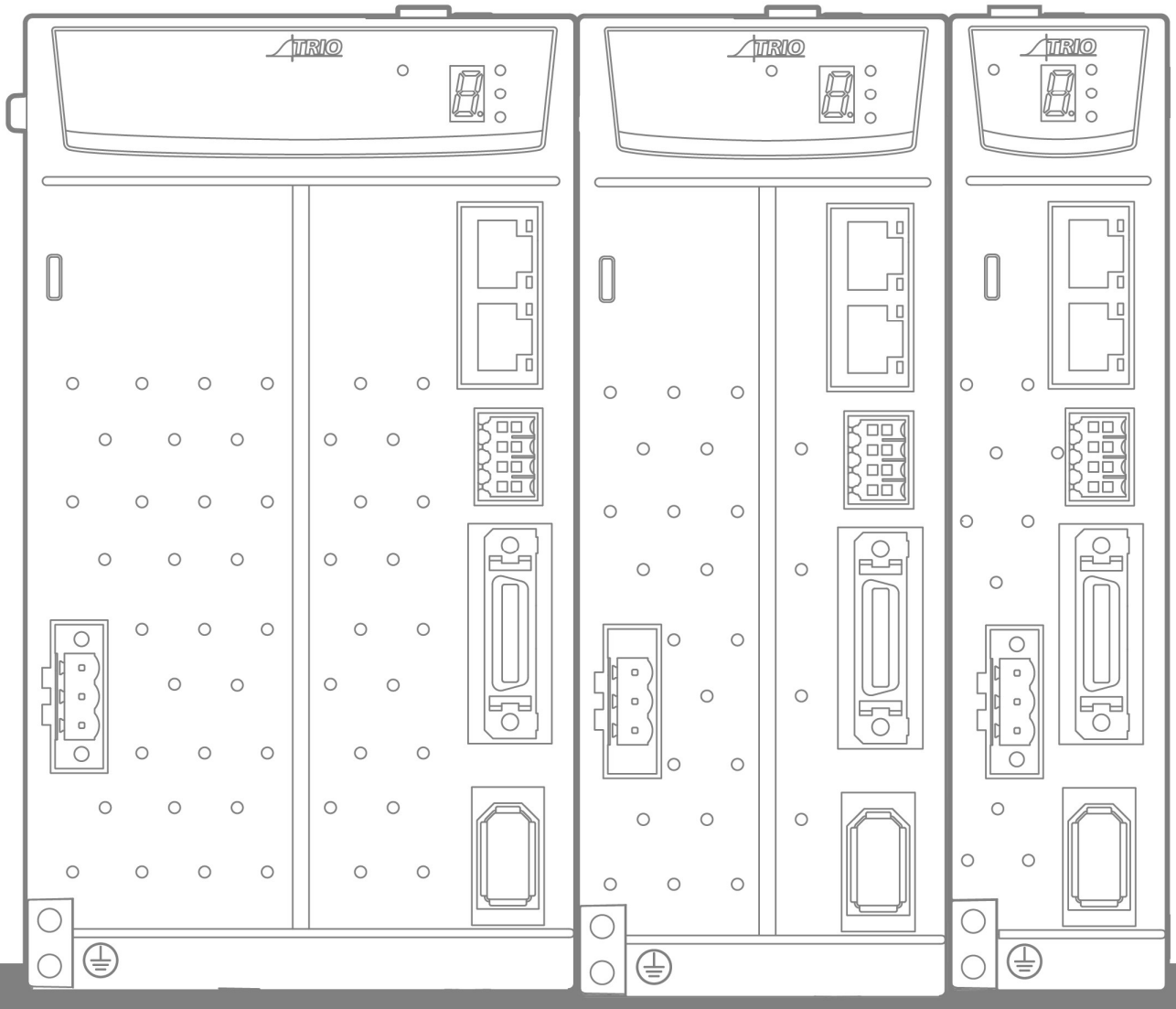
TRIO
MOTION TECHNOLOGY

A MEMBER OF THE ESTUN GROUP



DX4

SINGLE AXIS SERVO DRIVE

USER MANUAL

About this Manual

Purpose

This manual provides the information required for the Selection, Wiring, Connection, Setup, Trial Operation, Tuning and Functions of the DX4 Servo Drive (referred to as **DX4**).

Please read and understand this manual to ensure correct usage of the product.

Terms

Terms that may be used in this manual are defined as follows.

Term	Meaning
Motor	A Rotary Servo Motor.
Drive	A Servo Drive, which is used for controlling the motion of the Motor.
Servo System	A Servo Control System that includes a Motor, a Drive with a host controller and peripheral devices.
Servo ON	Supplying power to the Motor.
Servo OFF	Not supplying power to the Motor.
Motion Perfect	The PC Tool for commissioning and programming the Trio product suite.
STO	The Safe Torque Off function provides a safe means for preventing the Drive from generating torque in the Motor.
Fully Closed Loop	Dual encoder feedback

Symbols

The symbols that may be found in this document are defined as follows.

Symbol	Description
 DANGER	Indicates a hazard with a high level of risk that, if not avoided, may result in death or serious injury.
 WARNING	Indicates a hazard with a medium or low level of risk which, if not avoided, could result in minor or moderate injury.
 CAUTION	Indicates a potentially hazardous situation that, if not avoided, could cause equipment damage, loss of data, performance degradation, or unexpected results.
 IMPORTANT	Indicates precautions or restrictions that must be observed. Also indicates alarm displays and other precautions that will not result in machine damage.
 NOTE	Provides additional information to emphasize or supplement important points of the main text.

The names of inverted signals (ones that are taken effect when low) are written with a forward slash (/) before the signal abbreviation. For example:

$\overline{\text{S-ON}}$ = /S-ON $\overline{\text{P-CON}}$ = /P-CON

Parameters are referenced as PnXXX where XXX refers to a unique number. Some parameters have multiple functions encoded within a single parameter. For these parameters, sub-indices are used to reference the multiple functions.

For example:

Pn112 Speed Feedforward - is a single value without any sub-indices

Pn000 Basic Function Selection 0 - is made up of 4 sub-indexes describing different functions

- Pn000.0 Servo ON
- Pn000.1 Forward Drive Prohibit Input (P-OT)
- Pn000.2 Reverse Drive Prohibit Input (N-OT)
- Pn000.3 Reserved parameter (Do not change)

Safety Precautions

General Precautions

- Never remove covers, cables, connectors, or optional devices while power is being supplied to the Drive.
- Wait for five minutes after turning the power supply OFF and then make sure that the CHARGE indicator is not lit before starting wiring or inspection work.
- Never touch the power supply terminals after turning OFF the power supply while the CHARGE lamp is lit, because high voltages may still be present in the Drive.

- Use a power supply that is appropriate for the product, check number of phases, voltage, frequency, and AC/DC type.
- Connect the ground terminals on the Drive and Motor to ground poles according to local electrical codes.
- Never damage, pull on, apply excessive force to, place heavy objects on, or pinch cables.
- Never attempt to disassemble, repair, or modify the product.
- Make sure that the device in an emergency stop state at any time when the product has been connected to the machine and ready for the operation.
- Never touch inside the Drive.

- The Drive heat sinks, regenerative resistors, Motor, and other components can be very hot while power is ON or soon after the power is turned OFF. Implement safety measures, such as installing covers, so that hands and parts such as cables do not come into contact with hot components.
- For the control power supply, use a power supply device with double insulation or reinforced insulation.
- Never use the product in an environment that is subject to water, corrosive gases, or flammable gases, or near flammable materials.
- Never attempt to use a Drive or Motor that is damaged or that has missing parts.
- Install external emergency stop circuits that shut OFF the power supply and stops operation immediately when an error occurs.
- In locations with poor power supply conditions, install the necessary protective devices (such as AC reactors) to ensure that the input power is supplied within the specified voltage range.
- Always use a Noise Filter to minimize the effects of electromagnetic interference.
- Always use a Motor and Drive in one of the specified combinations.
- Never touch a Drive or Motor with wet hands.

