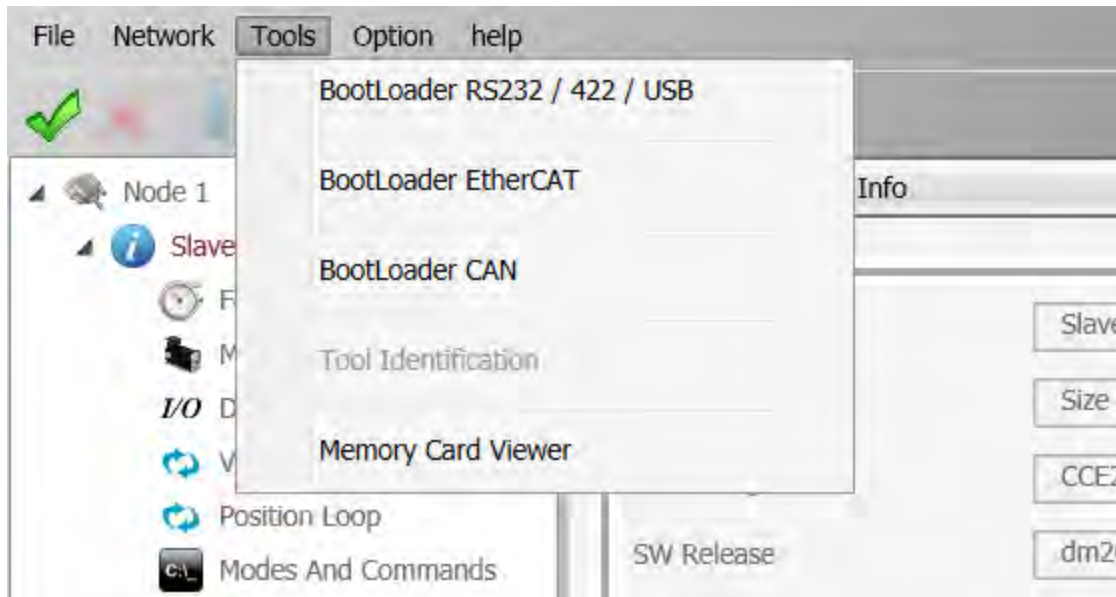
For more information, refer to the Dx2020 GUI online help.

6.2.7 Accessing the Dx2020 GUI online help

The Dx2020 GUI online help can be accessed as follows:

- Use Interface Dx2020 GUI: from the Menu bar, select "?" (Help)
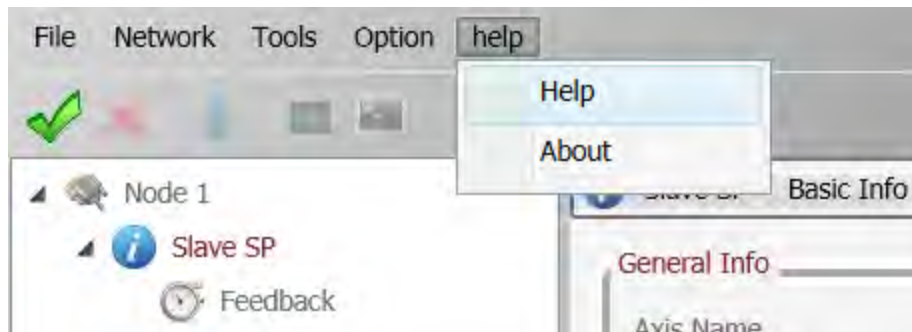
6.3 Activate Power

Activate power to the system (AC power and DC power supplies). For installation information, see Electrical Installation and Thermal Rating on page 66.

Use the monitor function on the GUI to verify the correct value of the DC bus voltage (560 V) (see Layout on page 90).

6.4 System Configuration

The following steps are used for the DS2020 system configuration:

6.4.1 Axis Identification

Follow the instructions in the Dx2020 GUI online help related to the specific modes of communication and identification.

For multiple axis DS2020 systems that are simultaneously connected, there must be a correspondence between the nodes listed in the "Navigation Area" of the GUI and the physically installed DS2020 drives in the application.

6.4.2 Motor Parameter Configuration

The DS2020 drive can be used to control:

- Synchronous motors with permanent magnets (brushless)

- Asynchronous motors with IFOC control

- Asynchronous motors with V/F control

There is a motor database, which can be accessed by clicking View Motors database. The database is editable, allowing addition of more motor models. The file DBMotors.xml is present in the Version installation folder of the GUI.

> If the phasing angle is not known in advance, after entering all other motor parameters, perform the procedure in STO Activation on page 114.

For all three types of motors, Thermal protection can be activated through software. You will need to enter the thermal model parameters.

If the drive is connected while the motor is hot, the thermal image provided by the Dx2020 GUI will return a false estimate. This protection supports but doesn't completely replace the thermal switch in the motor.

In the case of permanent magnet synchronous motor, you can activate the Field Weakening algorithm, refer to the following information.

Field Weakening Algorithm

This algorithm is available as a "torque increase function" at high speed, allowing increased torque available above the nominal speed. Obviously, this takes place at the expense of a greater output current and, consequently, lower yield of the system.

To enable this feature click the "Enable weakening" field. By enabling the "weakening", you can automatically take advantage of this feature without having to set any parameters. It will prompt you to select the type of algorithm to use depending on the type of application required; contact Applications Engineering for assistance.

If controlling an asynchronous motor with IFOC algorithm, the correct Id current and Sg scrolling values may be required by Applications Engineering, in order to provide the electrical motor parameters to control.

It is possible to configure the brake through the Brake Motor view. For more information on brake configuration, refer to the Dx2020 GUI online help, selecting Dx2020 GUI > Views > Configuration Parameters Motor.

1. From the Navigation Area, select "Feedback": choose the tab "Feedback Sources".

2. Set the timing. Use a current value at or below the rated motor current in order to prevent warm up of the motor, in case the procedure must be repeated. Later, this value can be increased if applied to the motor load (Field current timing).

3. Set Time of Phasing according to the application requirements (set to the maximum allowed value of 4 seconds).

4. Click "Start Phasing": it shows the progress indicator (green if everything OK, red if there are alarms). By selecting the tab "1st STD interface", "2nd STD interface" or "Interface Option", you can acquire the phasing value before and after the operation in order to check the angular change that occurred during the process (angle Theta).
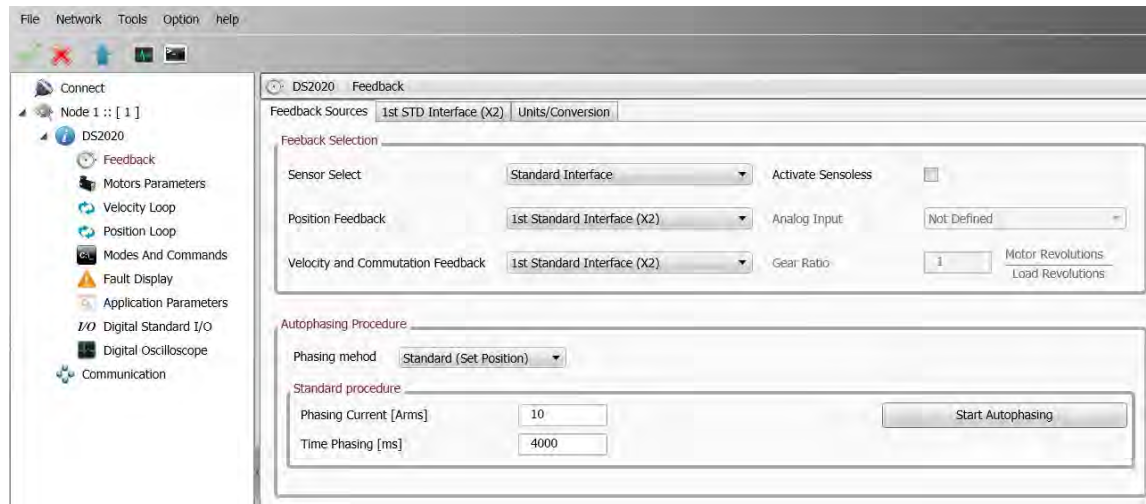
6.4.3 Transducer Configuration

The DS2020 can handle various types of feedback transducers to close the control loops.

• Resolver (standard)

• Encoder Incremental TTL single and differential

• Encoder, Stegmann Sinusoidal Absolute Single/Multi-Turn with Hiperface communication

• Encoder, Heidenhain Sinusoidal Absolute Single/Multi-Turn with ENDAT communication

• BISS Absolute Encoder

• Sensorless mode (test mode only)

To configure it, follow the instructions in the Dx2020 GUI online help, select Dx2020 GUI > Configuration views > Feedback.

> It is necessary for some encoders to enter the angle of timing. If this is not known, perform the STO Activation on page 114.

6.4.3.1 Sensorless

The DS2020 provides a sensorless mode, i.e., without a speed transducer.

To enable it,

1. Select Feedback from the Navigation Area.

2. In Tab Sources feedback, set the fields as indicated in the following figure.
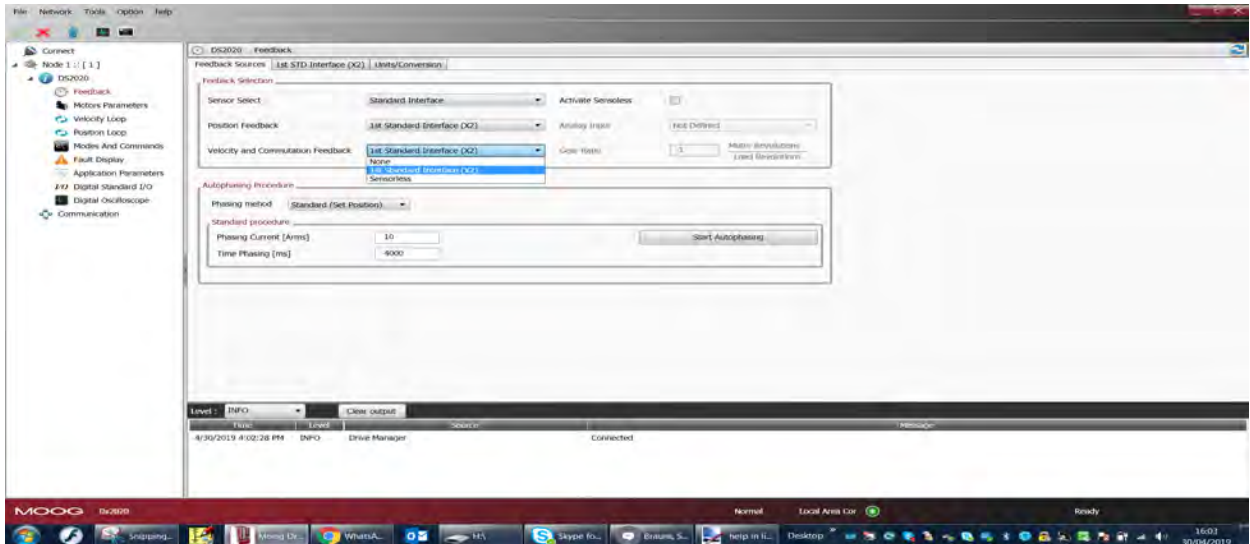
3. In Tab 1 Interface STD (X3), set the fields as indicated in the following figure.
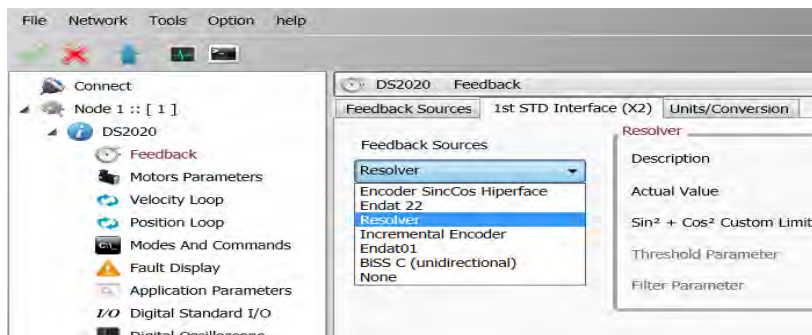
4. Finally, set the fault interface X3 - Missing Transducer Configuration to "No" as shown in the following figure.
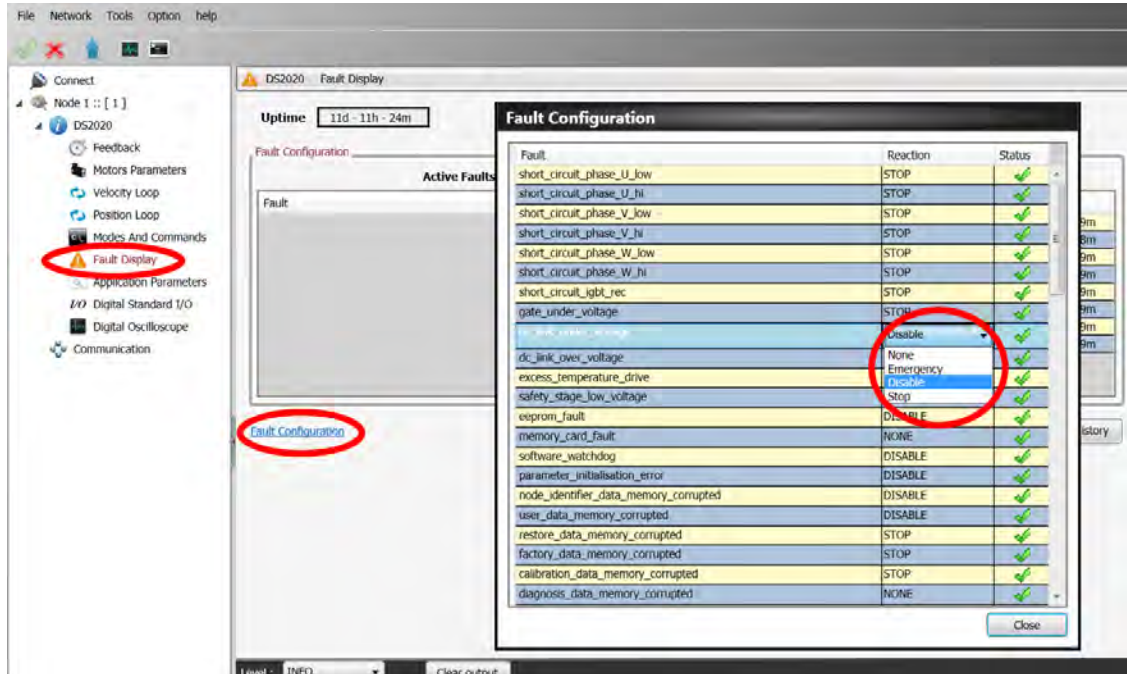
6.4.4 I/O Configuration

Through the interface, you can set the various configurations for the X4 and X5 connectors.

Programming analog and digital I/O connector X4:

	Configuration							
Channels	0	1	2	3	4	5	6	7
1	+24 Volt output							
2	INP A +	OUT A +	A +	SYNC 0 +	INP A +	OUT A +	INP A +	OUT A +
3	INP A -	OUT A -	A -	SYNC 0 -	INP A -	OUT A -	INP A -	OUT A -
4	INP B +	INP B +	B +	SYNC 1 +	INP B +	OUT B +	OUT B +	INP B +
5	INP B -	INP B -	B -	SYNC 1 -	INP B -	OUT B -	OUT B -	INP B -
6	TX	TX	C +	SM 2 +	INP C +	OUT C +	OUT C +	INP C +
7	RX	RX	C -	SM 2 -	INP C -	OUT C -	OUT C	INP C -
8	0 Volt							

> ℹ️ The maximum extractable current from PIN 1 (Output +24 Volt) is 200 mA.

6.4.4.1 Details of Possible Configurations

Configuration description 0

In this mode, the three channels are configured as 2 digital inputs plus the serial line RS-232.

Configuration description 1

In this mode, the three channels are configured as 1 digital output, 1 digital input, and the RS-232 serial line.

Configuration description 2

In this mode, the signals on the connector of an incremental encoder are generated starting with internal information from the drive (instantaneous position of the motor). With this, it is possible to close the position of the machine control through an external PLC, allowing the drive to control the speed with an analog reference. The number of encoder pulses is configurable in multiples of 2, starting with 128 pulses/rev., up to 8192 pulses/rev.

The amplitude of the marker on the output C is configurable as ¼ , ½ and 1 impulse.

The basic configuration is 4096 pulses per mechanical revolution of the motor with a ¼ mark.

Configuration description 3

This mode allows you to monitor the synchronization signals of the EtherCAT network used for synchronization of the various modules, working with distributed clock.

- SYNC 0 signal has a period of 62.5 μs (16 kHz) and corresponds to the basic servo time.

- SYNC 1 signal has a period equal to that set for the EtherCAT communication network and is used to synchronize the devices on the reception of the data packet.

- SM2 signal indicates the actual time of receipt of the data packet by the device.

Configuration description 4-5-6-7

All digital inputs (TTL Line Driver, differential), can be configured as follows:

- Drive enable

- Reference enable

- Quick stop

- Reset alarm

- Limit switch (CCW and CW)

- Reset fault

- No reference signal

- Emergency Stop activated

- CW

- CCW

- stopped axis

All digital outputs can be configured as follows:

- Copy of limit switch (if programmed on the digital inputs, available on J6).

- Warning motor temperature

- Warning for motor I^2T

- Warning drive temperature

The X4 connector is not opto-isolated.

6.4.4.2 Programming Analog and Digital I/O Connector X5

Analog Input 1 and 2

- Torque reference

- Speed reference

- Position reference

- Current limitation (maximum output torque)

Analog Output 1 and 2

- Measured voltage DC BUS

- Current measured Iq

- Current reference Iq

- Measured phase current U

- Measured phase current V

- Measured motor speed

- Internal test variable

Digital Output 1

- Halt function active

- Stop function active

- Positive rotation speed (clockwise)

- Negative rotation speed (counterclockwise)

- Rotation zero speed

Digital Input

- Signal command

- Points deactivation

- Reset fault command

- Drive enable command

- Reference enable command

- Quick stop command

- DX limit switch

- SX limit switch
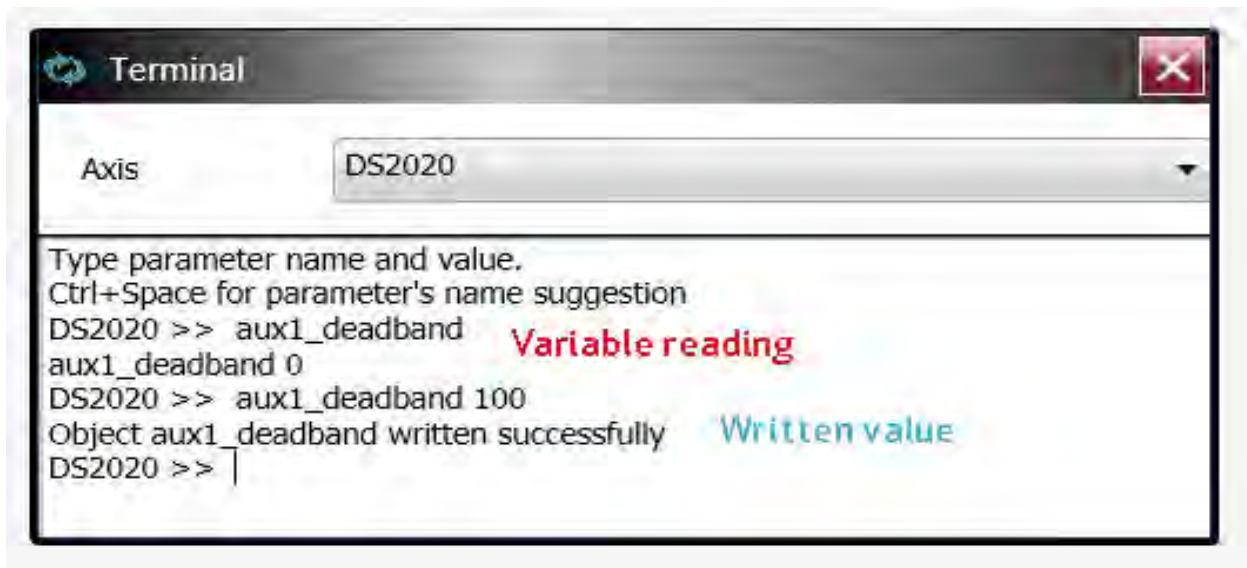
| (i) | Each analog input can be configured with a different parameter. |

| (i) | The digital outputs are active if +24 V power is supplied on the X5 connector pin 7 with ground on pin 8. |

6.4.5 Control Loops Configuration

6.4.5.1 Control mode configuration

The DS2020 operates up to three control loops according to the drive operation mode: torque, speed, and position. These are nested so that torque is the inner loop, speed is intermediate loop, and position is the outermost loop. The output of each nested loop will become the reference for the next one.