Storage Precautions

- Follow all instructions on the packages, and never place an excessive load on the product during storage.
- Never install or store the product in any of the following locations.
  - Locations that are subject to direct sunlight
  - Locations that are subject to ambient temperatures that exceed product specifications
  - Locations that are subject to relative humidity that exceed product specifications
  - Locations that are subject to corrosive or flammable gases
  - Locations that are subject to dust, salts, or iron powder
  - Locations that are subject to water, oil, or chemicals
  - Locations that are subject to vibration or shock that exceeds product specifications
  - Locations that are subject to radiation

Installation Precautions

- Install the Drive in a control cabinet that provides fire and electrical protection.
- Install the Drive and Motor in a way that will support their mass.
- Never install or store the product in any of the following locations.
  - Locations that are subject to direct sunlight
  - Locations that are subject to ambient temperatures that exceed product specifications
  - Locations that are subject to relative humidity that exceed product specifications
  - Locations that are subject to corrosive or flammable gases
  - Locations that are subject to dust, salts, or iron powder
  - Locations that are subject to water, oil, or chemicals
  - Locations that are subject to vibration or shock that exceeds product specifications
  - Locations that are subject to radiation
- Never allow any foreign matter to enter a Drive or a Motor with a Cooling Fan.
- Never cover the outlet from cooling fan of Drive or Motor.
- Never step on or place a heavy object on the product.
- Install the Drive in the specified orientation.
- Provide the specified clearances between the Drive and the control cabinet as well as with other devices.

Wiring Precautions

- Never bypass the electromagnetic contactor in the wiring between the Drive and the Motor.
- Firmly connect the power terminal to the Motor terminal.
- Provide an adequate air gap around the Drive installation.
- Use shielded twisted-pair cables or screened unshielded multi-twisted-pair cables for I/O Signal Cables and Encoder Cables.
- The wiring length of the command input line is up to 3 meters, and the wiring length of the encoder is up to 20 meters.
- Minimize the frequency that the power supply is turned ON and OFF.

Operation Precautions

- In order to prevent accidents, please test the Motor with no load (not connected to the Drive shaft).
- When starting to operate on the supporting machine, set the user parameters that match the machine in advance.
- Note that the signals for the Forward Drive Prohibit (P-OT) and the Reverse Drive Prohibit (N-OT) are disabled during JOG operation.
- When overtravel occurs, the power supply to the Motor is turned OFF and the brake is released. If the Motor is used to drive a vertical load, set the Motor to enter a 'zero-clamped' state after the Motor stops. Also, install safety devices (such as an external brake or counterweight) to prevent the moving parts of the machine from falling.
- If not using auto-tuning, make sure that an appropriate moment of inertia ratio is setup to avoid vibration.
- If an alarm occurs, reset it after troubleshooting the cause and ensuring safety.
- Never use the brake of the Motor for normal braking.

Maintenance Precautions

- Wiring and inspections must be performed only by qualified engineers.
- Disconnect all connections to the Drive when testing the insulation resistance of the Drive.
- Never use gasoline, thinner, alcohol, acid or alkaline detergent to avoid discoloration or damage to the casing.
- When replacing the Drive, transfer the user parameters from the replaced Drive to new Drive.
- Never change the wiring while the power is on.
- Never disassemble the Motor without permission.

Disposal Precautions

- When disposing of the product, treat it as ordinary industrial waste. However, local ordinances and national laws must be observed. Implement all labeling and warnings as required.

Contents

Chapter 1 DX4 Servo Drive

1.1 Product Features

The DX4 single axis AC servo drive is designed to work seamlessly with Trio controller and is fully integrated into Trio's application development tool, *Motion* Perfect. It comes in power ratings from 50 W to 3 kW. Matched with the MX motors it offers a high-speed, high-precision machine solution.

Integration into *Motion* Perfect allows complete machine configuration from one tool: commissioning, diagnostics and programming.

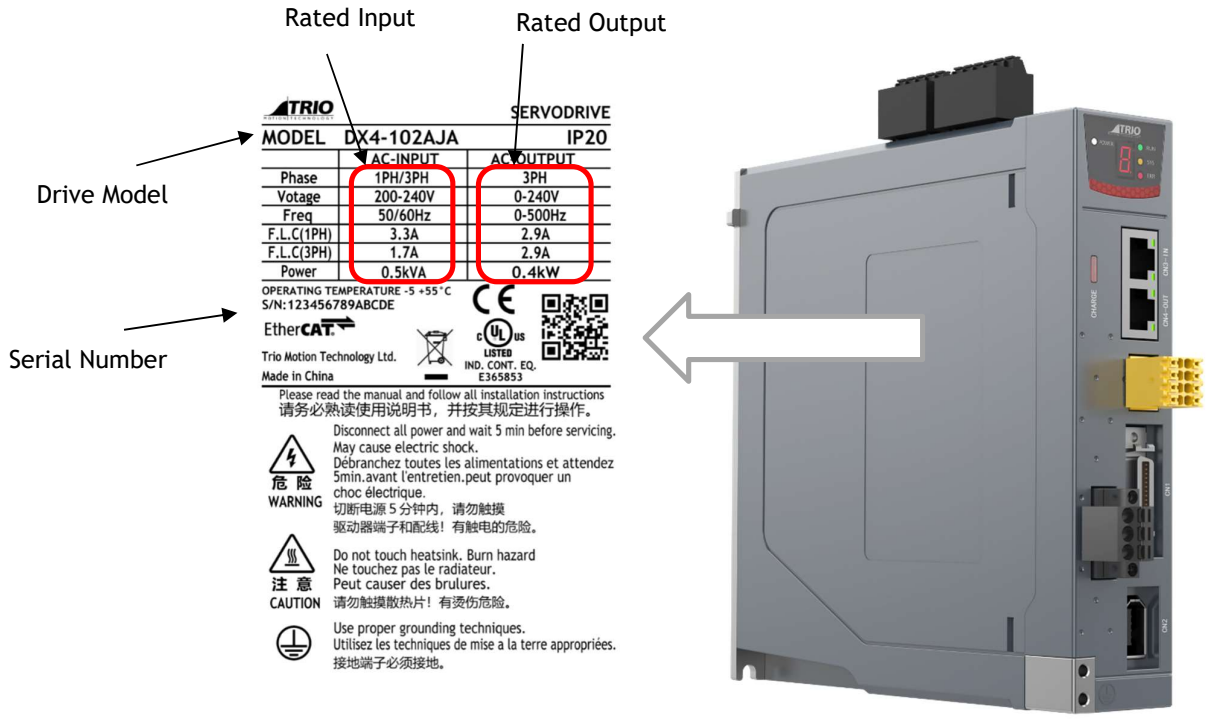
With a focus on performance and ease-of-use the DX4 maximizes machine performance while minimizing application development time.

Features

- Drive and Motion Controller fully integrated into *Motion* Perfect
- EtherCAT support, update rates down to 125 µs
- Compact size
- Zero stacking gap installation
- Functional Safety Dual STO (SIL3, PLe)
- 200 V ac from 50 W to 3 kW
- Matched with MX motor range of low and medium inertia motors
- 20-bit incremental or 23-bit absolute encoder interface
- Internal drive protection functions
- 7 digital inputs, 2 dedicated touch probe inputs for position latching
- 4 digital outputs, external encoder interface for dual encoder applications
- Comprehensive tuning technology including: Auto-tuning function, adaptive vibration suppression, friction compensation

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

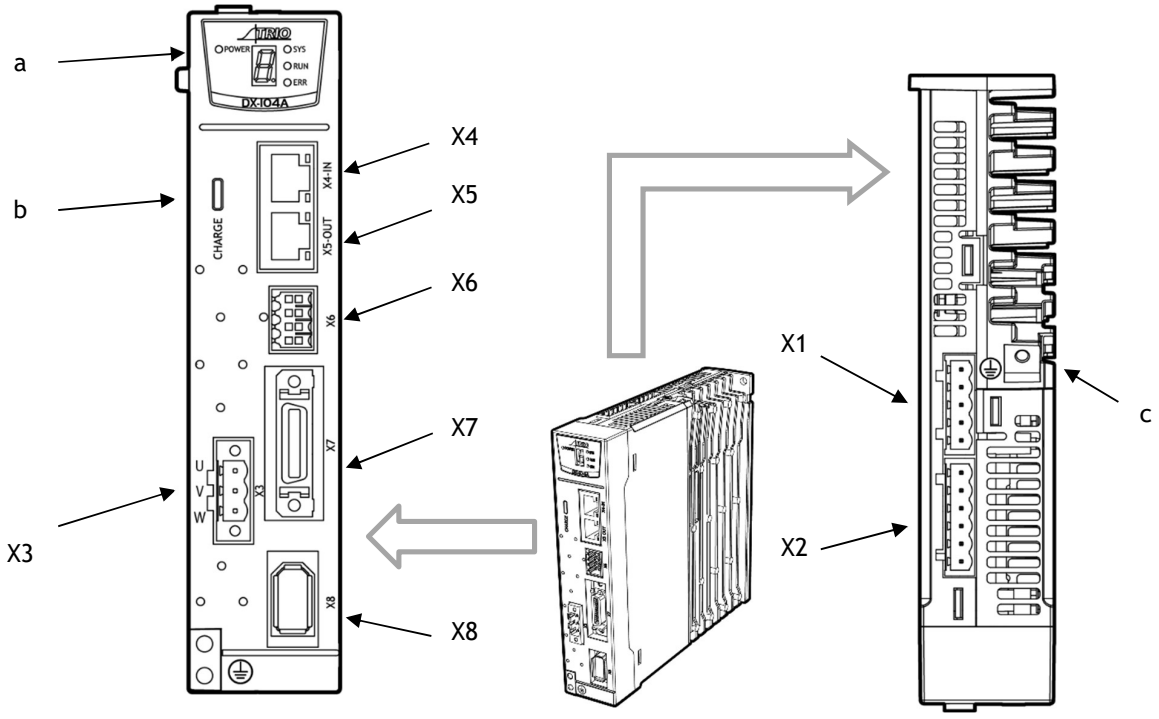
1.2 Interpreting the Nameplate



1.3 Model Designations

DX4	-	Number of axes		Output Power		Voltage		Options		Design Sequence	
		1	Single axis	A5	50W	A	200VAC	J	EtherCAT + STO	A	-
				01	100W						
				02	200W						
				04	400W						
				08	750W						
				10	1kW						
				15	1.5kW						
				20	2kW						
				30	3kW						

1.4 Part Names



No.	Name	Description
X1	Control Circuit Connector	Control power supply (5 pins)
X2	Main Circuit Connector	Main circuit power supply (6 pins)
a	Status Display	Drive status display
b	CHARGE Indicator Lamp	Main circuit power supply indicator (1)
X3	Motor Connector	Motor power
c	Grounding Terminal	Ground terminal for motor power cable
X4	EtherCAT Input Connector	EtherCAT input (RJ45)
X5	EtherCAT Output Connector	EtherCAT output (RJ45)
X6	Safety Connector	Safe Torque Off (STO)
X7	I/O Signal Connector	Digital I/O and external encoder input
X8	Encoder Connector	Encoder signals

(1): When the main circuit power is turned OFF, the CHARGE indicator will be lit as long as the internal capacitor remains charged. Do not touch the main circuit or Motor terminals while this indicator is illuminated as there is possibility of electric shock.

1.5 Ratings and Specifications

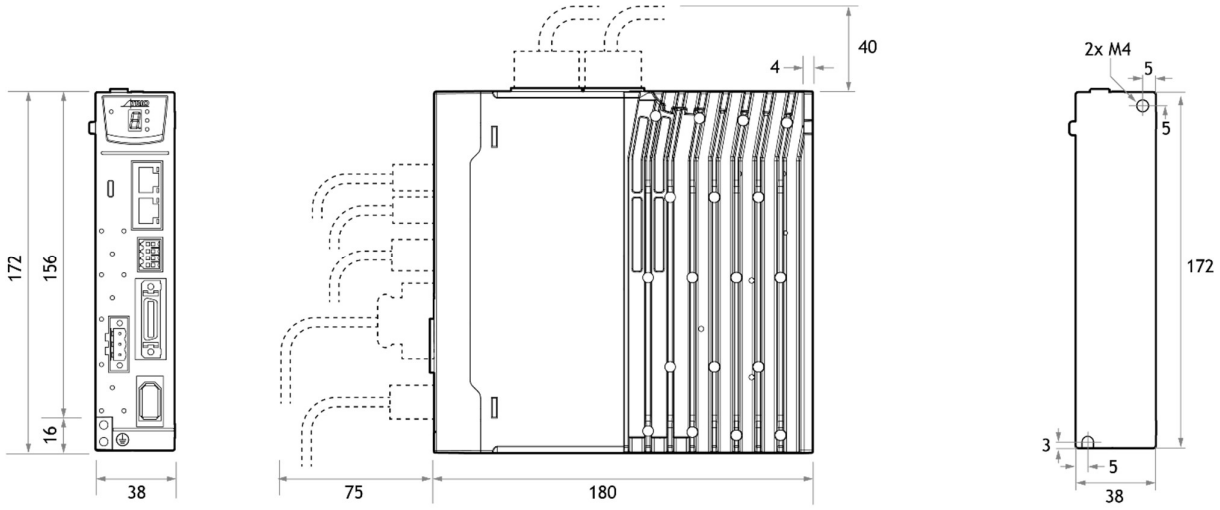
Drive Model: DX4		1A5A	101A	102A	104A	108A	110A	115A	120A	130A
Continuous Output Power [W]		50	100	200	400	750	1000	1500	2000	3000
Continuous Output Current [Arms]		0.9	1.1	1.5	2.9	5.1	6.9	8.2	11.3	16.0
Instantaneous Maximum Output Current [Arms]		3.3	4.0	5.8	11.5	19.5	21.0	24.6	33.9	54.0
Full Load Current (F.L.C) [Arms]	Single-phase	0.6	1.1	1.7	3.3	5.6	8.1	12.2	—	—
	Three-phase	0.3	0.6	0.8	1.7	3.1	4.8	6.2	8.3	12.0
Power Supply Capacity [kVA]	Single-phase	0.2	0.3	0.6	1.2	1.9	2.6	4.0	—	—
	Three-phase	0.2	0.3	0.5	0.9	1.6	2.0	3.0	3.5	4.5
Power Supply	Main Circuit	Single-phase or Three-phase 200 V ac to 240 V ac • -15% to +10%, 50 Hz or 60 Hz 270 V dc to 324 V dc • -15% to +10% DX4-115* is de-rated to 1.2kW when used with a single-phase supply DX4-120* and DX4-130* can only be used with a three-phase supply								
	Control Circuit	Single-phase 200 V ac to 240 V ac • -15% to +10%, 50 Hz or 60 Hz 270 V dc to 324 V dc • -15% to +10%								
Control Method		SVPWM (Maximum Output Frequency 500Hz)								
Feedback		Serial encoder: • 20-bits single-turn incremental encoder • 23-bits single-turn, 16-bits multi-turn absolute encoder								
Environmental Conditions	Temperature	Ambient temperature: -5˚C to 55˚C (less than 40˚C for zero-stacking gap installation) Storage temperature: -20˚C to +85˚C								
	Humidity	Both operating and storage: 5% to 95% (with no condensation)								
	Protection Class	IP20								
	Altitude	1,000 m or less								
	Vibration Resistance	4.9 m/s^2								
	Shock Resistance	19.6 m/s^2								
	Power System	TN System								
Mounting		Base-mounted								
Performance	Speed Control Range	1:5000								