The following figure illustrates the general block diagram of the control structure.
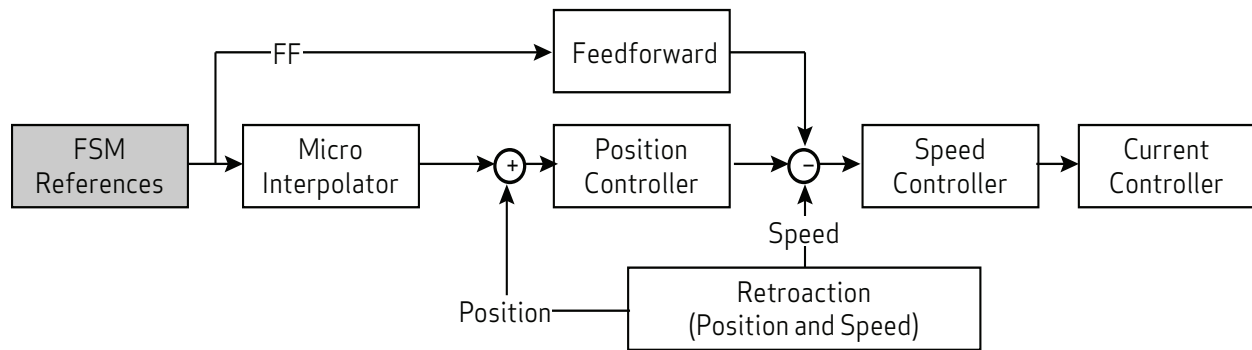
Depending on the structure chosen, the reference for torque, speed or position must be provided.

> Control loop settings must be adjusted by qualified personnel. Incorrect settings can adversely affect motor performance.

6.4.5.2 Torque loop parameter configuration

The torque loop is the innermost. Parameters are assigned automatically starting with the motor setup data with the menu Parameters Motor.

The user can configure the bandwidth of the closed loop of torque through the Terminal window. When setting the variable 'bandPass', the possible values are 3000 (default), 2000, 1000, 600, 400 in Hz.

> Changing the bandwidth from the default value may result in degraded motor performance.

6.4.5.3 Speed loop parameter configuration

The speed control must ensure that the motor speed follows, as closely as possible, the speed reference, both in static conditions and in dynamic conditions. The quality of response of the system depends on the loop parametrization.

The base rate is a PI (proportional-integral) type control with the addition of a feedforward control (ff_calc) and a Saturation Variable (SAT_VARIABLE).

The proportional term provides an action as strong as the error is large, while the integral term (speed error) corrects small errors that are maintained over time due to constant noise, allowing you to reach the required target.

The Feedforward block minimizes the velocity error in cases of disturbances as they occur. This contributes directly to the reference for speed processed by the PI controller, with the linear combination of the speed references, acceleration, jerk, delayed speed of n samples, calculated at the microinterpolator valley, and minimizes errors during transients.

The variable saturation block prevents the formation of a stationary axis position instability (zero speed reference acting as a "low pass" filter with very limited bandwidth).

To set the parameters, from the Navigation Area, select "Speed loop". This opens a window that shows the block diagram of the loop.
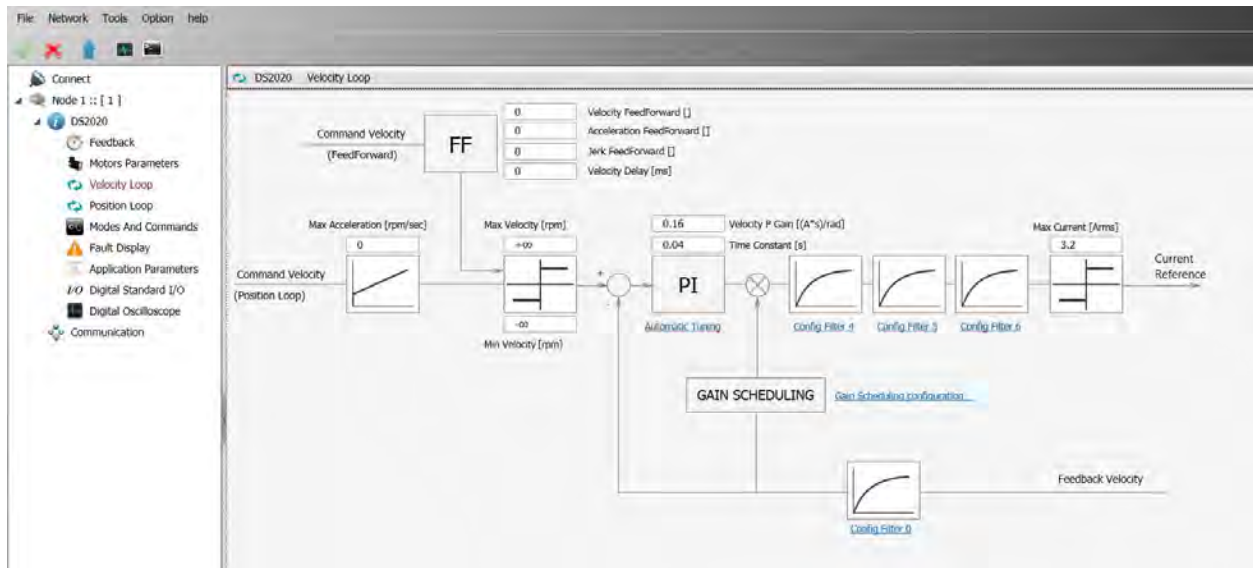
A standard correcting block (PI in the above image) is characterized by two parameters. It is followed by a sequence of filters, and a filter on the feedback chain. This allows the implementation of more complex control structures as well as filtering of known disturbances (Notch filter).

Filter configuration

The four filters all have the same basic structure (IIR 2nd order). it is possible to configure them as needed (to access the Configuration menu of each filter, click the link placed under each block). You can choose between the following types:

- Lag: The filter consists of a real pole and a real zero. Put the pole and zero frequency that must be positive or null.

- Bq: It is a standard biquadratic filter, with a pair of complex conjugate zeros and a pair of complex conjugate poles. The parameters are:

  - Zero frequency

  - Zero damping

  - Pole frequency

  - Pole damping

  Frequencies must be positive or null. The damping must be between -1 and 1.

- Pole: The filter has a single real pole. The parameter specified is the frequency of the pole, which will be positive or null.

- DbPole: The filter has two complex conjugate poles. The parameters are:

  - Pole frequency

  - Pole damping

  Frequencies must be positive or null. The damping must be between -1 and 1.

- Dircoef: insert the coefficients of the numerator and denominator of the filter (rarely used)
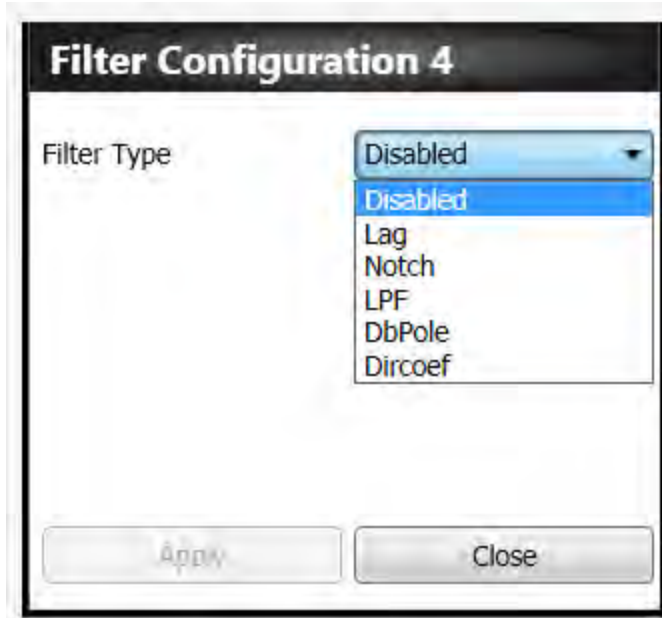
	Keep the filter disabled until all the other parameters of the filter are entered.

	You must enter the parameters in the following order: 1. Damping 2. Frequency 3. Filter type

Examples of filters

Example of a Notch filter configuration: insert a Notch filter centered at 30 Hz.
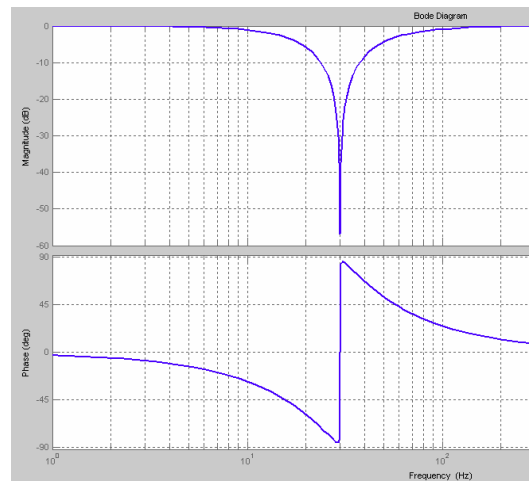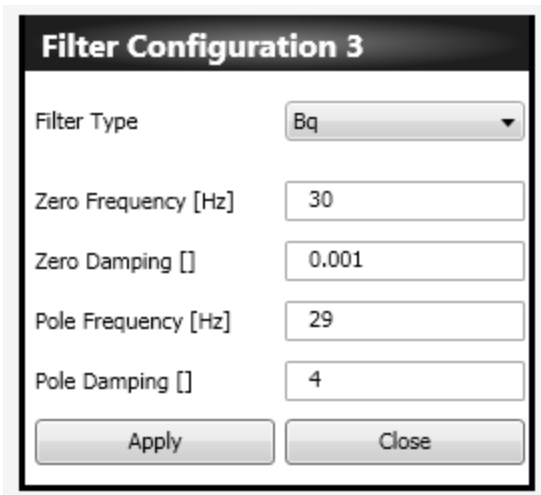
Example configuration of a low pass filter of 2nd order.
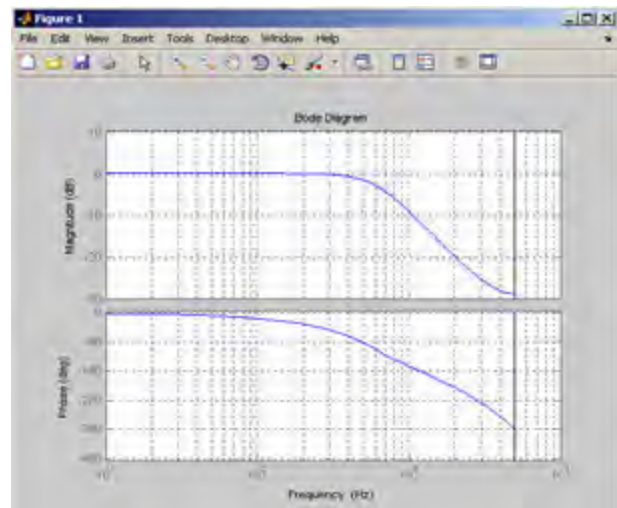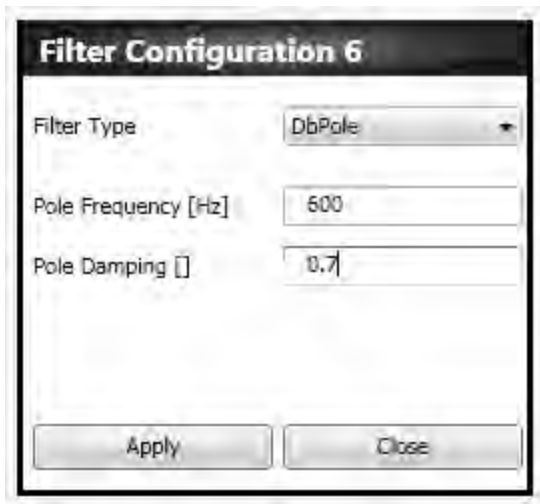
6.4.5.4 Configuration of the position loop parameters

The position control must ensure that the motor position follows, as faithfully as possible, the position reference. The response quality of the system depends on the loop parameterization. The position control is PID (proportional-integral-derivative).

- The proportional term provides an action as strong as the error is large.

- The derivative term notes if the error is increasing or decreasing the dampening behavior of the system.

- The integral term cancels the steady-state error.

To set the parameters, from the Navigation Area select "Position loop": it will open the window showing the loop diagram in question.
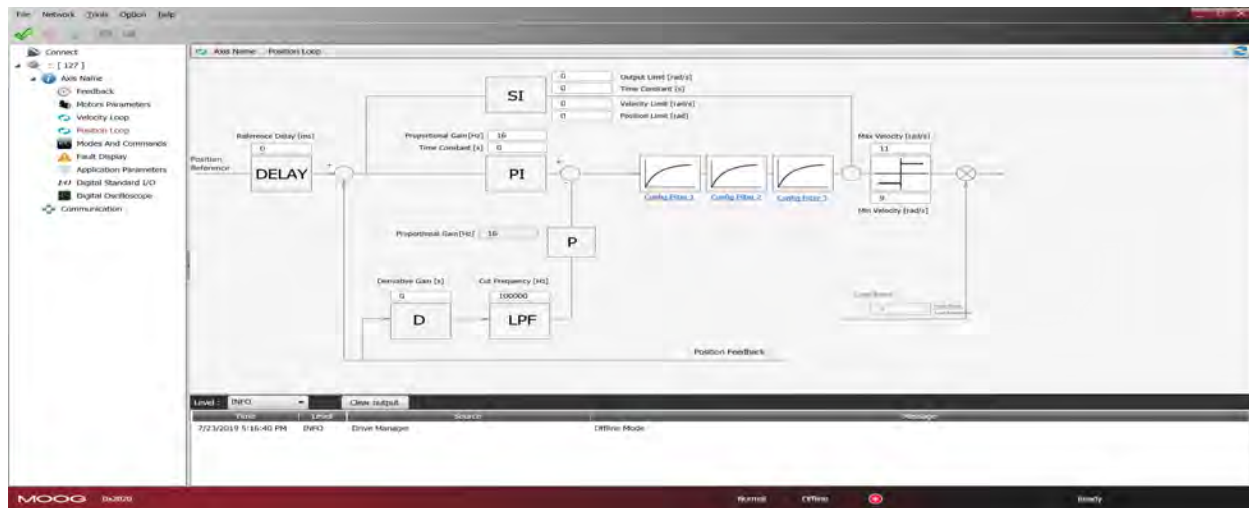
It recognizes the standard control loop (PID) characterized by four parameters. That is followed by a sequence of filters that the implementation of more complex control structures. For parameterization of the filters, see Filter configuration on page 103.

6.4.6 Fault Configuration

From the navigation area select "Display Fault". The fault management display will appear. On the left side of the window there is a list of active alarms (Active Fault List), on the right there is another with the last 8 alarms (Fault History).
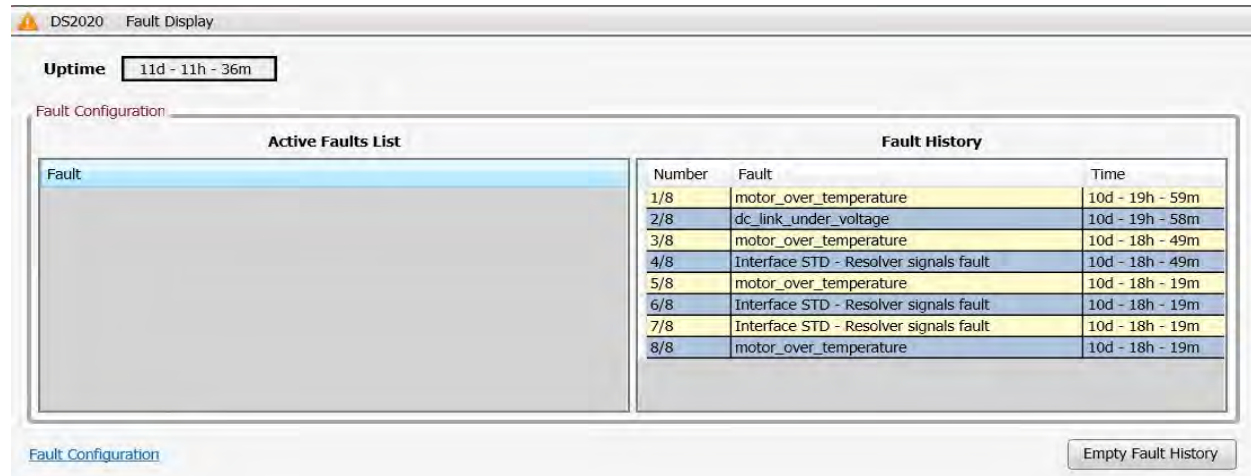
The drive response to each alarm can be configured individually by selecting the link Fault Configuration This will open the window with a list of the faults. For each fault, it will be possible to choose the reaction from a drop down menu.
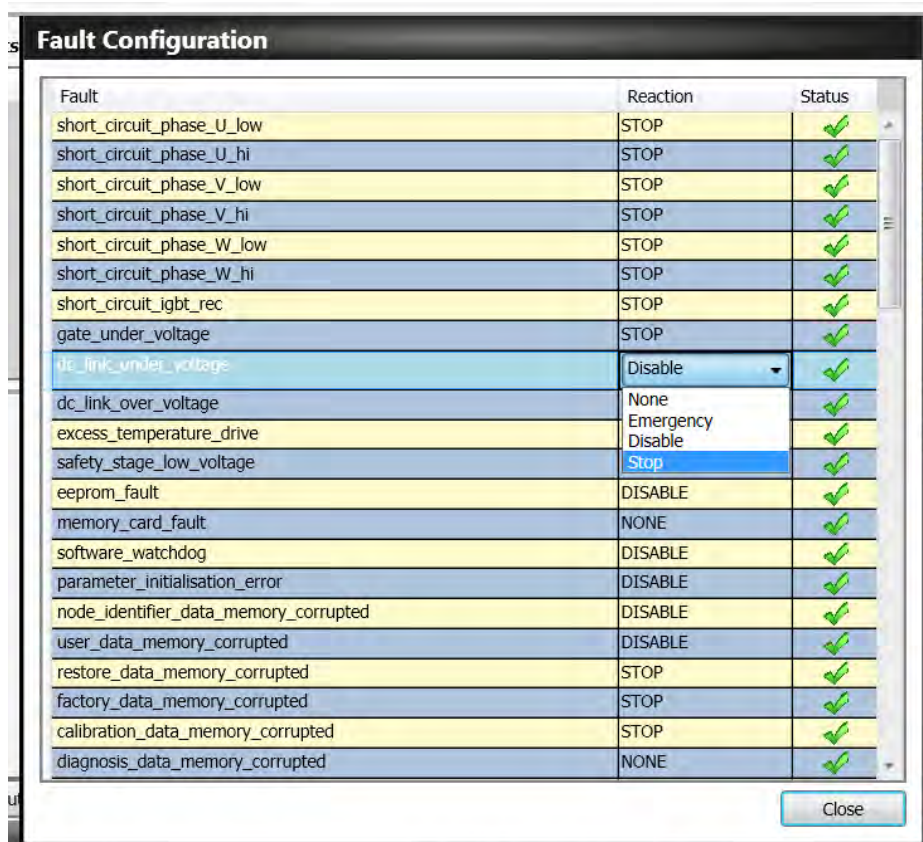
There are four options:

Reaction	Effect
None	The alarm is ignored CAUTION: For use during commissioning or troubleshooting only. Not to be used in normal working or operating conditions.
Emergency	The drive sends an emergency message but does not stop or disable.
Disable	Disables the drive and executes the stop procedure configured by the Application/Fault Response parameters.
Stop	Immediate disabling; the drive releases the motor control. If the axis was in motion, it continues to move by inertia.