Drive Model: DX4		1A5A	101A	102A	104A	108A	110A	115A	120A	130A
	Coefficient of Speed Fluctuation	±0.01% of rated speed max. (For a load fluctuation of 0% to 100%)								
		0% of rated speed max. (For a rated voltage fluctuation of ±10%)								
		±0.1% of rated speed max. (For a temperature fluctuation of 25°C±25°C)								
I/O Signals	External Encoder Input	Supports A, B, and Z TTL differential type sensor signal. Maximum line frequency of 500kHz.								
	Input Signals	Allowable voltage range: 24 V dc ±20% Number of input points: 7 (2 for high-speed optocoupler inputs, fixed as Touch Probe)								
		Touch Probe Signals are TP1 (Touch Probe 1), TP2 (Touch Probe 2). All other inputs are general purpose but can be assigned specific functions during commissioning. These inputs can also be inverted so act as active-low.								
	Output Signals	Allowable voltage range: 5 V dc to 30 V dc Rated current: 30mA / Max current: 150mA Number of output points: 4								
		All outputs are general purpose but can be assigned specific functions during commissioning. These outputs can also be inverted so act as active-low.								
EtherCAT Communications	Applicable Communications Standards	IEC 61158 Type12, IEC 61800-7 CiA402 Drive Profile								
	Physical Layer	100BASE-TX (IEEE802.3)								
	Communications Connectors	X4-IN (RJ45): EtherCAT signal input connector X5-OUT (RJ45): EtherCAT signal output connector								
	Cable	Category 5, Shielded/Foiled Twisted Pairs (CAT5e SF/UTP)								
	Sync Manager	SM0: Mailbox output, SM1: Mailbox input, SM2: Process data output, and SM3: Process data input								
	FMMU	FMMU 0: Mapped in process data output (RxPDO) area. FMMU 1: Mapped in process data input (TxPDO) area. FMMU 2: Mapped to mailbox status.								
	EtherCAT Commands (Data Link Layer)	APRD, FPRD, BRD, LRD, APWR, FPWR, BWR, LWR, ARMW, FRMW (APRW, FPRW, BRW, and LRW commands are not supported.)								
	Process Data	Assignments can be changed with PDO mapping.								
	MailBox (CoE)	Emergency messages, SDO requests, SDO responses (TxPDO/RxPDO and remote TxPDO/RxPDO are not supported.)								
	Distributed Clocks	Free-Run Mode and DC Mode (Can be switched) Applicable DC cycles: 125 µs to 8 ms								
	Slave Information	256 bytes (read-only)								

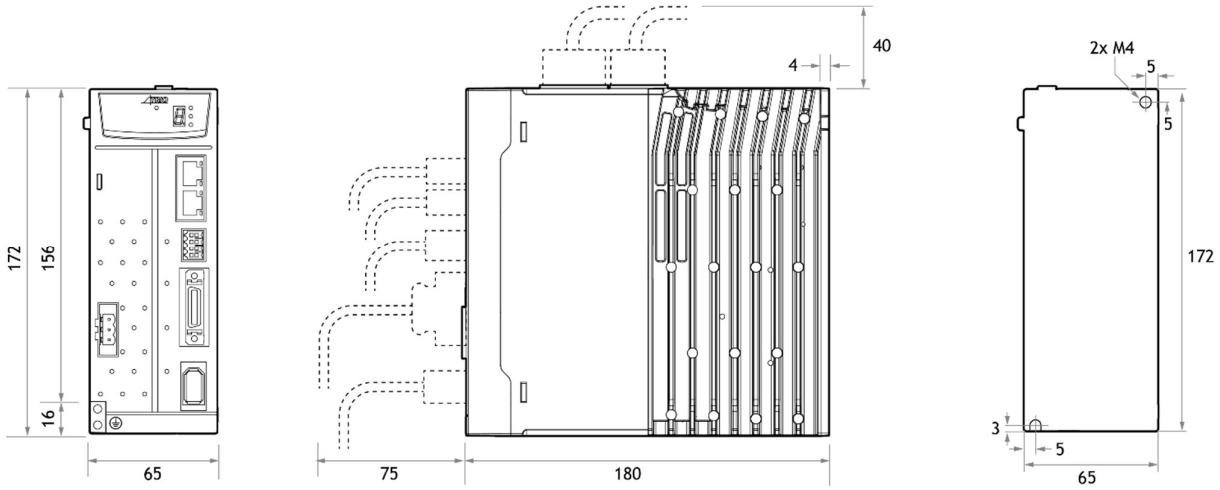
Drive Model: DX4		1A5A	101A	102A	104A	108A	110A	115A	120A	130A
	Interface									
CiA402 Drive Profile		Cyclic Synchronous Position Mode Cyclic Synchronous Velocity Mode Cyclic Synchronous Torque Mode Touch Probe Function Torque Limit Function								
Display		One 7-segment LED								
Indicator Lamps		CHARGE, POWER, RUN, SYS, ERR, L/A IN, L/A OUT								
Regenerative Processing		DX4-1A5*, DX4-101*, DX4-102* and DX4-104* must connect an external regenerative resistor. Other models are built in.								
Protective Functions		Overcurrent, Overvoltage, Undervoltage, Overload, Regeneration Error, Overspeed, etc.								
Utility Functions		Alarm history, Jogging, Load inertia identification, Auto-Tuning, etc.								
Safe Torque Off		According to IEC 61800-5-2. Cat.4, PLe according to ISO 13849-1, SIL3 according to IEC 61508, IEC 62061.								

1.6 External Dimensions

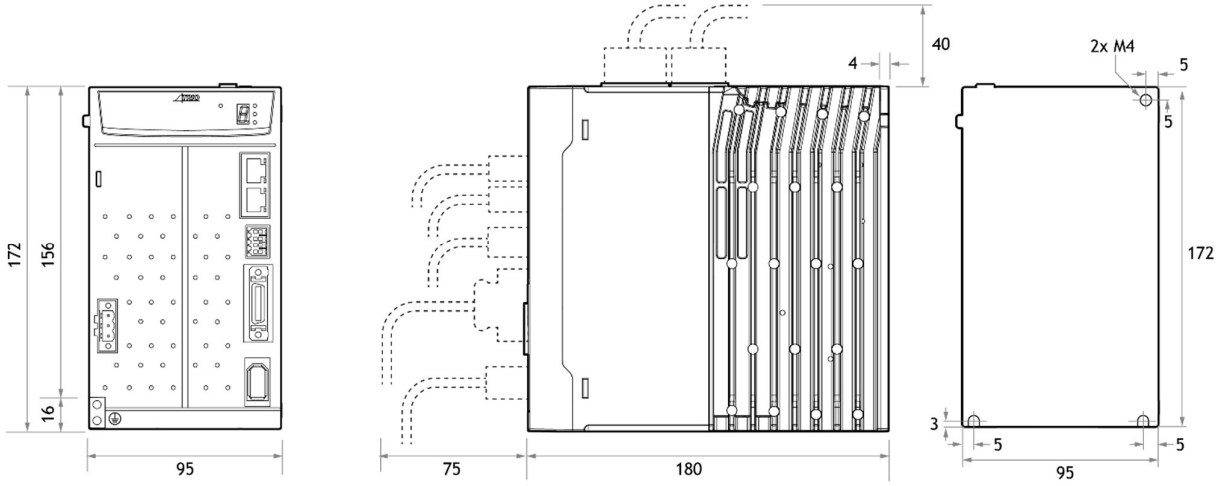
DX4-1A5* to DX4-104*



DX4-108* to DX4-115*

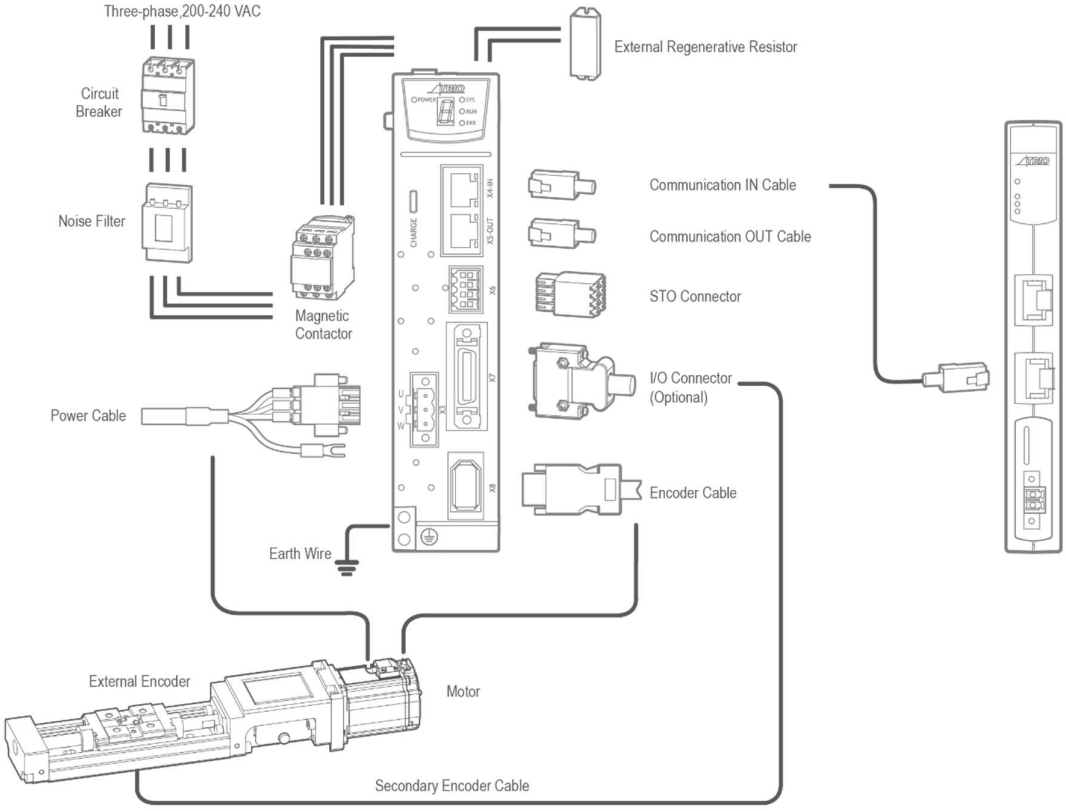


DX4-120* to DX4-130*



1.7 System Configuration

Example Diagram



Minimum system configuration is:

- Power Supply
- Breaker
- Filter
- Contactor
- Regen resistor
- Drive
- Motor
- Controller
- PC for commissioning
- Cables (encoder, motor power, EtherCAT, Ethernet, STO, IO cable)

Peripheral Devices Specification

<table>
<tr><th>Device Name</th><th>Description</th><th>Specification</th></tr>
<tr><td>Circuit Breaker</td><td>Used to protect the power supply line and cut off the circuit when an overcurrent occurs.</td><td>The minimum rated current of the circuit breaker depends on the Drive model.
Use Type C MCB
<table><tr><th>Drive Model</th><th>Circuit Breaker</th></tr><tr><td>DX4-1A5*
DX4-101*</td><td>5A</td></tr><tr><td>DX4-102*
DX4-104*</td><td>10 A</td></tr><tr><td>DX4-108*
DX4-110*</td><td>25 A</td></tr><tr><td>DX4-115*</td><td>35 A</td></tr><tr><td>DX4-120*</td><td>55 A</td></tr><tr><td>DX4-130*</td><td>70 A</td></tr></table></td></tr>
<tr><td>Noise Filter</td><td>Used to prevent external noise interference from the power supply.</td><td>The rated current is 10 A or 20 A.</td></tr>
</table>

<table>
<tr><th>Device Name</th><th>Description</th><th>Specification</th></tr>
<tr><td>External Regenerative Resistor</td><td>When the busbar capacitance is insufficient, remove the short wiring between B2 and B3, and connect an external regenerative resistor between B1 and B2. (1)
Ensure that Pn535 and Pn536 are both set to reflect the resistor value.</td><td>The minimum value of the regenerative resistor depends on the Drive model.
<table>
<tr><th>Drive Model</th><th>Regenerative Resistor</th></tr>
<tr><td>DX4-1A5*
DX4-101*
DX4-102*
DX4-104*
DX4-108*
DX4-110*</td><td>25 Ω</td></tr>
<tr><td>DX4-115*
DX4-120*
DX4-130*</td><td>10 Ω</td></tr>
</table>
</td></tr>
</table>

(1): DX4-1A5*, DX4-101*, DX4-102* and DX4-104* must connect an external regenerative resistor.

Chapter 2 Installation

2.1 Installation Precautions

Installation Near Sources of Heat

Implement measures to prevent temperature increases caused by external heat sources so that the ambient temperature of the Drive is within the specified limits.

Installation Near Sources of Vibration

Install a vibration absorber on the installation surface of the Drive so that the Drive will not be subjected to vibration.

Other Precautions

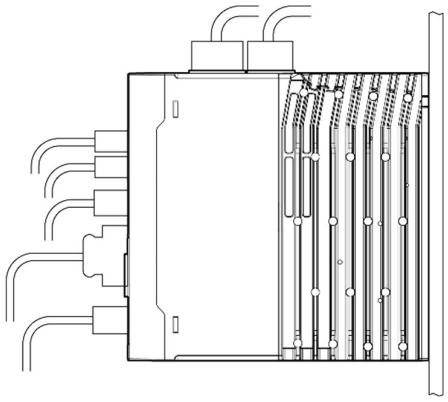
Never install the Drive in a location subject to high temperatures, high humidity, water drops, cutting oil, excessive dust, excessive dirt, excessive iron powder, corrosive gasses, or radioactivity.

2.2 Mounting Types and Orientation

The Drives are based mounted and should be fitted to a non-painted metal surface. Mount the Drive vertically, as is shown in Figure 2-1.

Mount the Drives so that the Display Panel is facing toward the operator. Prepare two or three mounting holes for the Drive and mount it securely in the mounting holes (The number of mounting holes depends on the size of the Drive).