For each alarm, the most appropriate response must be programmed based on the characteristics of the machine.

For some alarms, the Dx2020 GUI software prevents the selection of some reactions to ensure the integrity of the drive (for example, you cannot enable emergency braking due to "overvoltage").

The following Fault listed are not configurable and the reaction is always 'STOP':

- short_circuit_phase_U_low

- short_circuit_phase_U_hi

- short_circuit_phase_V_low

- short_circuit_phase_V_hi

- short_circuit_phase_W_low

- short_circuit_phase_W_hi

- restore_data_memory_corrupted

- factory_data_memory_corrupted

- calibration_data_memory_corrupted

Contact Applications Engineering for further assistance.

6.4.7 Application Parameters Configuration

From this menu, you can configure the reaction of the drive to particular events.

Details about the events and reactions are described in the Dx2020 GUI online help.

6.4.8 Commands and Modes Configuration

This menu allows to set the source of commands/controls and the drive operating mode.
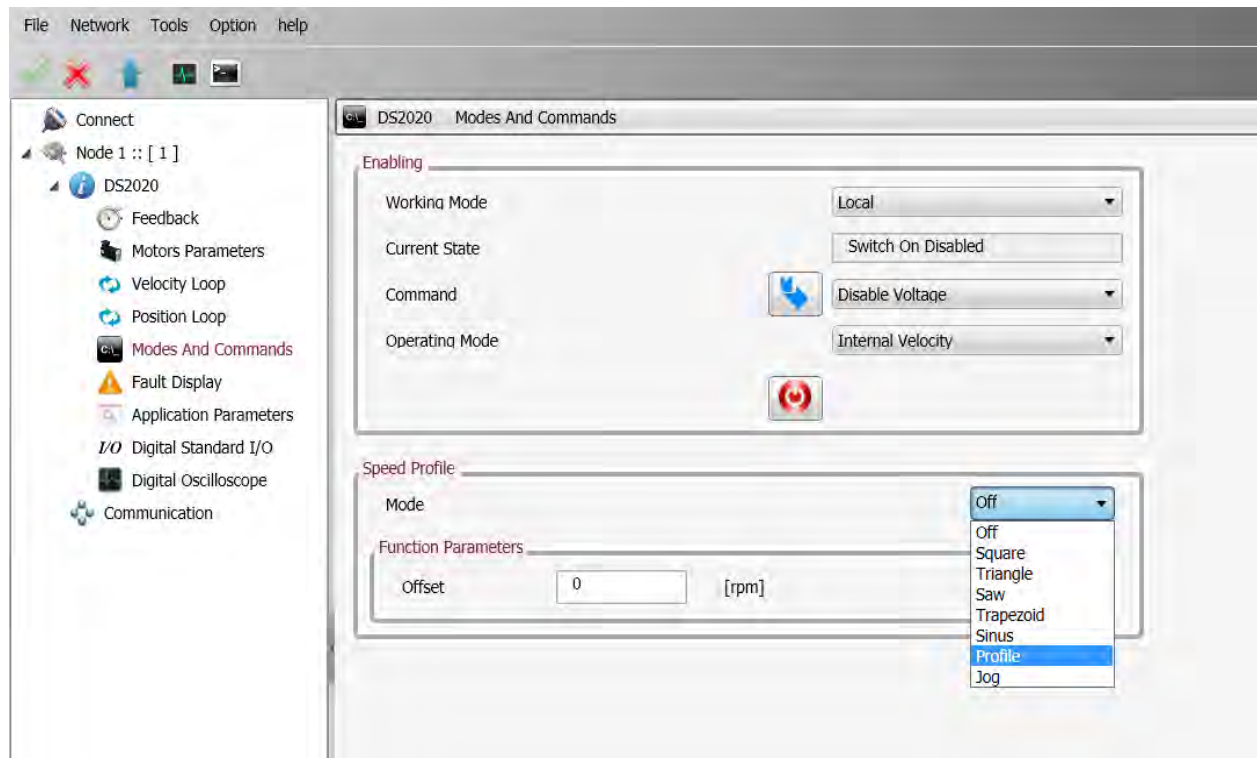
Operating mode

> **ⓘ** Check that the installed firmware supports the selected fieldbus (in the case of EtherCAT fieldbus, the firmware will have _ecat suffix; in the case of CAN fieldbus, the firmware will have _can suffix).

Sets the source of the drive commands. You can choose from the following values:

- **EtherCAT:** the drive receives the commands/setpoints remotely through the EtherCAT fieldbus (if supported by the drive)

- **CANopen:** the drive receives the commands/setpoints remotely through CAN bus (if supported by the drive)

- **Local:** the drive receives the commands/setpoints from the Dx2020 GUI

- **Analog:** the drive receives the commands/setpoints through digital and analog inputs configured (for more information see Dx2020 GUI online help: Dx2020 GUI > Configuration view > I/O Standard Digital)

Current status

The current status of the state machine (FSA) defined by the DS402 standard that governs the drive (see below, state machine).

Command

Selects the command that will be tried by the drive state machine. The command will fact launch when the Enter key is pressed, this button is enabled only if the operating mode is set to Local

Operating mode

Sets the operating mode or function performed by the drive. You can choose from the following values:

- **Analog speed:** the drive operates a speed control following a reference coming from an analog input. You can set a variable torque limit also coming from the analog input.
  (Typical operating mode: Analog)

- **Analog torque:** the drive operates a torque control following a reference coming from an analog input. You can set a variable torque limit also coming from the analog input.
  (Typical operating mode: Analog)

- **Internal speed:** the drive operates a speed control following an internally generated reference, see Function Generator on page 109
  (Typical operating mode: Local)

- **Internal torque:** the drive operates a torque control following an internally generated reference, see Function Generator on page 109
  (Typical operating mode: Local)

- **Sync Cyclic position:** the drive operates a position control following a cyclical reference generated by a device/remote control. This is the Cyclic Synchronous Position Mode defined in the DS402 standard.
  (Typical operating mode: EtherCAT/CANopen)

- **Cyclic Sync Speed**: the drive operates a speed control following a cyclical reference generated by a device/remote control. This is the Cyclic Synchronous Speed Mode defined in the DS402 standard.
  (Typical operating mode: EtherCAT/CANopen)

- **Cyclic Sync Torque:** the drive operates a torque control following a cyclical reference generated by a device/remote control. This is the Cyclic Synchronous Torque Mode defined in the DS402 standard.
  (Typical operating mode: EtherCAT/CANopen)

> **i**   Additional application-specific modes are available and are not described in this document.

When the drive commands are internally generated (e.g., Operating mode = Local, Operational Mode = Internal speed) is possible to characterize different reference profiles (Square, Triangulate, Sawtooth, Keystone, Sin, Profile, Jog).

Function Generator

The Dx2020 GUI includes a mode called "Function Generator": this type of control mode can be used only as "Local" and requires manually setting and generating the operations required for the movement of the motor with different types of waveforms. The internal function generator produces speed reference profiles when set on "Internal speed" and torque profiles when set on "Internal torque".

Through a drop-down sub-menu, it is possible to choose different types of references: constant (offset level), square, sinusoidal, trapezoidal, saw tooth, etc.; for each type of waveform it is possible to define the parameters of offset, square, frequency level.

In addition to generic waveforms, two further types of reference are available:

- Profile: Speed profile completely adjustable according to speed, deceleration, acceleration and period.

- Jog: Manual speed control reference adjustable according to the parameters: direction, acceleration and speed.

- Profile: Speed profile completely adjustable and moldable according to speed, deceleration, acceleration and period.

- Jog: Manual speed control reference adjustable according to the parameters: direction, acceleration and speed.

Refer to the following figures.
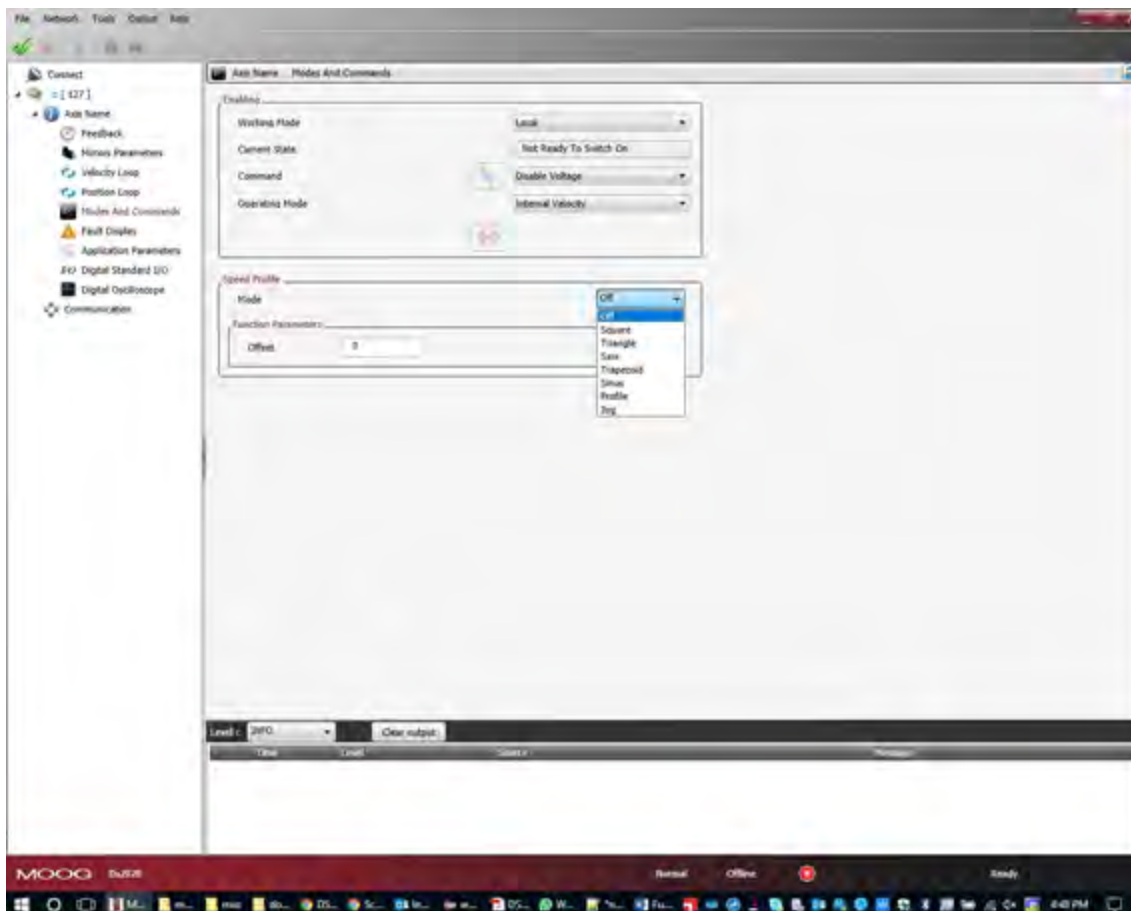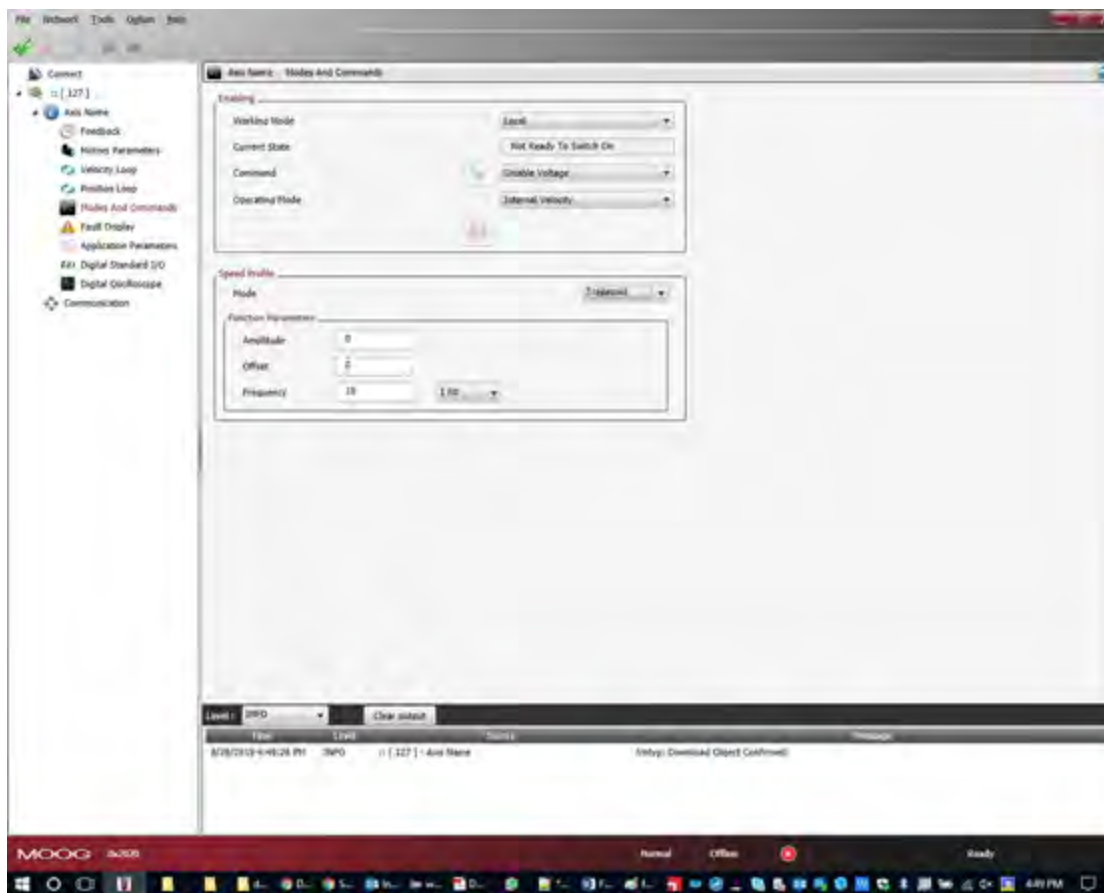
Quick Stop Command

The command called "quick stop" initiates the function of a controlled, rapid stop of motion. In other words, following a "quick stop" command, a rapid deceleration ramp is performed in a controlled manner and then the drive is placed in a disabled state.

The function has been implemented as defined by the EtherCAT profile DS402 reference regulation of motion control.

DS2020 State Machine

For details on the FSA, refer to the Dx2020 GUI online help, Dx2020 Gui > Configuration View > Modes and Commands.