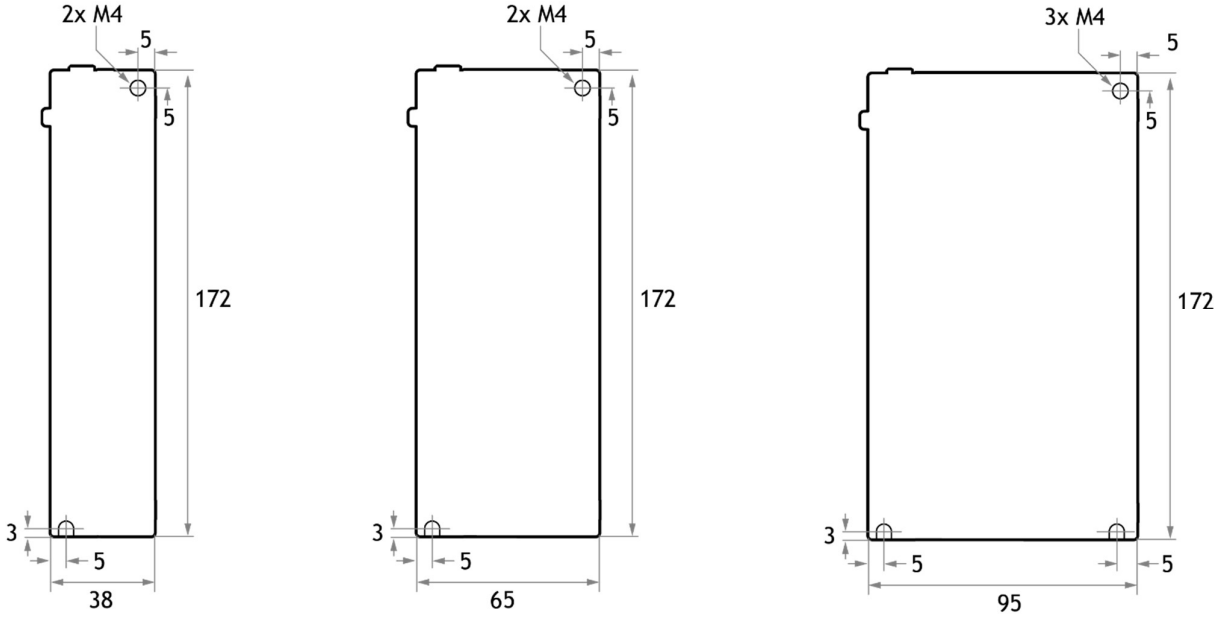
Figure 2-1 Base-mounted diagram



2.3 Mounting Hole Dimensions

Use all mounting holes to securely mount the Drive to the mounting surface.

To mount the Drive, use a screwdriver that is longer than the depth of the Drive.

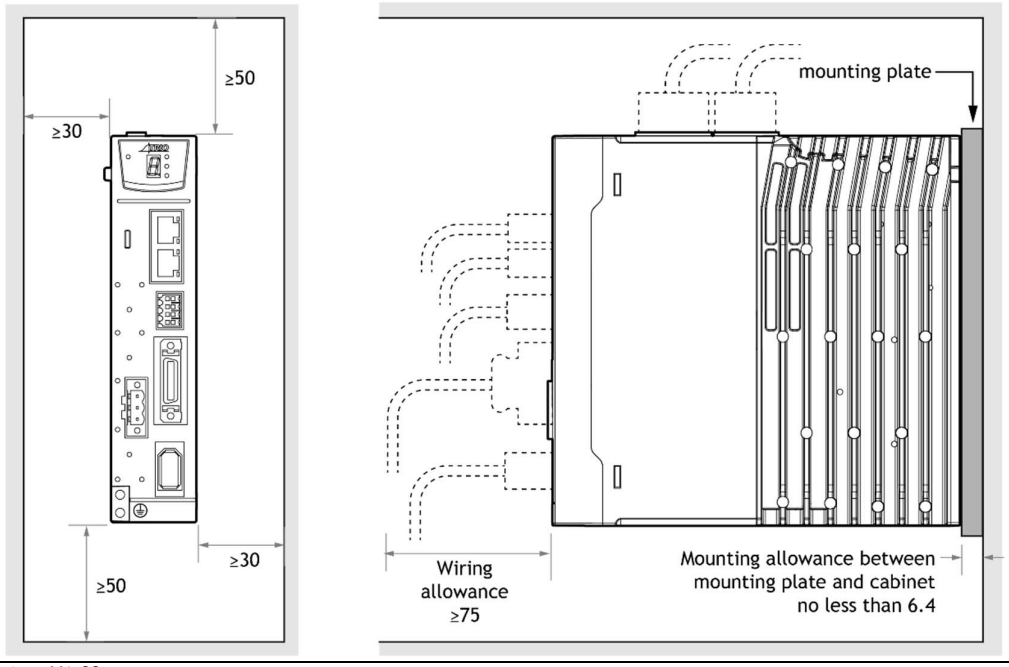


2.4 Mounting Interval

Installing One Drive in a Control Cabinet

When installing a single Drive use Figure 2-2 as a reference for free space around the installation.

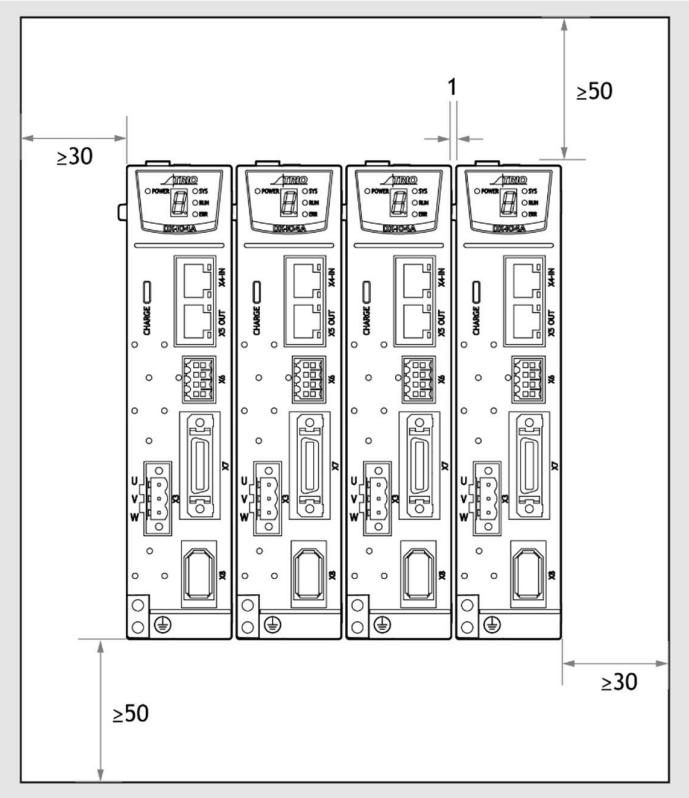
Figure 2-2 Installing a single Drive in a control cabinet



Installing multiple Drives in a Control Cabinet

When installing a multiple Drives use Figure 2-3 as a reference for free space around the installation.

Figure 2-3 Installing multiple Drives in a control cabinet



NOTE

The DX4 can be mounted so that the distance between adjacent Drives is 1mm.

Chapter 3 Wiring and Connections

3.1 Precautions for Wiring

3.1.1 General Precautions

DANGER

- Never change any wiring while power is being supplied in case of risk of electric shock or injury.

WARNING

- Wiring and inspections must be performed only by qualified engineers.
- Check all wiring and power supplies carefully.
- Incorrect wiring or incorrect voltage application to the output circuits may cause short-circuit failures. If a short-circuit failure occurs as a result of any of these causes, the holding brake will not work. This could damage the machine or cause an accident that may result in death or injury.
- Connect the AC and DC power supplies to the specified Drive terminals.

CAUTION

- Wait for at least five minutes after turning OFF the power supply and then make sure that the CHARGE indicator is not lit before starting wiring or inspection work. Never touch the power supply terminals while the CHARGE lamp is lit after turning OFF the power supply because high voltages may still be present in the Drive.
- Observe the precautions and instructions for wiring and trial operation precisely as described in this document.
- Check the wiring to be sure it has been performed correctly.
  Connectors and pin layouts are sometimes different for different models. Always confirm the pin layouts in technical documents before operation.
- Use shielded twisted-pair cables or screened unshielded multi-twisted-pair cables for I/O Signal Cables and Encoder Cables.
- The cable used for main circuit power to the Drive must be guaranteed to work at 75°C.
- Observe the following precautions when wiring the Drive's main circuit terminals.
  - Do not turn on the power supply to the Drive until all wiring, including the main circuit terminals, has been completed.
  - Ensure that power is removed from the Drive before wiring connectors.
  - Insert only one wire per insertion hole in the main circuit terminals.
  - Ensure that conductor wires (e.g. whiskers) do not come into contact with adjacent wires.
- Install Type C MCB and other safety measures to provide protection against short circuits in external wiring.

NOTE

- Whenever possible, use the Cables specified by Trio.
- Securely tighten cable connector screws and lock mechanisms to prevent mechanical failure during operation.
- Ensure that power lines (e.g. Main Circuit Cable) and low-current lines (e.g. I/O Signal Cables or Encoder Cables) are separated by at least 30 cm. Do not bundle power lines and low-current lines through the same duct.

IMPORTANT

- Use a Type C MCB to protect the main circuit.
  The Drive connects directly to a commercial power supply; it is not isolated through a transformer or other device. Always use a Type C MCB to protect the Servo System from accidents involving different power system voltages or other accidents.
- Install an earth leakage breaker.
  To configure a safer system, install a ground fault detector against overloads and short-circuiting, or install a ground fault detector combined with a Type C MCB.

3.1.2 Countermeasures against Noise

IMPORTANT

- The Drive is designed as an industrial device. It therefore provides no measures to prevent radio interference. The Drive uses high-speed switching elements in the main circuit. Therefore, peripheral devices may be affected by switching noise.
- If the equipment is to be used near private houses or if radio interference is a problem, take countermeasures against noise.

Since the Drive uses microprocessors, it may be affected by switching noise from peripheral devices.

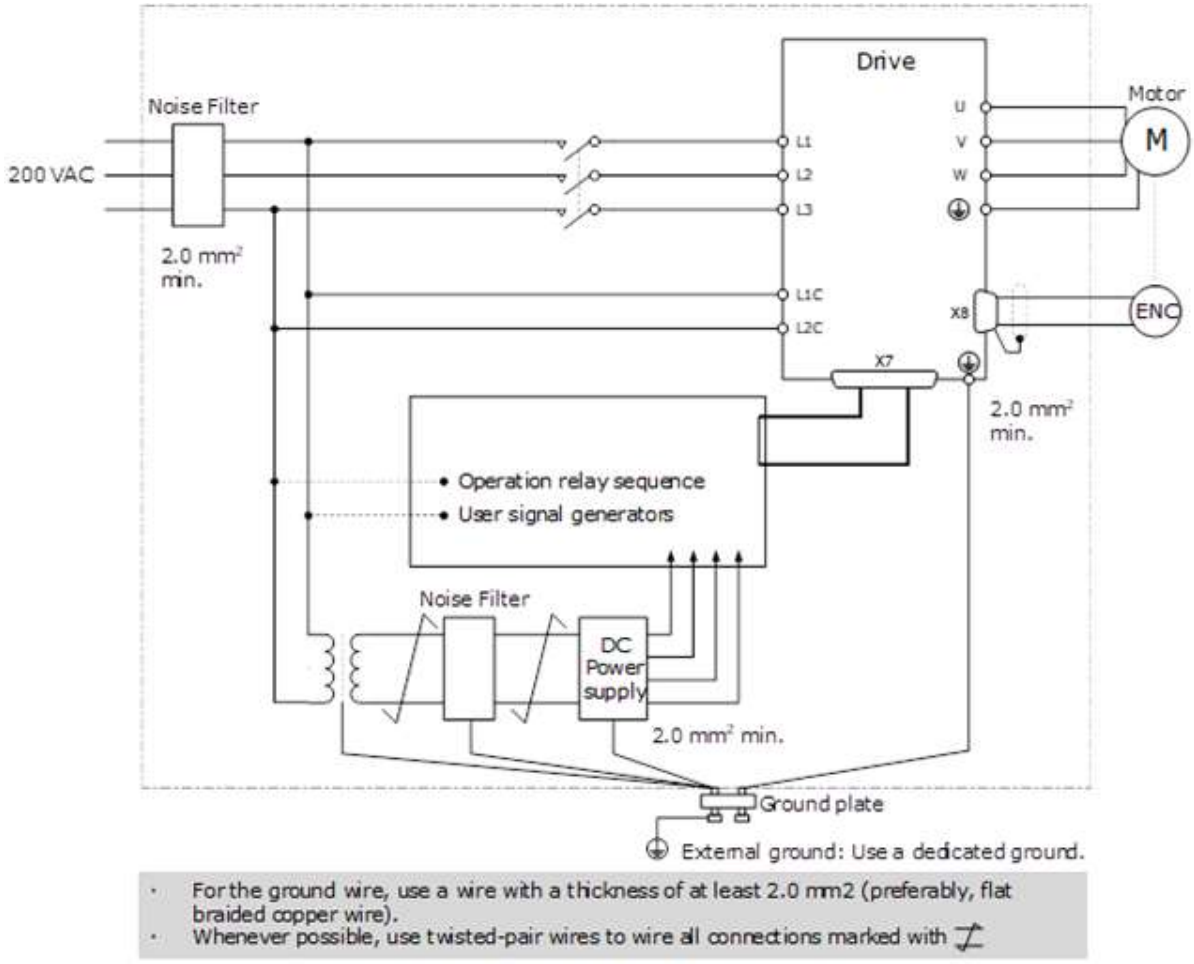
To prevent the noise from the Drive or the peripheral devices from causing malfunctions of any devices, take the following countermeasures against noise as required.

- Install the input reference device and Noise Filter as close to the Drive as possible.
- Always install a Surge Absorber for relays, solenoids, and Magnetic Contactor coils.
- Never place the following cables in the same duct or bundle them together. Also, separate the cables from each other by at least 30 cm.
- Never share the power supply with an electric welder or electrical discharge machine. If the Drive is placed near a high-frequency generator, install Noise Filters on the input side on the Main Circuit Power Supply Cable and Control Power Supply Cable even if the same power supply is not shared with the high-frequency generator. Refer to the section **Noise Filters** for information on connecting Noise Filters.
- Implement suitable grounding measures. Refer to the section **3.1.4 Grounding** for information on grounding measures.

Noise Filters

Noise Filters must be fitted in appropriate places to protect the Drive from the adverse effects of noise. Figure 3-1 is an example of wiring for countermeasures against noise.

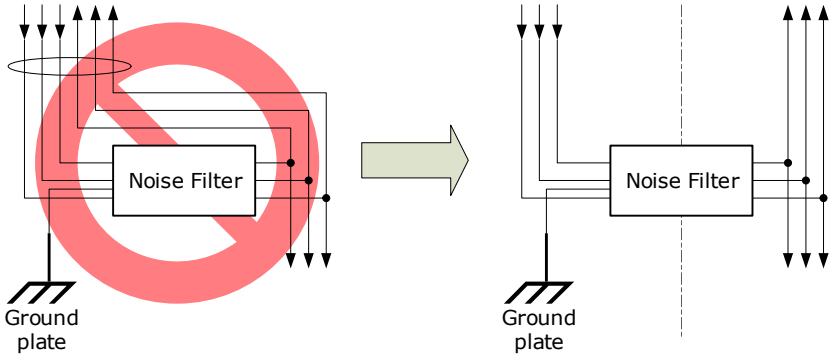
Figure 3-1 Wiring example for countermeasures against noise