The following figure shows the DS2020 drive state machine.
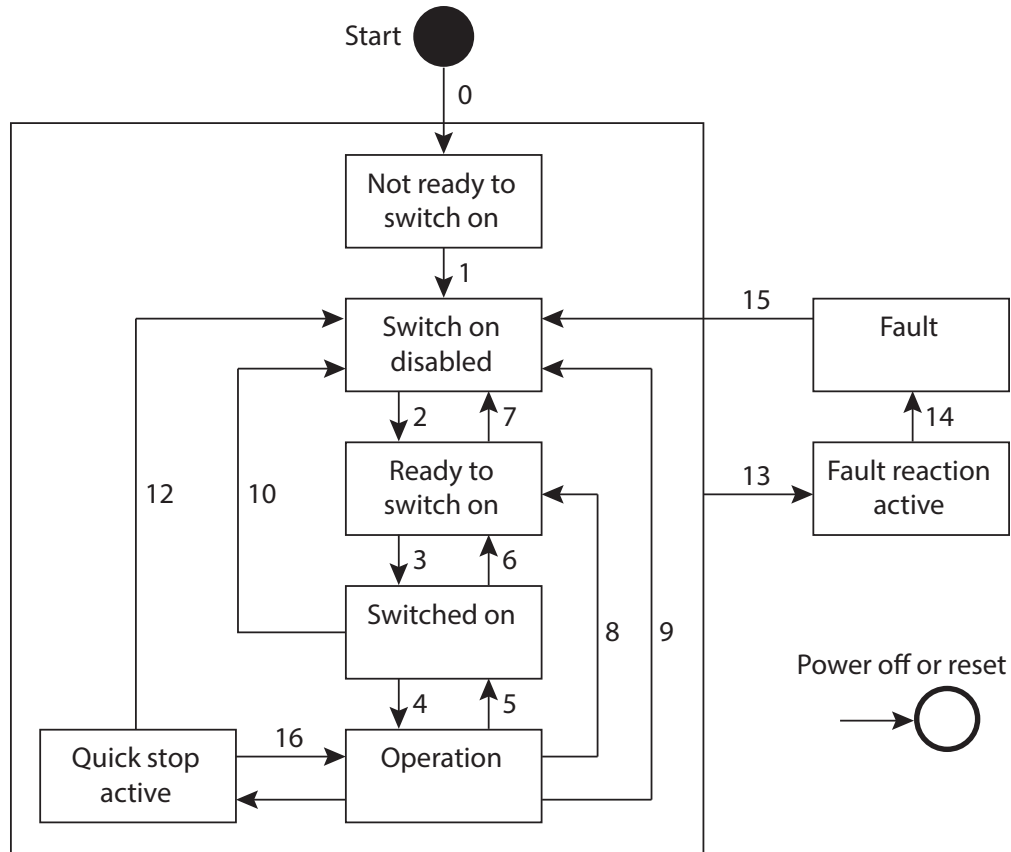
Figure 28 : DS2020 Drive State Machine

Function	FSA State							
	Not ready to start	Start disabled	Ready to start	On	Operation enabled	Quick stop active	Fault reaction active	Fault
If blocked, brake locked	Yes	Yes	Yes	Yes	Yes/No	Yes/No	Yes/No	Yes
Low level of applied power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
High level of applied power	Yes/No	Yes/No	Yes/No	Yes	Yes	Yes	Yes	Yes/No
Drive enabled function	No	No	No	No	Yes	Yes	Yes	No
Configuration allowed	Yes	Yes	Yes	Yes	Yes/No	Yes/No	Yes/No	Yes

Transition	Event(s)	Action(s)
0	Automatic transition after switching on or resetting the application	Automatic verification of drive and/or automatic initialization is performed
1	Automatic transition	Communication is activated.
2	Shutdown command sent from the drive or from the GUI	-

Transition	Event(s)	Action(s)
3	Ignition control command received from the drive or from the GUI	If possible, the high-level output is enabled.
4	Enable operation command received from the drive control or from the GUI	The operating mode is enabled and all the set-point extensions will be cleared.
5	Disable operation command received from the drive or from the GUI	The operating mode is disabled.
6	Shutdown command received from the drive or from the GUI	If possible, the high-level power is disabled.
7	Quick stop or voltage disable command received from the drive or from the GUI	-
8	Shutdown command received from the drive or from the GUI	If possible, the operating mode is disabled while the high-level power is disabled.
9	Voltage deactivation command received from the drive or from the GUI	If possible, the operating mode is disabled while the high-level output is disabled.
10	Voltage deactivation command or quick stop command received from the drive or from the GUI	If possible, the high-level power is disabled.
11	Quick stop command received from the drive or from the GUI	The Quick Stop function is started.
12	If the quick stop function is complete and the quick stop option code is 1, 2, 3 or 4, or the voltage deactivation command received by the drive, the auto transition is active (it depends on the Quick Stop option code)	If possible, the drive is disabled while the high-level power is disabled.
13	Fault Signal (also see IEC 61800-7-301)	The configured fault reaction function is executed.
14	Automatic transition	If possible, the drive is disabled while the high-level power is disabled.
15	Fault reset command received from drive or from the GUI	If the error does not exist and the restoration of the fault condition is performed, the fault condition is cleared by clearing the bit control word
16	If the code of the Quick Stop option is 5, 6, 7 or 8, the drive control Enables Operation is received. See NOTE.	The drive is disabled
NOTE: Support of transition 16 is not recommended.		

6.5 STO Activation

To enable the axis, you must enable the STO circuit. The 24 V power of the STO circuit must be integrated within the emergency fail-safe loop. See Safe Torque Off Safety Function on page 140.

⚠ WARNING
WARNING: Electrical hazard. The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment. ➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

⚠ WARNING
WARNING: Mechanical hazard. The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment. ➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

- Always check the STO function at the first system start up or after any system maintenance.

- Do not attempt to access a protected area (safety interlocked cover, door, barrier, etc.) while the machine is powered up or operating. Doing so triggers the emergency stop chain, which interrupts motor power, and causes the intervention of the STO.

- If the STO signal is not removed following the correct sequence, the display will show "F" (Fault).

6.6 Auto-Phasing Procedure

The auto-phasing is set through the Dx2020 GUI software.

The DS2020 system provides an auto-phasing procedure that is useful for unknown motors. This procedure finds the right phasing angle (THETA) to properly run the motor. At the end of the procedure the THETA parameter is automatically set. It can be done also to check the correct wiring of the motor.

	The motor must be free to move during the auto-phasing procedure.

To set the autophasing, select "Modes and Commands" in the Navigation Area.

Check that the power supply and STO are present, then from the "Command" field, select in sequence:

1. "Shutdown".

2. "Startup", leaving the drive in this state.

The drive signals the activation with an "S" on the display. See the following figure.
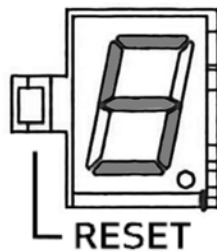
6.7 Drive (Axis) Enable and Limit Switch Enable/Disable

The drive implements profile DS402 (CIA standard). The enabling of the drive (axis) depends on the application of a command that can be received from remote EtherCAT or CAN fieldbus by hardware (Analog mode) or GUI (Local operation).

- Fieldbus (EtherCAT or CAN): enabled by the master (PLC) through the Control Word

- Analog: enabled through the hardware by configuring the I/O

- Local: enabled through the GUI (Modes and Commands > Command)

The following is the sequence of commands to enable:

1. Fault reset (if fault is present)

2. Shutdown

3. Startup

4. Enable operation

To disable, repeat the previous procedure in reverse order, or select the "Quick Stop" command (see Quick Stop Command on page 111).

Refer to the Dx2020 GUI online help for more details.

6.8 Oscilloscope Function and Log File (.UCX)

It is possible record and display numerous drive internal variables from the Dx2020 GUI by selecting "Digital Oscilloscope".

6.8.1 Log Configuration

Select the Channels tab for each channel in the drop down menu to choose the variable to display. The number of accessible variables depends on the mode of access (Advanced or Normal).

To change the access mode, from the toolbar, select Options > Modes and proceed with the choice. You can display up to four tracks.

Set the recording time in msec (Record Time) and Sampling Frequency in Hz.

Triggering is possible. To display (and record) on an event, choose Enabled in the Trigger field (choose Continuous for repeated display of the same event automatically).+ù'p0okiujyhg

The Pre Trigger setting lets you view 512 bytes before the signal is triggered.
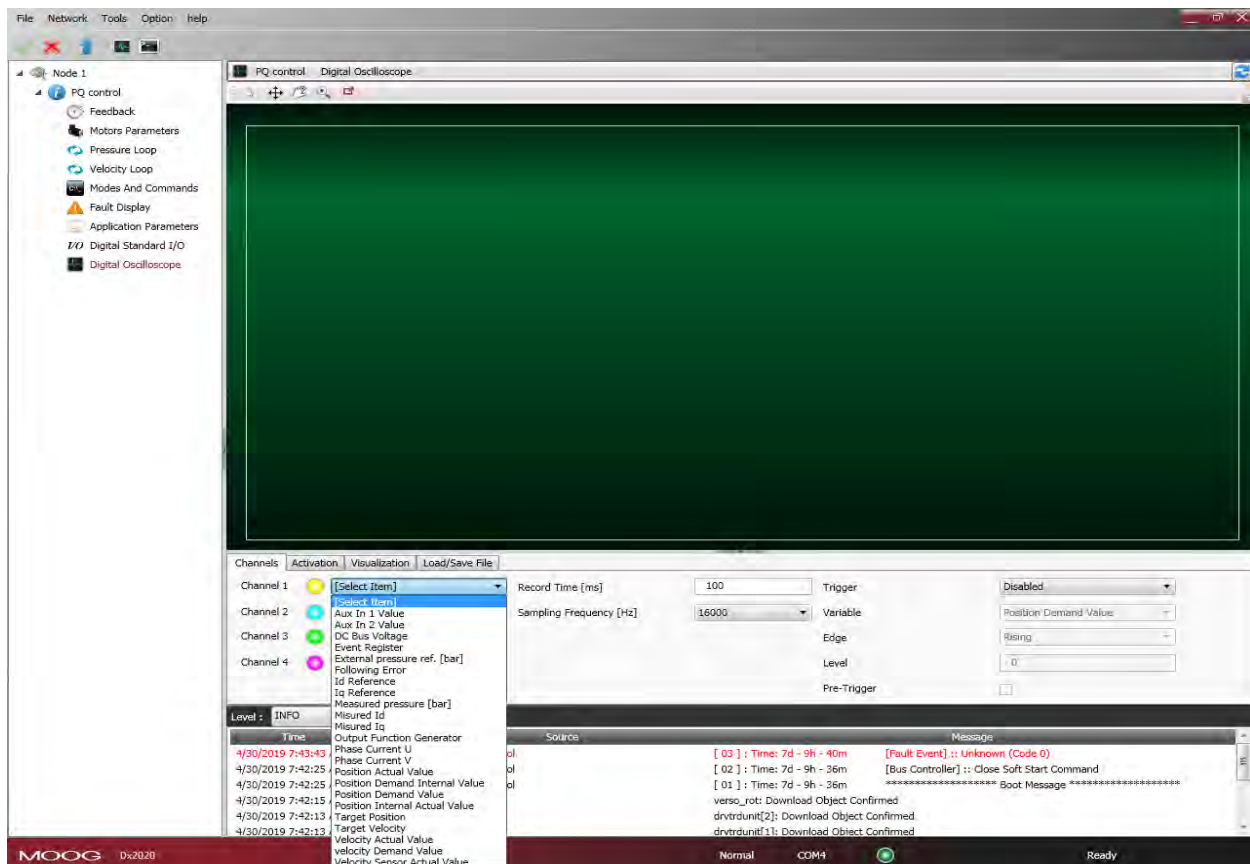
6.8.2 Start Logging

Select the Activation tab.

From Select Output, choose from the following options:

- Displays on the GUI: the data are only displayed and not recorded

- Save Locally: the data are displayed and saved on the PC in the directory specified in Output Folder

To start recording, click Start; to stop recording, click Stop.
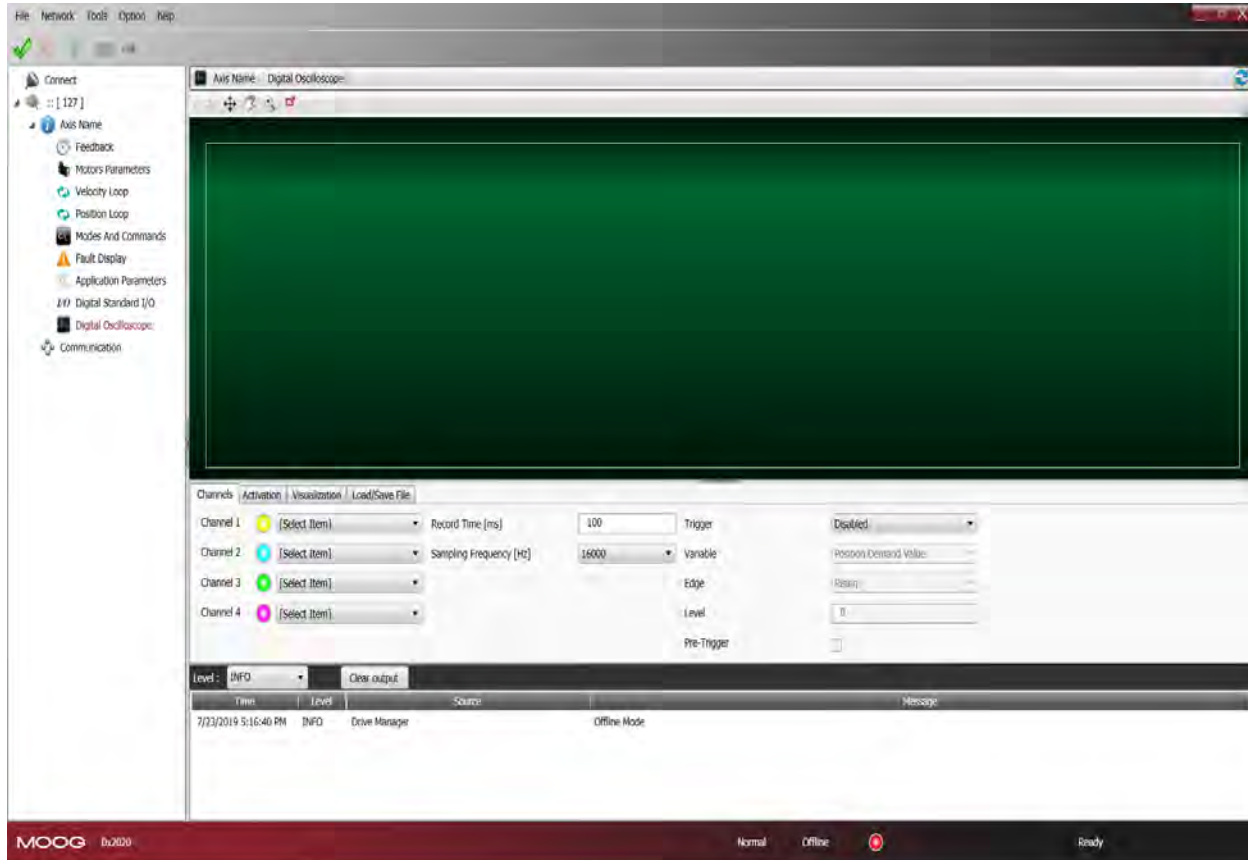
6.8.3 View Logs

Select the View tab.

After acquisition, the data is shown on the display.
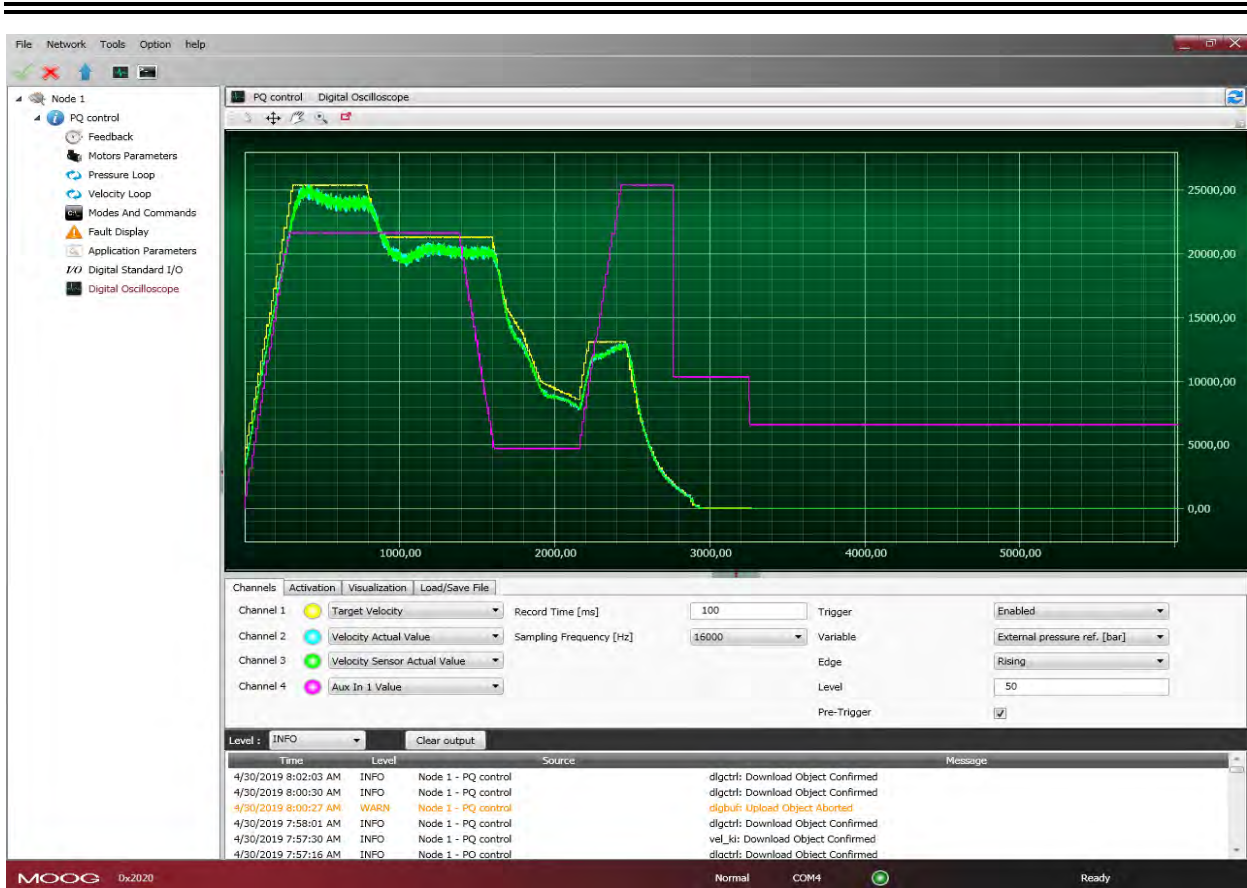
On the top left are the Cursor Activation (Cursor) and Displacement of the Graph (Pan) functions.

Magnification of the details (Zoom) and printing of the image (Screenshot); mouse cursor shall show the legend of the 4 buttons when hovering above them.

If the Auto Range check box is selected, each signal is shown in the window; otherwise, the data appear at the acquired scale unless you modify them with the Amplitude command.

6.8.4 UCX File Management

When data is saved in Local, a file is created with the name, date and time of capture. The extension of these files is "* .UCX". To view archived recordings, go to the Tab "Load/Save File", accessing the file system using the Open UCX button.
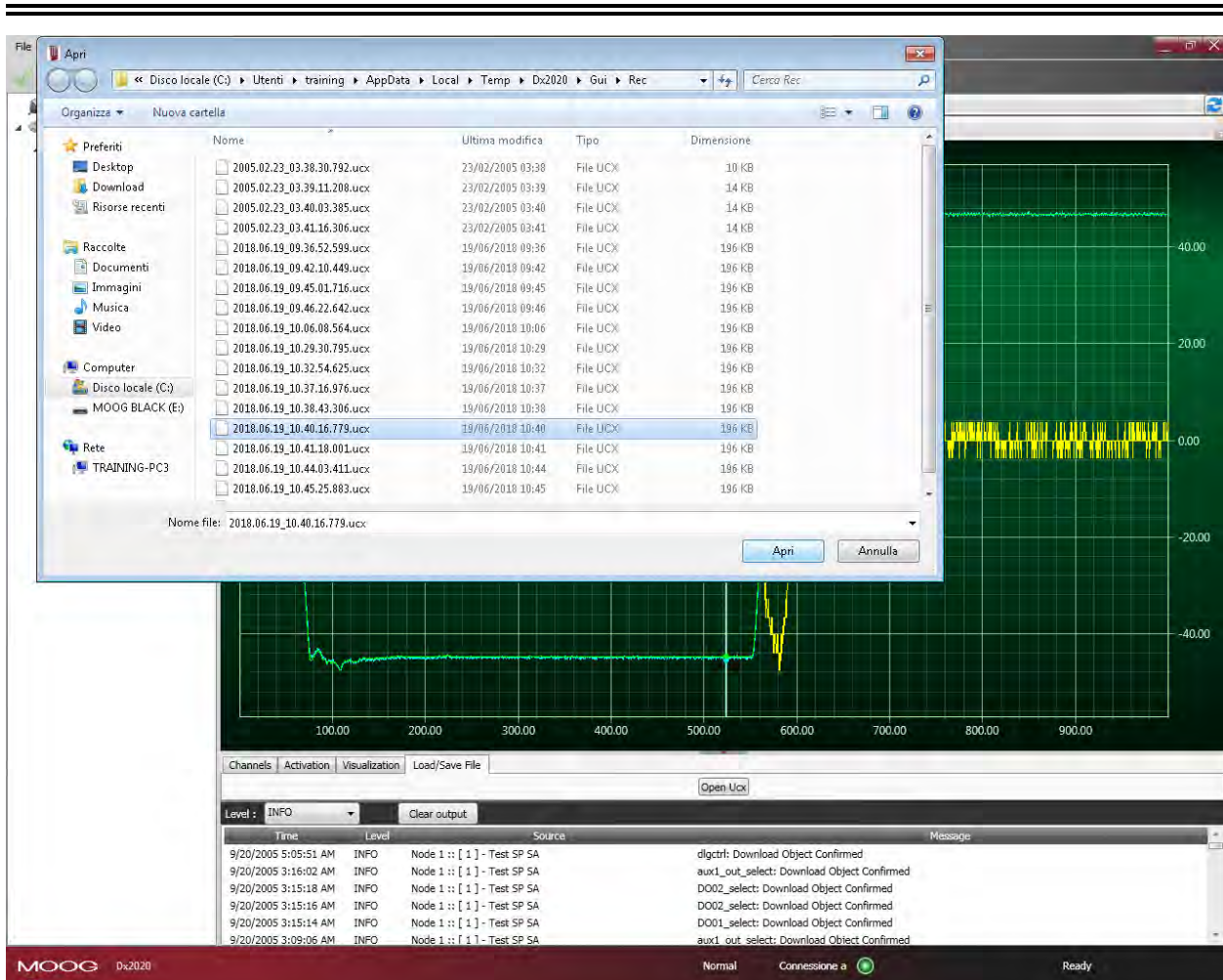
6.9 Using the GUI in Offline Mode

The Dx2020 GUI can be used in offline mode, in the absence of the drive, to create the drive configuration file, edit the file, or verify its contents.

To enter Offline mode, select File > Open. Select Yes button in the pop up window then load the SW release you need to use.
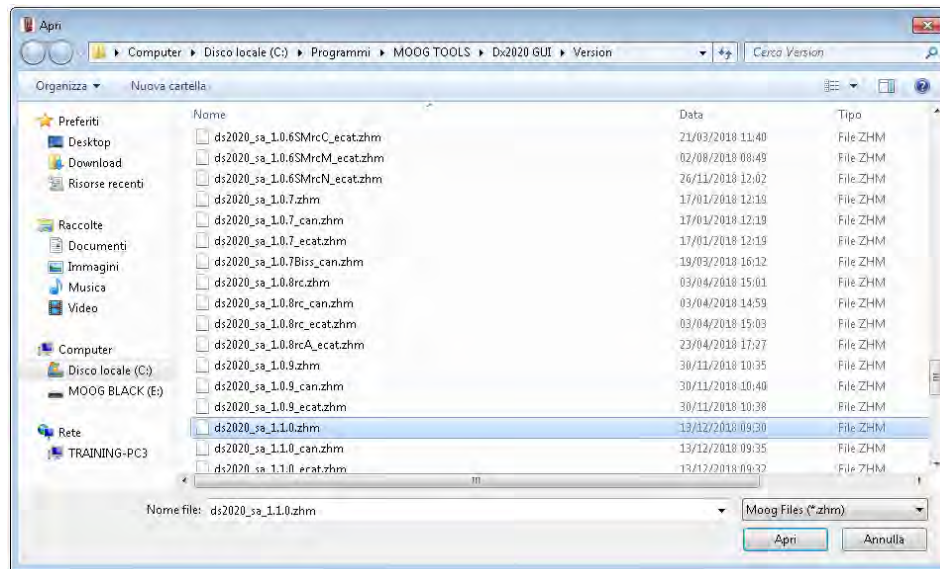
To check a parameter file, from the main menu:

1. Select the axis with the right mouse button.

2. Load the parameters as if there was a real drive connected.

3. Modify them if needed.

4. Save the new configuration to the new parameter file.
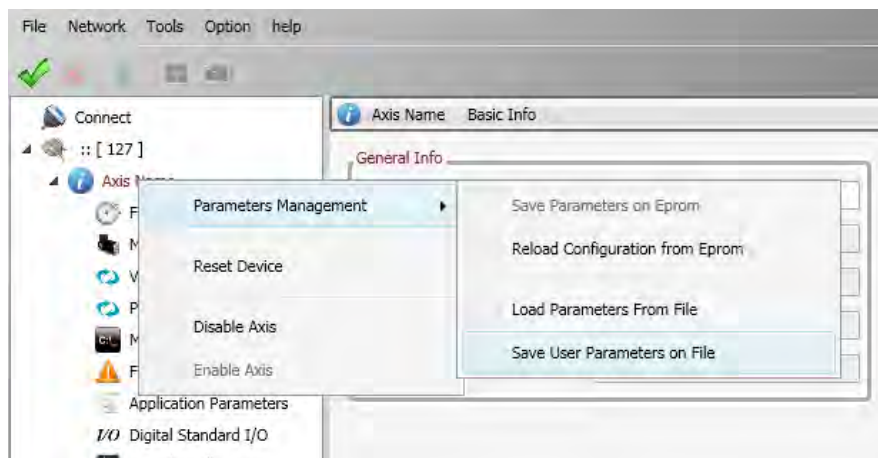
6.10 Contextual Help For Parameter Management

A context menu is available for parameter management. With it, the following operations are possible:

- Parameter Management:
  - Save the current configuration on the internal memory of the drive
  - Restore configuration previously saved in the internal memory
  - Load a saved configuration file (parameter download file)
  - Save the current configuration file (parameter file upload)
- Reset Device: Reset device selected

- Disable Axis: Disable axis selected

- Enable Axis: Enable axis selected

To open the menu, right click on the drive (axis) name.
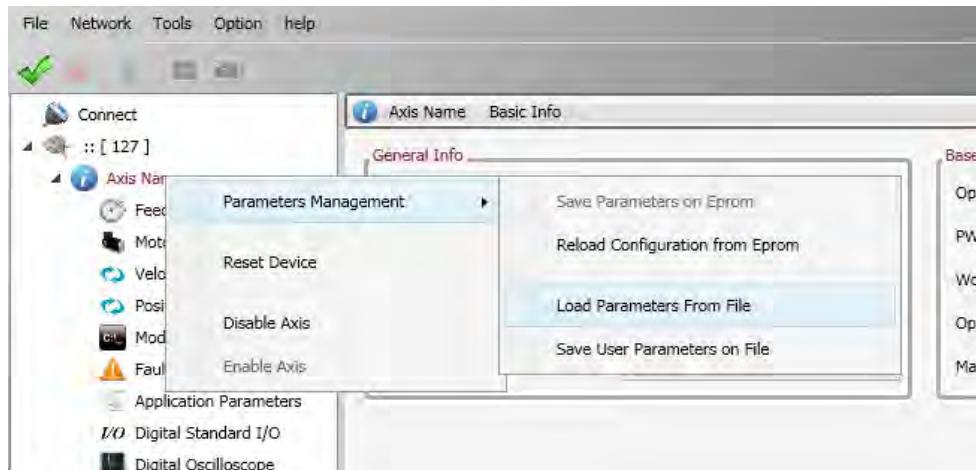
6.11 Decommissioning Procedure

⚠ WARNING
WARNING: Electrical hazard. The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment. ➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

⚠ WARNING
WARNING: Mechanical hazard. The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment. ➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

To disable a DS2020 (replacement, dismantling) follow the procedure below:

1. Disconnect and lock out the mains supply voltage of the electrical panel and wait at least eight minutes.

2. Measure for voltage at all contact points to ensure there is none present.

3. Check that the temperatures of the heat sink and of the mechanical parts are not too high; use gloves as needed.

4. Loosen all connections and disconnect all connectors.

5. Remove the DS2020 drive from the electrical panel.

6. To decommission the DS2020 system's motor, follow the decommissioning procedure described in the motor's installation guide.

7. Repackage the system components in their shipping containers for safe storage or return.

7 Shipment and Storage

Use the following guidelines when receiving or storing the shipment.

7.1 Receiving and Checking the Shipment

When the shipment is received:

1. Inspect the exterior of the shipping container for any signs of damage. Immediately report any damage to the shipping carrier.

2. Open the shipping container and check that the contents of delivery are as ordered. Immediately report any discrepancies to Moog Casella.

3. After removing the motor from its shipping box, check that no damage, especially in the areas of the shaft and connectors, has occurred during transit. Immediately report any discrepancies to Moog Casella.

!	Retain all packing materials that the DS2020 system was shipped in, as those must be used if the system components need to be sent to Moog Casella for service. This will ensure that they arrive safely.

7.2 Storage

DS2020 system components can be stored for a consecutive period of up to one year without special requirements or actions. If you have retained the original packing materials that the DS2020 system was shipped in, the system components should be repackaged in those materials for safe storage.

7.2.1 Regenerating the Electrolytic Capacitors after Storage

When the storage period is longer than one year, before installing and commissioning the drive, please contact Applications Engineering to perform the following regeneration procedure of the electrolytic capacitors:

1. Gradually apply a DC voltage of value 300 VDC with limited current by connecting the positive pole of the supply to the "X11-RRext" connector and the negative pole to the connector "X11-V1"

2. Maintain the voltage value for about 20 minutes.

3. Disconnect the power source and wait for the discharge time.

8 Maintenance

There are no user-serviceable parts inside the DS2020 system. Do not attempt to disassemble the DS2020 drive, as doing so will void the warranty.

➢ If your DS2020 drive needs to be serviced, return the faulty component(s) to the factory. See the next section.

⚠ WARNING
WARNING: Electrical hazard.
The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.
➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

⚠ WARNING
WARNING: Mechanical hazard.
The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.
➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

8.1 Periodic Maintenance

Periodically, check the following items:

Component	Inspect	Frequency
Exterior case	Do not immerse or spray the drive with water or any cleaning agents. Check for accumulated dust/dirt. If the surface is dirty, clean with a dry cloth. If the ventilation grids are dirty, clean with a dry brush.	Application specific (depends on operating environment, frequency of use, etc.)
Signal and power cables	Check for wear, damaged jacket, loose connectors; ensure that all connectors are properlytightened. Note that all M-style connectors must be finger tightened only, do not use tools.	
Brake (if equipped)	Check for full engagement and disengagementof the brake.	

Component	Inspect	Frequency
Motor mounting fasteners	Check for loose mounting fasteners (nuts, bolts); ensure that all fasteners are properly torqued.	Application specific (depends on operating environment, frequency of use, etc.)
Bearings and motor noise	Check for bearing/motor noise or vibrations during normal operation of the motor.	
Other motor maintenance	Consult your Moog motor installation guide for any motor-specific maintenance.	

8.2 What to Do If Repairs Are Required?

If repair of a Moog drive or motor is needed, an RMA (Return Material Authorization) number is required to return the motor. Instructions for packaging and shipping the motor back to Moog will be provided with the RMA. Contact your Moog Casella representative for more information.

🛈	Retain all packing materials that the DS2020 system was shipped in, as those must be used if the system components need to be sent to Moog Casella for service. This will ensure that they arrive safely.

9 Troubleshooting

⚠ WARNING

⚠ **WARNING: Electrical hazard.**

The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.

> ➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

⚠ WARNING

⚠ **WARNING: Mechanical hazard.**

The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.

> ➢ Before attempting this operation, follow the safety information and procedures in General Hazards and Safeguards on page 20.

Troubleshooting of the DS2020 system is primarily done through the Dx2020 GUI software, The following sections describe typical malfunctions and provides a series of recommendations on how to fix them. If the problem persists, contact Applications Engineering.

9.1 Power Section Anomalies

Cause	Action
The drive temperature is high	Check the continuous current supplied to the axes
	Check the efficiency of the fans
Failure recovery	Check the braking resistor
Overvoltage	

If the resistance is not open, in short circuit or does not disperse to ground, try removing the braking resistor and slowly move the axis to see if the problem still exists. If it persists, replace the drive.

9.2 Drive Alarms (Faults)

The drive-axis alarms (faults) are shown on the axis display by the letter F; to troubleshoot the condition, connect to the Dx2020 GUI software, in the software, select the item Fault Display, and then proceed with the analysis of the anomalies.
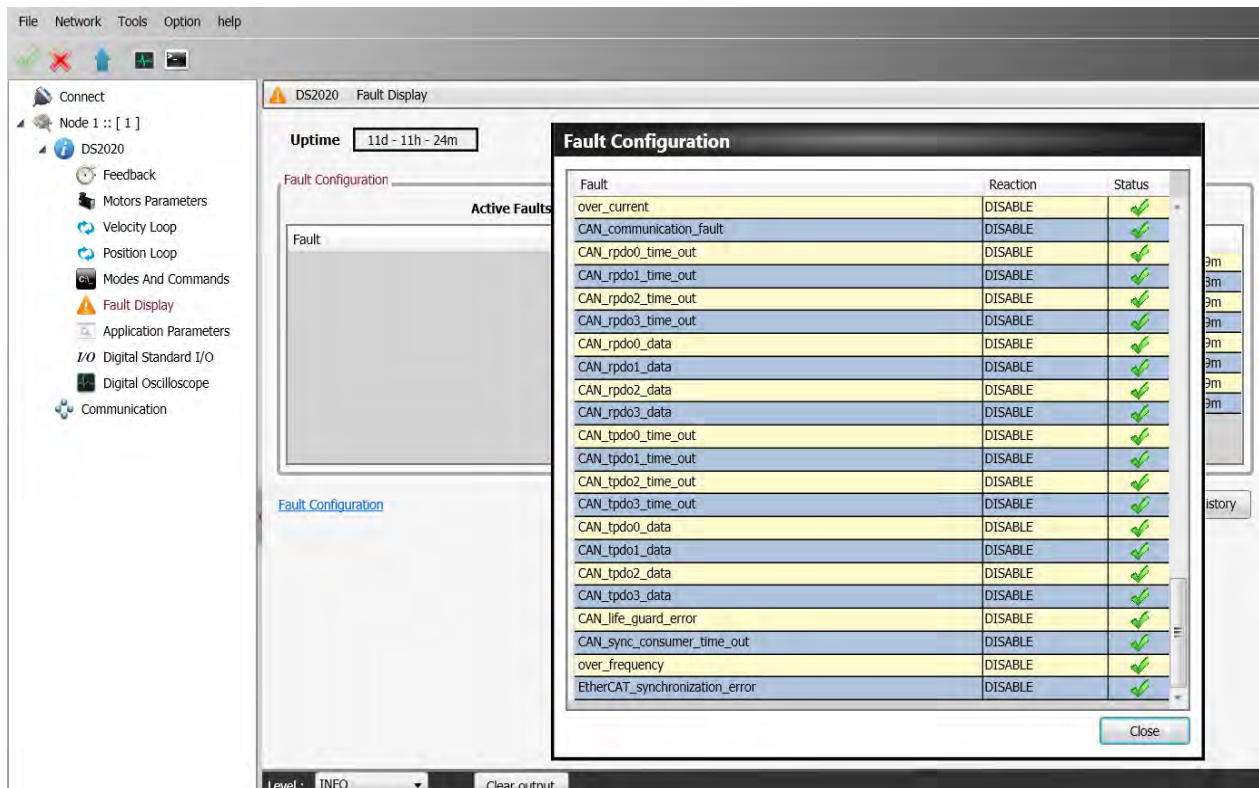
9.2.1 Alarms on the Power Section

The following alarms identify the IGBT (Insulated Gate Bipolar Transistor) affected by the phase x: (U, V or W):

- Short_Circuit_Phase_x_Low

- Short_Circuit_Phase_x_Hi

This type of alarm occurs when the drive detects an excessive current or a short circuit on one of the six IGBT output stages.

> (i) With this type of alarm, the reaction is always disabling, as appropriate control of the motor is no longer possible.

The probable causes of this type of alarm are listed in the following table.

Cause	Suggested action
Short circuit in the motor	Check the motor insulation with a multimeter or other suitable tool.Alternatively: • unplug the power cable from the motor • re-enable the axis • If the problem persists, replace the replace the drive, if the problem disappear, replace the motor.
Short circuit betweenthe motor cables	Disconnect the cable from the motor and from the drive, then check the cable insulation with a multimeter or other suitable tool. Alternatively: • unplug the power cable from the drive side • re-enable the axis
Wrong setting of thecurrent loop	Check the motor parameters stored in the drive configuration.
Damaged internal drive components	If the problem persists after the previous tests, replace the drive.

9.2.2 Alarm for VBUS Voltage Out of Tolerance

Fault		Cause	Action
DC_Link_Under Voltage	Voltage lower than the minimum threshold set	Sensing circuit fault	Measure the voltage on the DC bus and compare with that measured by the drive
DC_Link_Over Voltage	Voltage higher than the maximum threshold set	Brake resistor not connected to the power supply or faulty	Measure the ohm value of the resistor and replace it if necessary

> In the case of controlled braking, the available kinetic energy is regenerated on the DC BUS and is partly stored in the capacitors; the excess, if not dissipated by the braking resistor (RR power supply) can cause a DC_Link_Overvoltage that can damage to the drives..

9.2.3 Drive or Motor Overtemperature

• Excess_temperature_drive

• Motor_temperature_warning

• Motor_over_temperature

In case of excessive drive or motor temperature warning, an analysis of the cause of the problem must be performed according to the following table.

Cause	Action
The drive temperature is high (above 50 °C on the chassis)	Check the efficiency of the cooling fans; if they do not work, replace the drive. Check the continuous current supplied by the axes; if greater than the expected value, check the operation state of the machine.
The temperature of the motor is high (higher than 85 °C on the structure of the motor)	Check that there are no changes in the work cycle of the machine, and that the control parameters are still correct for the application. Make sure the phasing has not changed.
The drive temperature is low (below 50 °C)	A failure of the internal temperature reading circuit is possible.
The engine temperature is low (below 60 °C on the structure of the motor)	There could be a fault in the temperature sensor inside, or an error in the thermal protection settings (software).

9.2.4 Removal of STO Signal

- Safety_stage_low_voltage: STO protection intervention

When the STO circuit removes power, it releases the axis, disabling the output power. If there is a discrepancy between the command and the feedback signal, the STO circuit inside the drive may be damaged. Therefore, verify at both inputs that the absorption at 24 VDC is approximately 50 mA per input. If the absorption is different from that value (null or greater than 200 mA), replace the drive.

9.2.5 Errors on Memory Devices

- eeprom_fault

The drive's internal memory is damaged or inaccessible. Replace the drive.

9.2.6 Data Corrupted Fault

- parameter_initialization_error
- node_identifier_data_memory_corrupted
- user_data_memory_corrupted
- restore_data_memory_corrupted
- factory_data_memory_corrupted
- calibration_data_memory_corrupted
- diagnosis_data_memory_corrupted

If there is invalid information in the memory, the drive signals an alarm. To solve the problem:

- Use the Dx2020 GUI software to verify the correct configuration of the drive, and then save the parameters.

- Reset the drive and restart the Dx2020 GUI software.

If the problem persists, replace the drive.

9.2.7 Brake Feedback Fault

- brake_feedback_fault

This alarm indicates a fault in the motor braking circuit.

The drive controls the voltage output to be consistent with the command. The alarm can be caused by a discrepancy between command and voltage output.

The internal circuit is protected against short circuits, and the protection is triggered if the output current exceeds 2 A for the motor brake. If this happens, the causes can be:

Cause	Action
Short circuit on the connection cable to the brake	Check for short circuits in the brake cable or between the brake cable and ground using a multimeter or other appropriate tool, or: • Disconnect the brake cable on the drive side and enable • If the problem does not reoccur, replace the brake cable
Brake short circuit	Check for short circuits in the brake cable or between the brake and ground using a multimeter or other appropriate tool, or: • Disconnect the brake cable on the motor side and enable • If the problem does not reoccur, replace the motor
Failure detection circuit	• Send the drive for analysis and possible repair

9.2.8 Errors on Feedback Devices

For correct operation, all the feedback signals must arrive at the drive in an appropriate manner. If this does not happen, the causes are indicated by the alarm that specifically identifies what functionality of the transducer is wrong or missing.

To analyze a feedback signal problem, check that the cable is wired correctly, that the signal path is not interrupted, and that the settings are correct. This analysis must be repeated for all the situations described below.

In the Fault Configuration window, the feedback errors are:

- Interface X3-XXX

- Interface X2-XXX

- Interface X1-XXX

Fault Configuration

Fault	Reaction	Status
dc_link_under_voltage	DISABLE	✓
dc_link_over_voltage	DISABLE	✓
excess_temperature_drive	DISABLE	✓
safety_stage_low_voltage	DISABLE	✓
eeprom_fault	DISABLE	✓
memory_card_fault	NONE	✓
software_watchdog	DISABLE	✓
parameter_initialisation_error	DISABLE	✓
node_identifier_data_memory_corrupted	DISABLE	✓
user_data_memory_corrupted	DISABLE	✓
restore_data_memory_corrupted	STOP	✓
factory_data_memory_corrupted	STOP	✓
calibration_data_memory_corrupted	STOP	✓
diagnosis_data_memory_corrupted	NONE	✓
brake_feedback_fault	DISABLE	✓
motor_temperature_warning	EMERGENCY	✓
motor_over_temperature	DISABLE	✓
Interface X3 - Missing transducer configuration	DISABLE	✓
Interface X3 - General Fault	DISABLE	✓
Interface X3 - Resolver synchronization fault	DISABLE	✓
Interface X3 - Resolver signals fault	DISABLE	✓
Interface X2 - Missing transducer configuration	DISABLE	✓
Interface X2 - General Fault	DISABLE	✓

Close

Fault	Cause	Action
Missing Transducer Configuration	Interface transducer enabled but not configured	Configure it
Resolver Signals Fault	Error resolver signal level (amplitude)	Perform compensation of the cable
Resolver synchronization fault	Resolver signal synchronization error (phase)	Check that the cable connections are correct
Erroneous value of sincos signals	Each of these alarms details a problem with the transducer. After investigating and eliminating the lack of feedback or the wrong configuration as the cause, replace the motor.	
Hiperface position conflict		
Hiperface status error		
Hiperface transmit error		
Hiperface receive error		
EnDat22 warning message		
EndDat22 error1 message		
EndDat22 error2 message		
EndDat22 CRC error		
EndDat22 position not ready		
EndDat22 not ready for strobe		

9.2.9 Synchronization , Interrupt Time and Task Time Error

Fault	Cause	Action
Synchronization error	Internal interrupt irregular frequency	Reprogram the drive (firmware and parameters). If the alarm persists, replace the drive
Interrupt_time_exceeded	Internal interrupt signal not detected	
Task_time_exceeded	The execution of the task has exceeded the maximum duration	

9.2.10 EtherCAT Fault

Fault	Cause	Action
EtherCAT_communication_fault	Communication error	Check wiring configuration of the drive communication and/or EtherCAT master
EtherCAT_link_fault	Link to Ethernet not present	
EtherCAT_rpdo_data	PDO data received incorrectly	
EtherCAT_rpdo_time_out	PDO data not received or received after the time out	
EtherCAT_tpdo_data	Data received not transmitted	
EtherCAT_tpdo_time_out	Data not transmitted or transmitted after the time out	
Internal_transmit_pdo_time_out	Communication error, PDO internal data (double axle)	
Internal_receive_pdo_time_out	Timeout, internal PDO communication (dual axis)	

9.2.11 Alarms Related to the Control Loops

Fault	Cause	Action
Velocity Control Monitoring	The maximum speed permitted by the application (set width max speed parameter) has been exceeded.	Check the control signals and their consistency with the configured data and the functioning of the drive
Following Error	The maximum following error allowed by the application (set with a parameter) has been exceeded (in position mode only).	Check the control signals and their consistency with the configured data and the functioning of the drive and of the driven machine

9.2.12 CAN Bus Alarms

Fault	Cause	Action
CAN_communication_fault	PDO data not received or received	Check wiring configuration of

Fault	Cause	Action
	after the timeout	the drive communication and/or the CAN master
CAN_rpdo0_time_out	PDO data not received or received after the timeout	
CAN_rpdo1_time_out		
CAN_rpdo2_time_out		
CAN_rpdo3_time_out		
CAN_rpdo0_data	PDO data received incorrectly	
CAN_rpdo1_data		
CAN_rpdo2_data		
CAN_rpdo3_data		
CAN_tpdo0_time_out	PDO data not received or received after the timeout	
CAN_tpdo1_time_out		
CAN_tpdo2_time_out		
CAN_tpdo3_time_out		
CAN_tpdo0_data	Data not transmitted	
CAN_tpdo1_data		
CAN_tpdo2_data		
CAN_tpdo3_data		
CAN_sync_consumer_time_out	Sync not received or received after the time out	
CAN_life_guard_error	Error on the life guarding protocol	Check the configuration

9.3 Alarm Display in Analog Operating Mode

If the drive is operating in "Analog" mode (Mode and Commands / Mode Operation: Analog), the LED display on the front panel indicates the presence of an alarm and an additional error index, consisting of 2 numerical digits. This allows the operator to identify the cause of the error present without a PC. For example, in the case of an EEPROM fault (Fault Index 13), it will display the error F-1-3.

> If the drive is used in fieldbus mode (EtherCAT/CAN), the display will show a fixed F, the error code will be transmitted through an EMERGENCY message (according to the CANopen standard) using ErrorCode and ErrorRegister.

The following table lists the set of available faults and their descriptions. Note that the hard faults (the first 8 bold rows) are not configurable; the reaction is always "Disable". For details on configuring fault reactions, see System Configuration on page 94.

Fault Index	Error Code	Error Register	Fault	Description
1	0x2344	0x04	short_circuit_phase_U_low	IGBT fault, phase U, low arm
2	0x2345	0x04	short_circuit_phase_U_hi	IGBT fault, phase U, high arm

Fault Index	Error Code	Error Register	Fault	Description
3	0x2346	0x04	short_circuit_phase_V_low	IGBT fault, phase V, low arm
4	0x2347	0x04	short_circuit_phase_V_hi	IGBT fault phase V, high arm
5	0x2348	0x04	short_circuit_phase_W_low	IGBT fault, phase W, low arm
6	0x2349	0x04	short_circuit_phase_W_hi	IGBT fault, phase W, high arm
7	0x2351	0x04	short_circuit_Igbt_rec	Recovery IGBT fault
8	0x2350	0x04	gate_under_voltage	Under voltage of IGBT gate
9	0x3220	0x04	dc_link_under_voltage	Bus under voltage
10	0x3210	0x04	dc_link_over_voltage	Bus over voltage
11	0x4310	0x08	excess_temperature_drive	Excessive temperature of the drive (IGBT thermal mode)
12	0x5114	0x04	safety_stage_low_voltage	Supply of STO circuit not detected (fault active only in Operation Enabled state)
13	0x5530	0x01	eeprom_fault	Error reading the EEPROM or content not valid
14	0x5540	0x01	sd_memory_fault	External memory card not detected.
15	0x6010	0x01	software_watchdog	Software alarm
16	0x6320	0x01	parameter_initialization_error	Initialization error
17	0x6311	0x01	node_identifier_data_memory_corrupted	Memory of the user parameters corrupted or not configured
18	0x6312	0x01	user_data_memory_corrupted	Memory of the user parameters corrupted or not configured
19	0x6313	0x01	restore_data_memory_corrupted	Not used
20	0x6314	0x01	factory_data_memory_corrupted	"factory parameters" region of the memory corrupted or not configured
21	0x6315	0x01	calibration_data_memory_corrupted	Not used
22	0x6316	0x01	diagnosis_data_memory_corrupted	Not used
23	0x7110	0x01	brake_feedback_fault	Brake status signal inconsistent
24	0x7124	0x08	motor_temperature_warning	Warning - motor temperature

Fault Index	Error Code	Error Register	Fault	Description
25	0x7125	0x08	motor_over_temperature	Fault - motor temperature
26	0x73A2	0x01	Interface STD - Erroneous value of sincos signals	Sinusoidal signal amplitude inconsistent (optional interface X1)
27	0x73A3	0x01	Interface STD - Hiperface position conflict	Digital position (Hiperface protocol) inconsistent with the calculated position (optional interface X1)
28	0x73A4	0x01	Interface STD - Hiperface status error	Error - encoder status (Hiperface protocol) (optional interface X1)
29	0x73A5	0x01	Interface STD - Hiperface transmit error	Transmission error encoder (Hiperface protocol) (optional interface X1)
30	0x73A6	0x01	Interface STD - Hiperface receive error	Reception error encoder (Hiperface protocol) (optional interface X1)
31	0x73A7	0x01	Interface STD - EndDat22 warning message	Warning from encoder EnDat 22 (optional interface X1)
32	0x73A8	0x01	Interface STD - EndDat22 error 1 message	Error - type 1 encoder EnDat 22 (optional interface X1)
33	0x73A9	0x01	Interface STD - EndDat22 error 2 message	Error - type 2 encoder EnDat 22 (optional interface X1)
34	0x73AA	0x01	Interface STD - EndDat22 crc error	Error - CRC encoder EnDat 22 (optional interface X1)
35	0x73AB	0x01	Interface STD - EndDat22 position not ready	Error - position not ready encoder EnDat 22 (optional interface X1)
36	0x73AC	0x01	Interface STD - EndDat22 not ready for strobe	Error - strobe not ready encoder EnDat 22 (optional interface X1)
37	0x73AD	0x01	Interface STD - Resolver synchronization fault	Resolver signal synchronization error (phase)
38	0x73AE	0x01	Interface STD - Resolver signals fault	Resolver level signal error (amplitude)

Fault Index	Error Code	Error Register	Fault	Description
39	0x8700	0x01	synchronization_error	Internal interrupt frequency irregular
40	0x6102	0x01	interrupt_missing (was Interrupt_time_exceeded)	Internal interrupt frequency not detected
41	0x6103	0x01	Task_time_exceeded	Execution time of the task exceeded maximum time
42	0x8400	0x01	velocity_control_monitoring	Error - maximum speed exceeded
43	0x8611	0x01	following_error	Position tracking error
44	0x8612	0x01	position_reference_limit	Not used
45	0x8101	0x10	EtherCAT_link_fault	EtherCAT link not detected
46	0x8100	0x10	EtherCAT_communication_ fault	EtherCAT communication generic error
47	0x8231	0x10	EtherCAT_rpdo_time_out	Time out received PDO (EtherCAT)
48	0x8241	0x10	EtherCAT_rpdo_data	Data error received PDO (EtherCAT)
49	0x8235	0x10	EtherCAT_tpdo_time_out	Time out transmitted PDO (EtherCAT)
50	0x8245	0x10	EtherCAT_tpdo_data	Data error transmitted PDO (EtherCAT)
51	0x8181	0x10	Internal_comunication_fault	Generic Fault internal communication (double-axis module)
52	0x8182	0x10	Internal_comunication_ heartbeat_error	Fault - internal communication - the axis 1 (2) does not detect the presence of axis 2 (1) (dual-axis module)
53	0x8183	0x10	internal_receive_pdo_time_ out	Fault - internal communication - PDO reception timeout (double-axis module)
54	0x8184	0x10	internal_transmit_pdo_time_ out	Fault - internal communication - timeout PDO transmission (Double-axis module)
55	0x3100	0x10	Phases_not_ok	Not used
56	0x3200	0x04	over_current	Overcurrent fault
57	0x8100	0x04	CAN_communication_fault	Generic CAN communication fault
58	0x8231	0x10	CAN_rpdo0_time_out	Time out - PDO0 reception (CAN)
59	0x8232	0x10	CAN_rpdo1_time_out	Time out - PDO1 reception (CAN)

Fault Index	Error Code	Error Register	Fault	Description
60	0x8233	0x10	CAN_rpdo2_time_out	Time out - PDO2 reception (CAN)
61	0x8234	0x10	CAN_rpdo3_time_out	Time out - PDO3 reception (CAN)
62	0x8241	0x10	CAN_rpdo0_data	PDO0 data reception error (CAN)
63	0x8242	0x10	CAN_rpdo1_data	PDO1 data reception error (CAN)
64	0x8243	0x10	CAN_rpdo2_data	PDO2 data reception error (CAN)
65	0x8244	0x10	CAN_rpdo3_data	PDO3 data reception error (CAN)
66	0x8235	0x10	CAN_tpdo0_time_out	Time out- PDO0 data transmission (CAN)
67	0x8236	0x10	CAN_tpdo1_time_out	Time out - PDO1 transmission (CAN)
68	0x8237	0x10	CAN_tpdo2_time_out	Time out - PDO2 data transmission (CAN)
69	0x8238	0x10	CAN_tpdo3_time_out	Time out - PDO3 data transmission (CAN)
71	0x8246	0x10	CAN_tpdo1_data	Error - PDO1 data transmission (CAN)
72	0x8247	0x10	CAN_tpdo2_data	Error - PDO2 data transmission (CAN)
73	0x8248	0x10	CAN_tpdo3_data	Error - PDO3 data transmission
74	0x8130	0x10	CAN_life_guard_error	Life guard time expired (CAN)
75	0x823A	0x10	CAN_sync_consumer_time_out	Sync message timeout (CAN)

9.4 Faults During the GUI – Drive Connection

If the communication between the PC and DS2020 system fails, an error message will appear.
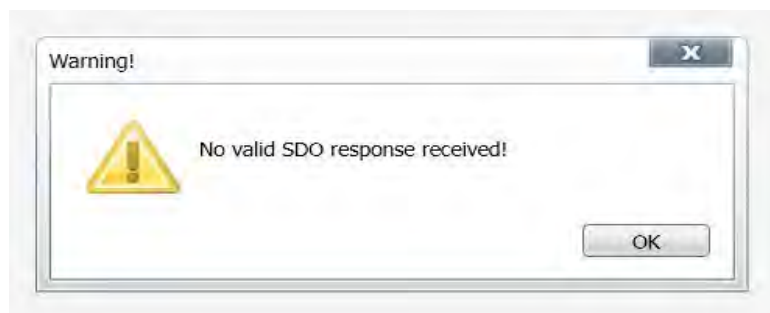
	Other error messages are possible. See the SMI software online help for details.

For a serial connection, verify that:

- The correct COM port is selected

- The baud rate to 115200

For a CAN connection, verify that:

- The CAN bus is properly terminated

- The IXXATe CAN USB adapter is installed along with the appropriate drivers on the PC

- The baud rate and the node are configured to match the settings on the drive

> ⓘ The default baud rate is 500 Kbps. The default node 127.

To check the values set on the drive:

- Connect to the drive using another network

- From the terminal, read the value of the baud rate (canbdr parameter)

- From the terminal, read the ID of the node (modide parameter)

For an EtherCAT connection, verify that:

- The correct network adapter is selected

- The appropriate cable is used

> ⓘ Cat 5 EtherCAT cable must be straight, not crossover.

10 Safe Torque Off Safety Function

This chapter describes the Safe Torque Off (STO) safety function for the DS2020 system.

10.1 Application

The DS2020 system's safety function, Safe Torque Off (STO), has been designed with an integrated redundant circuit in the control board.

It is considered misuse to use the STO function outside of the instructions provided in this guide.

10.2 Installation Risk Assessment

The safety functional requirements of a DS2020 drive depend on the application and should be considered during the evaluation of the overall risk of the installation. If the drive manufacturer is also liable for the operated equipment, the designer of the installation is responsible for the risk assessment, and the specification of requirements for levels of functional integrity and safety integrity levels (SIL) of the drive according to CEI EN 62061: 2005 +A1:2013 +A2:2015 and/or performance levels (PL) according to UNI EN ISO 13849-1: 2016.

The following table, identical to Table 4 of the UNI EN ISO 13849-1: 2016, shows the relationship between performance levels (PL) and safety integrity levels (SIL).

PL	SIL (IEC 61508-1) operational mode high/continuous
a	No match
b	1
c	1
d	2
e	3

Table 1: Relationship Between Performance Levels (PL) and Safety Integrity Levels (SIL)

> Because SIL 4 level refers to catastrophic events, it does not cover the risks relating to machinery. The risk assessment presented by the machine must be carried out in accordance with Directive 2006/42 / EC, referring to UNI EN ISO 12100: 2010 and must contain the safety circuit configuration relating to the entire machine by taking into account all components of the integrated safety system, including the drive.

Also, refer to Risk Assessment on page 24.

10.3 Safe Torque Off Function

The Safe Torque Off safety function of the DS2020 has been validated according to the level of safety integrity SIL 3 as defined in the product standard CEI EN 61800-5-2: 2008 showing that:

- The probability of dangerous failure per hour (PFHd) is 9×10^{-10} hours-1 (see the tables in the following subsections).

The validation of the function and the relative STO circuit involve the use of two distinct types of monitoring: the first consists of a normally closed electric contact (referred to as "Hardware Feedback"), the second is identified by a binary type digital signal (referred to as "Software Feedback") defined by the standard IEC 61800-7-201, CIA 402, Object 60FD (digital inputs), bit 3.

Also, compliance with UNI EN ISO 13849-1: 2016 has been verified using the PFHd calculated by reference to CEI EN 61800-5-2: 2008. According to this standard, STO complies with performance level (PL) "e" (see the tables in the next subsection).

The STO function is located in a subsystem as defined by the Standard CEI EN 62061: 2005 +A1:2013 +A2:2015, with a SIL limit requested SILCL3.

The STO safety function of the DS2020 can also be used to ensuring the safe stop of the injection molding machines, for the interlocked guards in the area of the mold and in other less hazardous areas in compliance with the standard UNI EN 201:2010.

10.3.1 Characteristic Values According to UNI EN ISO 13849-1

Hardware Feedback standard values according to UNI EN ISO 13849-1:2016:

	Value	Observations
Level of performance	PL e	
Category	4	The external subsystems must be capable of carrying out the diagnostic function in correspondence with, or before, the next request of the safety function, for example immediately at power up or at the end of an operating cycle of a machine
MTTFd	> 100 years	According to the UNI EN ISO 13849-1:2016, it can be taken into account a maximum value of 100 years
Diagnostic coverage	DC=99%	The external subsystems that perform the diagnostic function must use techniques capable of providing a DC ≥ 99%
Service life	20 years	Change the drive
Repair Time	8 hours	
Diagnostic test interval	8 hours max	See also the observation relative to the category

Software Feedback standard values according to UNI EN ISO 13849-1:2016:

	Value	Observations
Level of performance	PL e	
Category	4	The external subsystems must be capable of carrying out the diagnostic function in correspondence with, or before, the next request of the safety function, for example immediately at power up or at the end of an operating cycle of a machine
MTTFd	> 100 years	According to the UNI EN ISO 13849-1:2016, it can be taken into account a maximum value of 100 years
Diagnostic coverage	DC = 99%	The external subsystems that perform the diagnostic function must use techniques capable of providing a DC ≥ 99%
Service life	20 years	Change the drive
Repair Time	8 hours	
Diagnostic test interval	8 hours max	See also the observation relative to the category

10.3.2 Characteristic Values According to CEI EN 62061

Hardware Feedback standard values according to CEI EN 62061: 2005 +A1:2013 +A2:2015:

	Value	Observations
Levels of integrity of security	SIL 3	
PFHd	9×10^{-10} hours-1	
Verification test interval	20 years	

Software Feedback standard values according to CEI EN 62061: 2005 +A1:2013 +A2:2015:

	Value	Observations
Levels of integrity of security	SIL 3	
PFHd	9×10^{-10} hours-1	
Verification test interval	20 years	

10.4 Safety Requirements

This section describes the requirements for the Safe Torque Off safety function.

10.4.1 Full Stop

The Safe Torque Off safety function prevents unintended restart of a motor in an arrest status. This circuit can be used in the machine "Safe arrest" function. When the motor is in the process of rotating, the activation of the Safe Torque Off function generates an uncontrolled stop (Category 0 according to EN 60204-1: 2006). When prompted for a controlled stop category 1 according to EN 60204-1: 2006, must be satisfied the condition of motor stop within predefined limits of deceleration or after a delay function of the application. The final machine must be able to stop the motor.

⚠ **WARNING**

WARNING: Electrical hazard.

The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.

➢ Observe the following safety precautions.

⚠ **WARNING**

WARNING: Mechanical hazard.

The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.

➢ Observe the following safety precautions.

- During the risk assessment, the designer must evaluate the stopping time of the machine. The safety function Safe Torque Off time of intervention must be greater than the deceleration ramp braking time set by the drive with maximum speed and maximum load on the axle. The

assessment should include the possibility of a fault. The machine may have a dangerous overload in the event of failure of the motor and additional protective measures may be required to achieve a more secure state.

- Answer time: The maximum response time for the activation and the deactivation of the STO safety function is 10 ms.

- Environmental conditions: (The following conditions have been validated for safety. The other conditions can be found in System Overview on page 27.)

- Ambient temperature: 0 to + 40 °C

- EMC immunity: According to EN 61800-3: 2004, second environment (industrial), category C3 (not suitable for use in the first environment that includes domestic environments)

- Vibration resistance: from 2 to 9 Hz, with a 3 mm amplitude (peak); 9 to 200 Hz, acceleration of 1 g, according to EN 60721-3-3: 1995, Class 3 M4

- Shock resistance: 10 g, half-sine, 11 ms, according to EN 60721-3-3: 1995, Class 3 M4

- Body: The electronic device has to be installed in an enclosure with a minimum degree of protection (IP54).

- Pollution degree 2: The device must be installed in an environment with pollution degree 2, where there is normally only non-conductive pollution. Occasionally, however, there may be a temporary conductivity, caused by condensation, when the electronic device is not in operation.

- When the Safe Torque Off circuit is activated, the motor can no longer produce torque. When external forces are acting on the axis (e.g., through the vertical force of gravity), suitable protection must be provided such as a mechanical automatic lock or a weight equalization system.

- The Safe Torque Off function does not provide electrical isolation. There is no protection against electric shock. The machine or the system must always be electrically isolated from the power line through the main disconnection device and locked (lockout/tagout) in the disconnect position, before performing any work on the machine or system, such as maintenance, service or cleaning (refer to EN 60204-1: 2006, par. 5.3). The staff must be aware that exposed connection surfaces can carry dangerous voltages even after power off (capacitive voltage), and that the discharge time is about 6 minutes.

10.5 Safe Torque Off Circuit

The Safe Torque Off function is designed with redundant blocking devices, which act independently on the power modules. This is advantageous because it does not disable the power supply of the drive and avoids the normal restart process.

⚠ WARNING
WARNING: Personal injury and property damage risk. **The restart of the STO function is automatic when the safety inputs are active, which may cause death or serious injury to personnel or damage to equipment.** ➢ It is the responsibility of the machine manufacturer to check and install, if necessary, a manual reset function to prevent the automatic restart of the motor.

The DS2020 system controls the movements of a three-phase AC motor through the generation of a rotating magnetic field. To this end, the microprocessor generates a complex pattern of pulses (PWM), which are amplified and used to pilot the power semiconductors. The Safe Torque Off function of the DS2020 system operates through hardware with two channels that interrupt the direct impulses to IGBT.

Two modes of monitoring are provided for detecting dangerous faults: the monitoring system "Hardware Feedback" indicates the status of the circuit; the same information is available through the "Software Feedback" a system consisting of a binary digital signal defined by the IEC 61800-7-201, 402 CIA Object 60FD, (digital inputs) bit 3.

10.6 Safe Torque Off Connections

Management channels, including the "Hardware feedback" of the Safe Torque Off circuit, are controlled using the X6 Connector, also referred to as JRC1.

Both of the monitoring channel modes are always available. It is the user's prerogative to choose which type of monitoring to use; "Hardware feedback", "Software feedback" or both features simultaneously.

10.6.1 Connector X6 – JRC1

The following figure and table describes the connector pinouts: 6 contacts, Weidmüller model B2 3.50 / 06/180 SN BK BX. Note that the drive's power stage cannot start until STO signals are not active.
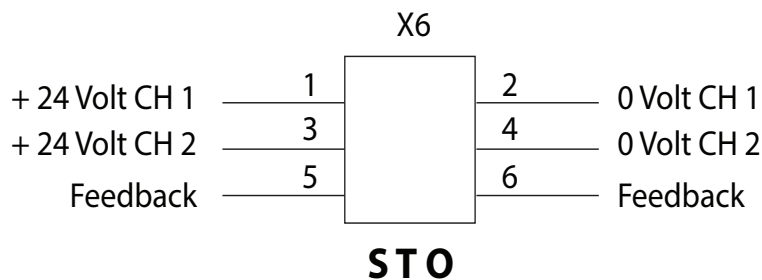
Figure 29: Movable Connector Pinout: 6 Contacts, Model B2 3.50 / 06/180 SN BK BX Weidmuller

Pin	Name	Function
1	+ "Channel 1"	+24 VDC input of Channel 1. This input must be high (+24 V) to power the motor. When the input goes low (0V), the motor is not powered.
2	- "Channel 1"	0V of Channel 1
3	+ "Channel 2"	+24 VDC input of Channel 1. This input must be high (+24 V) to power the motor. When the input goes low (0V), the motor is not powered.
4	- "Channel 2"	0V of Channel 2
5	Monitoring Channel	The "hardware feedback" electrical contact uses a "Photo-Mos" fuse protected relay . When both control channels, "Channel 1" and "Channel 2", are low (0V), the STO circuit is in a safe state (safety function enabled), the monitoring signal is active and provides closed contact. In all other cases, the tracking signal is always off and provides open contact. To properly run the plausibility check, the Monitoring Channel of the complete system must include this signal.
6	Hardware Feedback	

⚠ **WARNING**
WARNING: Electrical hazard. The DS2020 system and connected motor may present an electrical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.   ➢ Observe the following safety precautions.

⚠ **WARNING**
WARNING: Mechanical hazard. The DS2020 system and connected motor may present a mechanical hazard if the safety precautions are not observed, which may result in death or serious injury to personnel, or damage to equipment.   ➢ Observe the following safety precautions.

- To be validated according to categories 1 to 4, according to the basic safety principles of the UNI EN ISO 13849-2: 2013, tab. D.2, the external cables entering the JRC1 connector must have the screens connected to the grounding circuit.

- To avoid common failure causes, the cable of the "Channel 1" (pins 1, 2 and 6 of JRC1) must be separated from the cable of the "Channel 2" (pins 3, 4 and 5 of JRC1) during the installation.

- To prevent a short circuit between the input and the verification signal, the mufti-strand wires of the two channels should be terminated with cable lugs or other appropriate devices.

- The verification of the two channels of the signal wiring must be protected against short circuits from the voltage sources. Never apply external power to the verification signal, even in case of failure.

10.6.2 Electrical Input/Output Specifications

Input Channel	Inom = 30 mA (± 10%) Vnom = 24 Vcc (± 10%) Vmax = 30 Vcc
Output – Verification Channel	Imax = 200 mA Vmax = 30 Vdc

10.7 Example Application

The following figure illustrates an example circuit for Safe Torque Off after a controlled stop.
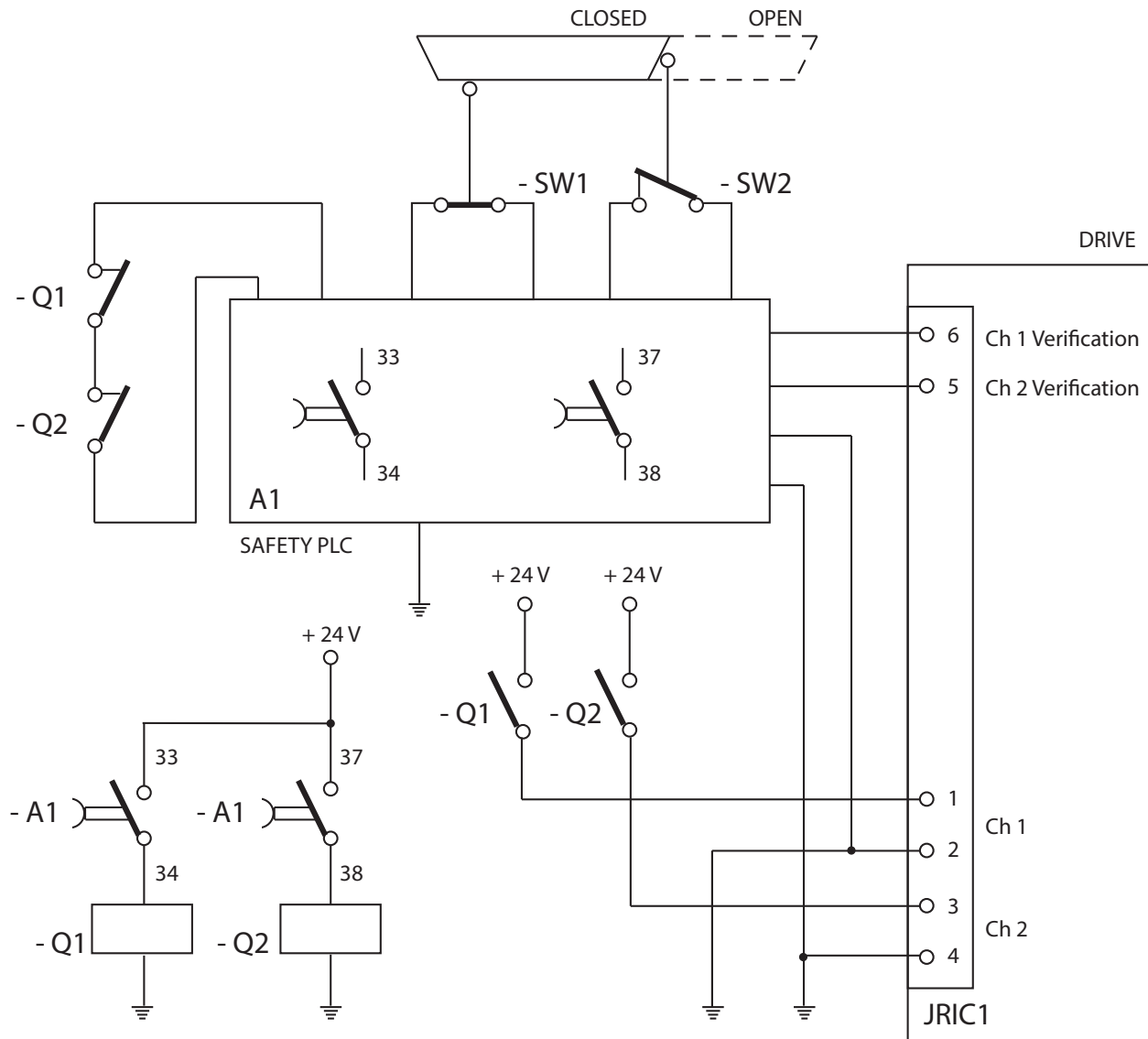
Figure 30: Example of Safe Torque Off After a Controlled Stop

10.7.1 Description

Two redundant channels are used. The switches SW1 and SW2 are connected to an A1 safety PLC that controls two contactors, Q1 and Q2, with associated contacts. The NO contacts of Q1 and Q2 control the two input channels of the DS2020 safety for the shutdown of the motor power connections. The NC contacts of Q1 and Q2 are used in series to control the A1 safety PLC in the event of welding of a NO contact. The two output safety channels of the DS2020 are connected to an A1 safety PLC to allow the diagnostic coverage of the DS2020 subsystem.

> In the example, the controlled stop can be achieved using the delayed outputs of A1. The controlled stop is not an integrated security function in the drive. Therefore, its circuit is not shown in the figure.

According to UNI EN ISO 13849-1:2016, the subsystem to the input and output devices can reach PL=e because:

- The channels are redundant

- The switches SW1 and SW2 have high MTTFd and DC

- The SW2 switch operates with positive opening

- Q1 and Q2 have high MTTFd and DC

- CCF value is > 65

Subsystems:

- PLC A1 has PL = e

- DS2020 drive (STO circuit) has PL = e

The security system can reach PL = e and the Category is 4.

According to CEI EN 62061: 2005 +A1:2013 +A2:2015, the subsystem to the input and output devices can achieve SIL 3 because:

- All safety-related devices have PFHd <10^{-7}

Subsystems:

- Safety PLC A1 has SIL 3

- DS2020 drive (STO circuit) has SIL 3

The safety system can reach SIL 3.

10.7.2 Example Requirements

- Before activating the STO function, it is necessary to stop the motor while maintaining the power supply during the stop (controlled stop).

- Delay of outputs A1, which operate the contactors Q1 and Q2, should be > T (general shutdown capability).

- The A1 safety PLC has to fulfill the requirements for PL e according to UNI EN ISO 13849-1:2016.

- The Q1 and Q2 safety contactors should be linked to contacts according to IEC 60947-5-2, Annex L ("mirror contacts").

- In accordance with the risk assessment, when it is possible that personnel can physically enter the danger zone, i.e., beyond the protective cover or barrier: either a detection system must be installed; or, the restart must be available only after the safety guards are back in place and it is confirmed that no personnel is in the danger zone.

- A short circuit between conductors connected to 33-34 A1, between conductors connected to 37-38 A1, and between those connected to pins 1 and 2 of the drive must be avoided.

- There must be physical separation between signal paths.

- The multi-wired cables connected to the multi-pole connectors must be terminated with cable lugs or other appropriate devices.

- The verification of the two channels of the signal wiring must be protected from short circuit to voltage sources and should never be exposed to voltage external to the verification signal, even in case of failure.

- The safety system must be validated according to UNI EN ISO 13949-2: 2013

10.8 Safe Torque Off Installation and Maintenance Procedure

The following method of installation and maintenance should always be performed as indicated and by qualified personnel who are familiar with the safety procedures required by current regulations:

- On the first start

- At restart in the event that a fault has been detected and removed

- Otherwise, at least every 8 hours

Run the sequence of on/off commutation shown in the following figure by providing +24 VDC and 0V on the two input channels connected to the X6-JRC1 connector; perform a plausibility check with monitoring signals:

- Hardware feedback: on the JRC1 connector, contacts 5:06, check closed (ON) or open (OFF) electrical contact

- Software feedback: check the "INTERLOCK STATUS" parameter value, object 60FD (digital inputs), bit 3, defined by the standard IEC 61800-7-201, CIA 402

⚠ WARNING
⚠ WARNING: Personal injury and property damage risk.
If one of the conditions in the following figure is not met, the STO function cannot be used, which may result in death or serious injury to personnel, or damage to equipment.
➢ After the fault has been removed, the procedure must be repeated.

The following figure illustrates the STO mandatory sequence circuit test.
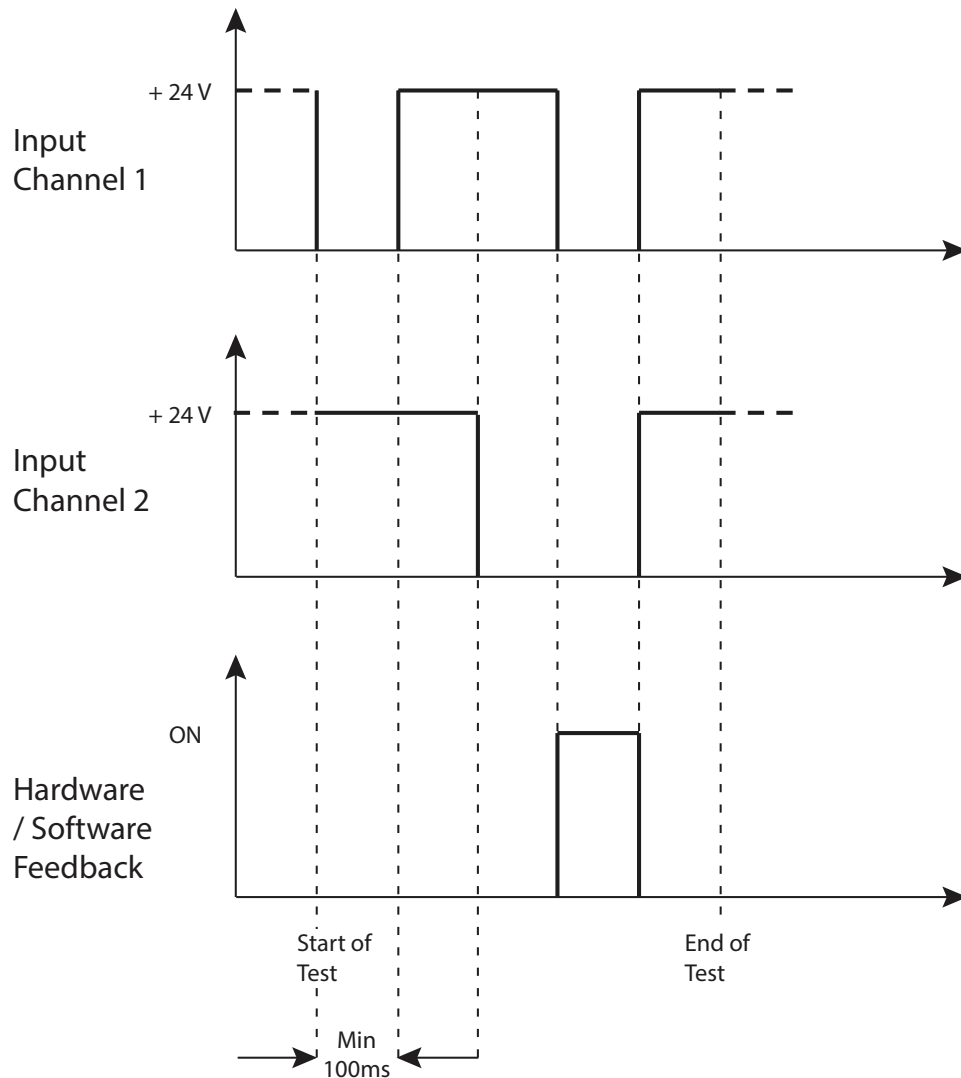
Figure 31: STO Mandatory Sequence Circuit Test

Stop Category 1

- Disable the protection devices, e.g.. open safety guards, while the motor is running, and check that the motor goes into an arrest state.

- If the arrest is a Category 1 according to EN 60204-1: 2006, check that the motor is braked in a controlled manner and that the Safe Torque Off function is active after the arrest. This should not cause dangerous situations.

10.9 Assembly and Serial Tests

The Safe Torque Off (STO) circuit is assembled and tested at Moog Casella.

10.10 Identification of the STO Function on the Drive Plate

The Safe Torque Off circuit is identified by the words "Safe Torque Off" on the drive plate. For an example, see Example Drive Plate on page 31.

11 System Disposition

⚠ CAUTION
In accordance to Directive 2012/19 / EC electronic devices are "special waste" and should receive treatment and professional disposal. ➢ After notification, the old system components and related accessories can be returned at the sender's expense to Moog Casella for the correct disposal.

When disposing of a DS2020 system, recycle the components per the regulations applicable for your site (National/International standards or regulations).

Alternatively, you may choose to return the components to Moog Casella for disposal. Contact your Moog Casella representative for information on motor disposal.

11.1 What to Do If Repairs Are Required?

If repair of a Moog drive or motor is needed, an RMA (Return Material Authorization) number is required to return the motor. Instructions for packaging and shipping the motor back to Moog will be provided with the RMA. Contact your Moog Casella representative for more information.

12 Ordering Code

12.1 DS2020 Ordering Code

DS2020 part numbers are encoded to include the drive size, mechanical configuration, and various options. To "decode" an existing part number or find the correct part number for a drive you wish to order, see Model Codes on page 32.

12.2 Moog Motor Ordering Code

Moog motor part numbers are encoded to include the motor size, stack length, rated speed, and various options. To "decode" an existing part number or find the correct part number for a Moog motor you wish to order, see the Ordering Code section of the installation guide for your Moog motor.

13 Appendix

This chapter provides a glossary and metric/AWG conversion table.

13.1 Example I/O Connections on X5

The following figure shows some example I/O connections on the X5 I/O connector of the DS2020 system.
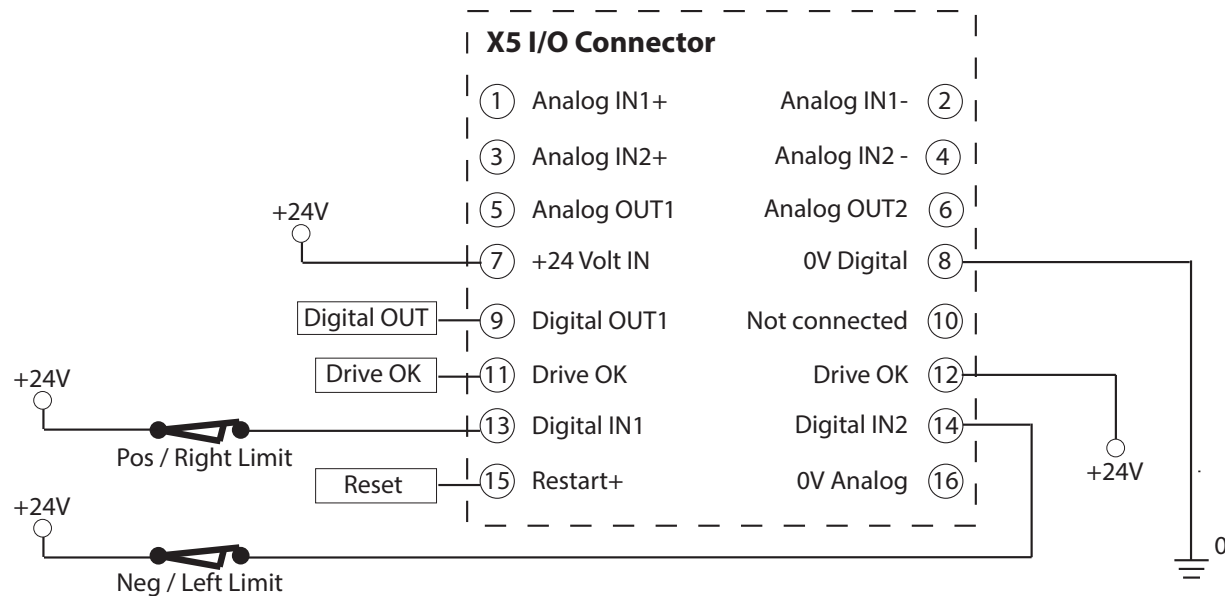
Figure 32: Example I/O Connections on the X5 Connector

- Positive and negative limit switches are normally-closed contacts that connect Digital IN1 and Digital IN2 to an external 24 VDC supply, referenced to 0V Digital (pin 8). When the limit switch is opened (so, the digital input is not connected), it is considered as asserted (limit is reached).

- Digital OUT1 (pin 9) can be driven by the OUT(5)=x command. To power it, an external +24 VDC supply must be connected to +24 Volt IN (pin 7) and 0V Digital (pin 8).

- Drive OK (pins 11 and 12) are a relay contact in the DS2020 drive, which is isolated from the rest of the system. You can supply one of the two pins (e.g., pin 12) with +24 VDC to get a Drive OK signal on the other pin (e.g., pin 11).

13.2 Example RS-485 Driver on X4

An example RS-485 driver using the SN75176 IC is shown, refer to the following figure. Its purpose is to convert a single-ended Drive Enable signal into a differential signal used by the DS2020 system.

Figure 33: Example RS-485 Driver Using the SN75176 IC

A similar circuit can be built around any other RS-485 transceiver IC. Consult the IC's datasheet for pinout details.

13.1 Glossary

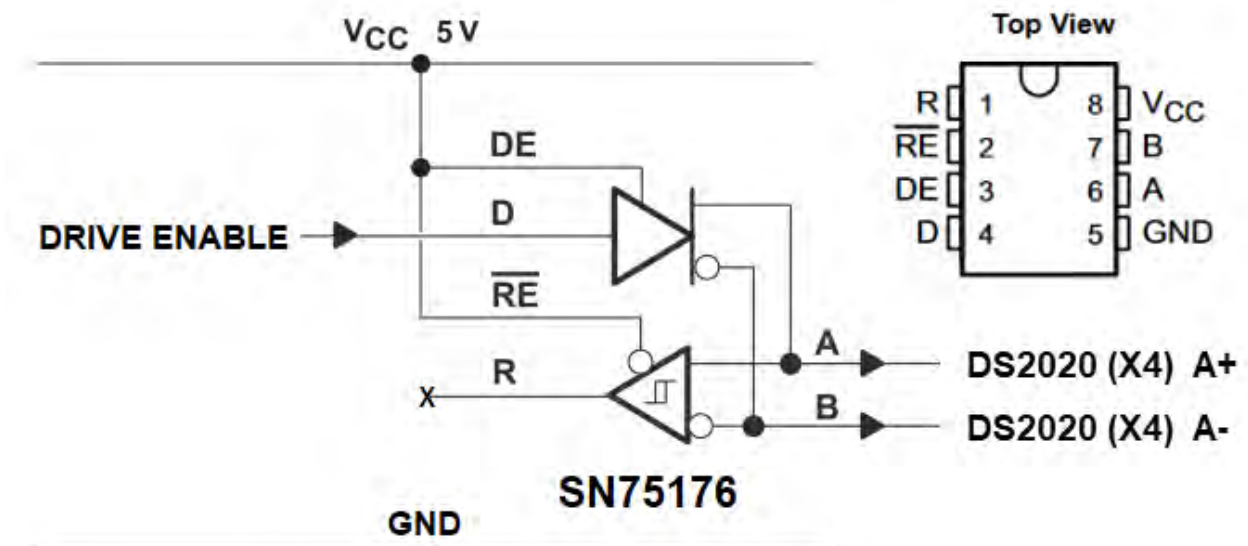| A	
Acceleration	The rate of increase of velocity with respect to time
Alarms	Irregular operating situations highlighted by LED or display message, with subsequent analysis through the Dx2020 GUI
Asynchronous Motor	Motor in which the rotor and the magnetic field turn at different speeds.
B	
Base control board	Section of the main control circuit with interface to other internal or external functions and slots for optional modules.
Brushless motor	Class of motors that operate using electronic commutation of phase currents rather than electromechanical (brush-type) commutation. Brushless motors typically have a permanent magnet rotor and a wound stator.
C	
CANopen	CANopen is a communication protocol used in automation systems. The communication profiles and the basic specifications of the CANopen devices are provided by the CAN in Automation (CiA) draft standard CiA 301. The motion control is specified in CiA 402.
Capacitance to ground	The drives and the power supply have a capacitance to ground (the metal case) composed mainly by the capacitors on the DC bus circuit. This provides a low impedance connection for high frequency current dispersion.
DC bus	Circuit composed of the rectified and flattened supply voltage.
Braking Circuit	Circuit that converts the excess energy regenerated by the motor into heat during the deceleration phase.
Circuit, short	Typically unintended electrical conduction between two phases or conductors with different polarity of an alternating or continuous voltage.
Clock	Timing signal.
Controller	A term describing a functional block containing an amplifier, power supplies and possibly position-control electronics for operating a servomotor or step motor.
Control loops	Set of hardware and firmware circuits that determine the control of the quantities relating to torque, speed and position on the basis of the values measured by the relative sensors. They can be closed or open. Closed control loops are based on sensors for the feedback signals: resolvers and encoders for position and speed loop; Hall effect current sensors for the current loop. A typical open control loop is related to the control voltage/frequency (V/f) of an asynchronous motor without speed transducer.
Convection	Free movement of air (not forced) for cooling.
D	
DC bus - Intermediate circuit	The power supply for the individual axis modules formed from the rectified grid voltage and filtered by powerful capacitors.
Disable	Removes the ENABLE signal.
Deceleration	The rate of decrease of velocity with respect to time
Display	Part of the front panel used for the visual signaling of information.
Directive (Machine)	The Machinery Directive is a set of rules defined by the European Union,

	which serve to provide the necessary requirements for health and safety relating to the design and construction of machinery present on the European market. It applies to fixed, mobile, transportable and hoisting/moving.
Directive (Low Voltage)	The Low Voltage Directive concerns machinery in which electric low voltage circuits are present. The manufacturer must compile a technical dossier, make a declaration of conformity, and affix the CE marking.
Dispersion towards ground	Current (usually of reduced intensity) flowing from a wire to ground.
Dynamic braking	The energy accumulated by the motor during the acceleration is converted into heat through the braking resistor.
Directive (EMC)	The EMC Directive requires that all electrical and electronic devices placed on the market from 1 January 1996 must satisfy the essential requirements of electromagnetic compatibility. The essential electromagnetic compatibility requirements are met by applying the harmonized technical standards published in the EU Official Journal. The harmonized standards can be essentially divided into: • Product standards • Generic standards • Basic standards
E	
Electric Drive	Electric power converter for controlling torque speed and position of a motor. It consists of four main parts: • Rectifier of AC mains voltage • DC link voltage rectified and leveled • Inverter of the rectified voltage • Control circuit that transmits signals for the switching of the power semiconductors of the inverter
Electrical noise	Set of unwanted signals or current that overlap the useful signal, typically transmitted on a communication channel between electronic devices.
EMC	Radio frequency emitted during electronic power equipment operation, likely to generate or induce disturbances in other electronic equipment.
Emissions	Electromagnetic interference caused by electronic equipment operating at frequencies likely to generate or induce disturbances.
Enable	Signal that enables the drive.
Encoder	Motor feedback component that detects a change in position of the shaft and transmits it to the drive for controlling the motor.
Encoder, incremental	Motor feedback component that detects incremental changes in the position of the shaft and transmits that to drive for controlling the motor.
Encoder, simulated	TTL encoder signals (A, B and C) differential line drivers generated by the drive, starting from internal information, to emulate an encoder.
Encoder, sinusoidal	Motor feedback component that detects incremental changes in the position of the shaft and transmits that to the drive for controlling the motor. The information is acquired through the reading of two sinusoidal signals that are sampled from the drive.
EnDat 22	Serial protocol for communication with Heidenhain encoder. Allows the reading of the position of absolute encoders, as well as updating and saving data

	stored in the encoder. It is compatible with the previous version, EnDat 21, but offers advantages such as the transfer of other data together with that of position without a separate request.
EtherCAT	Communication protocol implemented on the Ethernet network for the synchronous transmission of information.
Ethernet	High speed data communication network.
F	
Filter, EMC	Device that reduces noise generated by the power supply cables.
FMEA	Failure Mode and Effects Analysis.
Fieldbus	An industrial network structure that allows communication between different devices. The digital information is transferred from one or more sources to one or more destinations using network topologies like ring, star, daisy chain, etc., as defined by the specific fieldbus protocol.
Fuses	Overcurrent protection devices
G	
Grade of protection (Protection grade)	Security level of the system components.
Ground	Connection of the conductor or the frame to the ground connector.
GUI	Graphical User Interface.
H	
Hiperface	Fully digital, synchronous, two-way, multi-channel protocol to transfer position information and speed; it requires minimal wiring between the drive and feedback from the motor (2-wire).
I	
IGBT	Semiconductor devices for the control of PWM switching..
Interface Fieldbus	EtherCAT or CANopen
IFOC (control)	Indirect Field Oriented Control
M	
Machine	Set of mechanical devices, connected to each other of which at least one is in motion.
Multiaxis system	Machine with two or more axes that can be driven/controlled independently.
R	
Rectifier	Circuit that converts an AC voltage into a DC voltage.
Regulator, P	Control circuit functioning in a purely proportional manner.
Regulator, PI	Control circuit functioning in a proportional and integral manner.
Regulator, PID	Control circuit functioning in a proportional, integral and derivative manner.
Reset	Restart the microprocessor.
Resistor, braking	When the motor decelerates, a braking resistor converts the kinetic energy of the motor into heat. The braking resistor automatically intervenes in the braking circuit when the DC bus voltage exceeds its threshold.
Resolver	Analog motor feedback component that detects a change in position of the shaft and transmits it to the drive for controlling the motor.
RS-232	A common standard that defines the serial transmission of signals with the same voltage level. Suitable for low transmission rates and limited distances.

S	
Serial Communication	Transmission based on sending each signal at different times (i.e., one after the other).
Shield	Devices designed to reduce electromagnetic emissions.
Servodrive	Drive that operates the regulation of torque, speed and position of a servomotor.
Safety	All necessary protective and operational measures to prevent death or injury to personnel and prevent damage to property.
Soft-start	Circuit for limiting the power from the supply to the system during power up
Stiffness	Capacity of a mechanical system to withstand the stresses or disorders that are applied from outside.
STO	Safe Torque Off: protection against unexpected restart. The STO function safely interrupts the power supply to the motor.

13.2 Metric/AWG Conversion Table

AWG	Diameter		Cross-section		Ohmic resistance at 20 °C	Weight
	mils	mm	Circ. mils	mm2	W/km	g/m
44	2.0	0.50	4.00	0.0020	8498	0.0180
43	2.2	0.055	4.84	0.0025	7021	0.0218
42	2.5	0.063	6.25	0.0032	5446	0.0281
41	2.8	0.071	7.84	0.0039	4330	0.0352
40	3.1	0.079	9.61	0.0049	3540	0.0433
39	3.5	0.089	12.3	0.0062	2780	0.0552
38	4.0	0.102	16.0	0.0081	2130	0.0720
37	4.5	0.114	20.3	0.0103	1680	0.0912
36	5.0	0.127	25.0	0.0127	1360	0.1126
35	5.6	0.142	31.4	0.0159	1080	0.1412
34	6.3	0.160	39.7	0.0201	857	0.1785
33	7.1	0.180	50.4	0.0255	675	0.2276
32	8.0	0.203	64.0	0.0324	532	0.2886
31	8.9	0.226	79.2	0.0401	430	0.3571
30	10.0	0.254	100	0.0507	340	0.4508
29	11.3	0.287	128	0.0649	266	0.5758
28	12.6	0.320	159	0.0806	214	0.7157
27	14.2	0.361	202	0.102	169	0.9076
26	15.9	0.404	253	0.128	135	1.1383
25	17.9	0.455	320	0.162	106	1.4433
24	20.1	0.511	404	0.205	84.2	1.8153
23	22.6	0.574	511	0.259	66.6	2.3064
22	25.3	0.643	640	0.324	53.2	2.8867
21	28.5	0.724	812	0.411	41.9	3.6604
20	32.0	0.813	1020	0.519	33.2	4.6128
19	35.9	0.912	1290	0.653	26.4	5.8032
18	40.3	1.02	1620	0.823	21.0	7.3209
17	45.3	1.15	2050	1.04	16.6	9.2404
16	50.8	1.29	2580	1.31	13.2	11.6212
15	57.1	1.45	3260	1.65	10.4	14.6885
14	64.1	1.63	4110	2.08	8.28	18.4512
13	72.0	1.83	5180	2.63	6.56	23.3616
12	80.8	2.05	6530	3.31	5.21	29.4624
11	90.7	2.30	8230	4.17	4.14	37.0512

AWG	Diameter		Cross-section		Ohmic resistance at 20 °C	Weight
	mils	mm	Circ. mils	mm2	W/km	g/m
10	101.9	2.588	10380	5.26	3.277	46.7232
9	114.4	2.906	13090	6.63	2.600	58.9248
8	125.5	3.264	16510	8.37	2.061	74.4000
7	114.3	3.655	20820	10.55	1.634	93.744
6	162.0	4.115	26240	13.30	1.296	118.1472
5	181.9	4.620	33090	16.77	1.028	148.8
4	204.3	5.189	41740	21.15	0.8152	187.488
3	229.4	5.287	52260	26.67	0.6466	235.592
2	257.6	6.543	66360	33.62	0.5128	299.088
1	289.3	7.348	83690	42.41	0.4065	376.464
1/0	324.9	8.252	105600	53.49	0.3223	474.672
2/0	364.8	9.266	133100	67.43	0.2557	599.664
3/0	409.6	10.40	167800	85.01	0.2028	755.904
4/0	460.0	11.68	211600	107.22	0.1608	953.808

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WHEN PERFORMANCE REALLY MATTERS

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