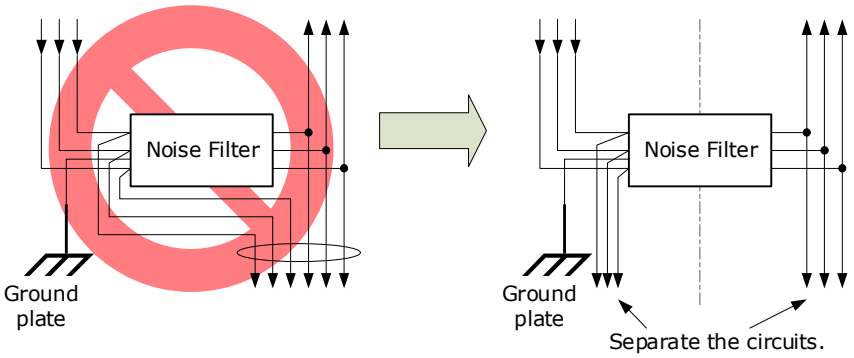


Noise Filter Wiring and Connection Precautions

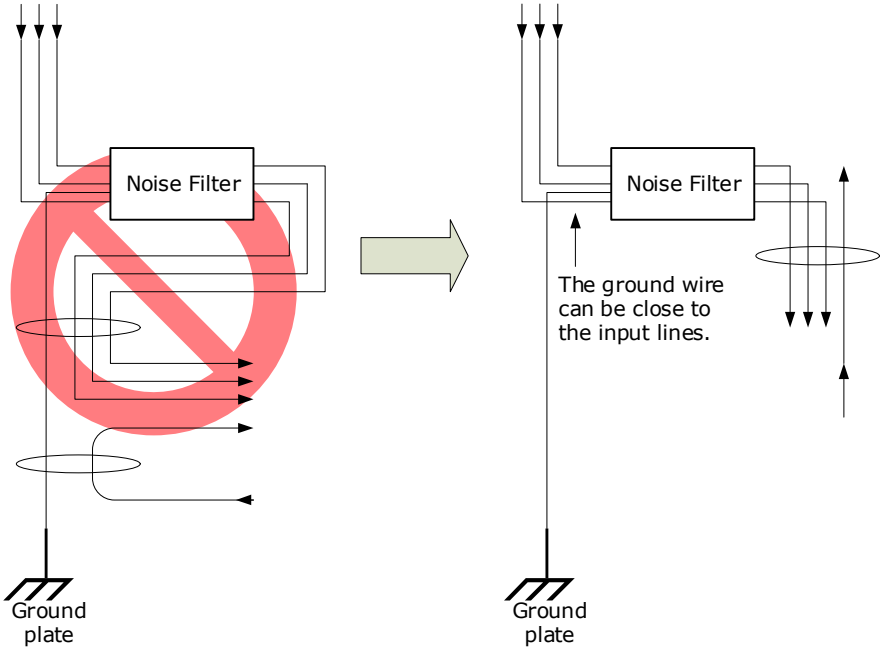
Always observe the following precautions when wiring or connecting Noise Filters.

- Separate input lines from output lines. Do not place input lines and output lines in the same duct or bundle them together.

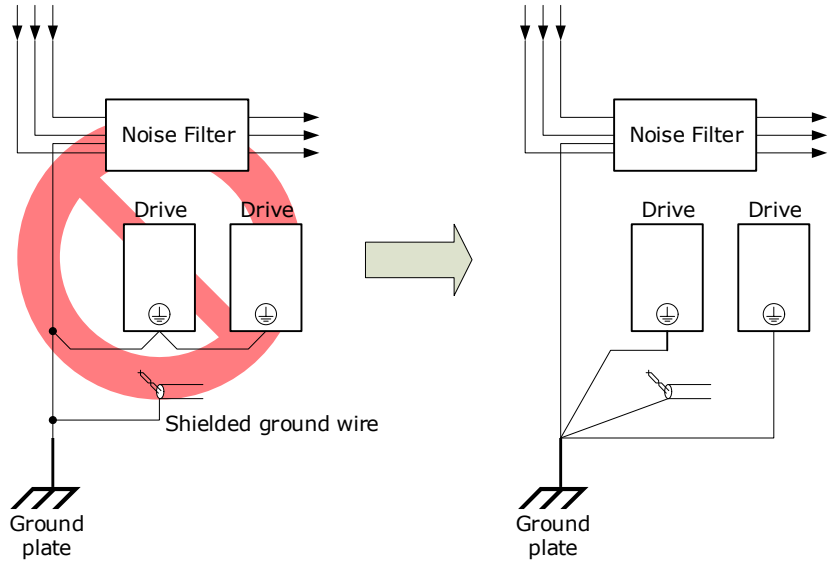




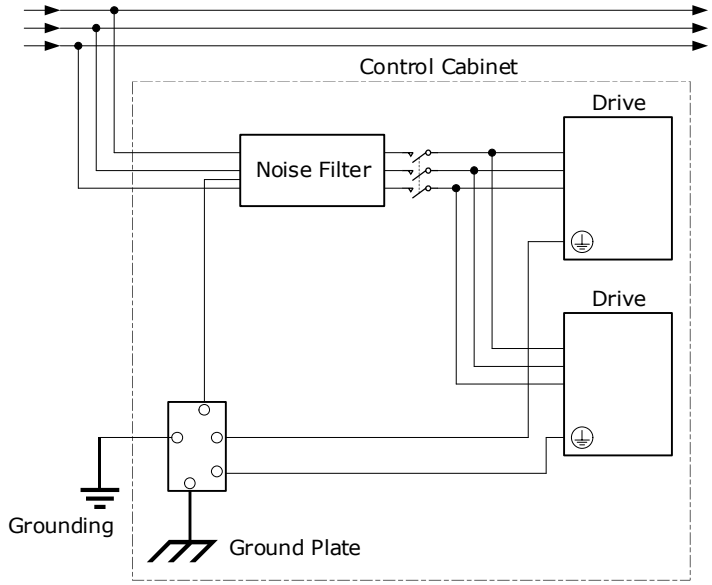
- Separate the Noise Filter ground wire from the output lines. Do not place the Noise Filter ground wire, output lines, and other signal lines in the same duct or bundle them together.



- Connect the Noise Filter ground wire directly to the grounding plate. Do not connect the Noise Filter ground wire to other ground wires.



- If a Noise Filter is located inside a control panel, first connect the Noise Filter ground wire and the ground wires from other devices inside the control panel to the grounding plate for the control panel, then ground the plate.



3.1.3 Recommended EMC Filters

To comply with the limits based on IEC/EN 61800-3 second environment (C2) the Drive and Motor must be installed with an EMC/RFI filter. Recommended filters are:

DX4 Frame Size	EMC C2 (three phase supply)	EMC C2 (single phase supply)
Frame A (50 W to 400 W)	Schaffner FN3270H-10-44	Schaffner FN2090-10-06 Trio X0806 Foot mount filter (model number RF 1006-TD4)
Frame B (750 W to 1.5 kW)	Schaffner FN3270H-10-44	Schaffner FN2090-10-06 Trio X0807 Foot mount filter (model number RF 1020-TD4)
Frame C (2 kW to 3 kW)	Schaffner FN3270H-20-44	n/a

These filters have been tested with cable lengths of 3m and 20m.

3.1.4 Grounding

Implement grounding measures as described in this section. Implementing suitable grounding measures will also help prevent malfunctions, which can be caused by noise. Always use an unpainted backplane for electrical cabinets.

Observe the following precautions when wiring the ground cable.

- Ground the Drive to a resistance of 100 mΩ or less.
- Be sure to ground at one point only.
- Ground the Motor directly if the Motor is insulated from the machine.

Motor Frame Ground or Motor Ground

If the Motor is grounded thought the machine, the switching noise current can flow from the main circuit of the Drive through the stray capacitance of the Motor. To prevent this always connect the Motor frame terminal (FG) or ground terminal (FG) of the Motor to the ground terminal ⏚ on the Drive. Also, be sure to ground the ground terminal ⏚.

Noise on I/O Signal Cables

To prevent noise entering the I/O Signal Cable connect the shield of the I/O Signal Cable to the connector shell and ensure the shell is connected to ground.

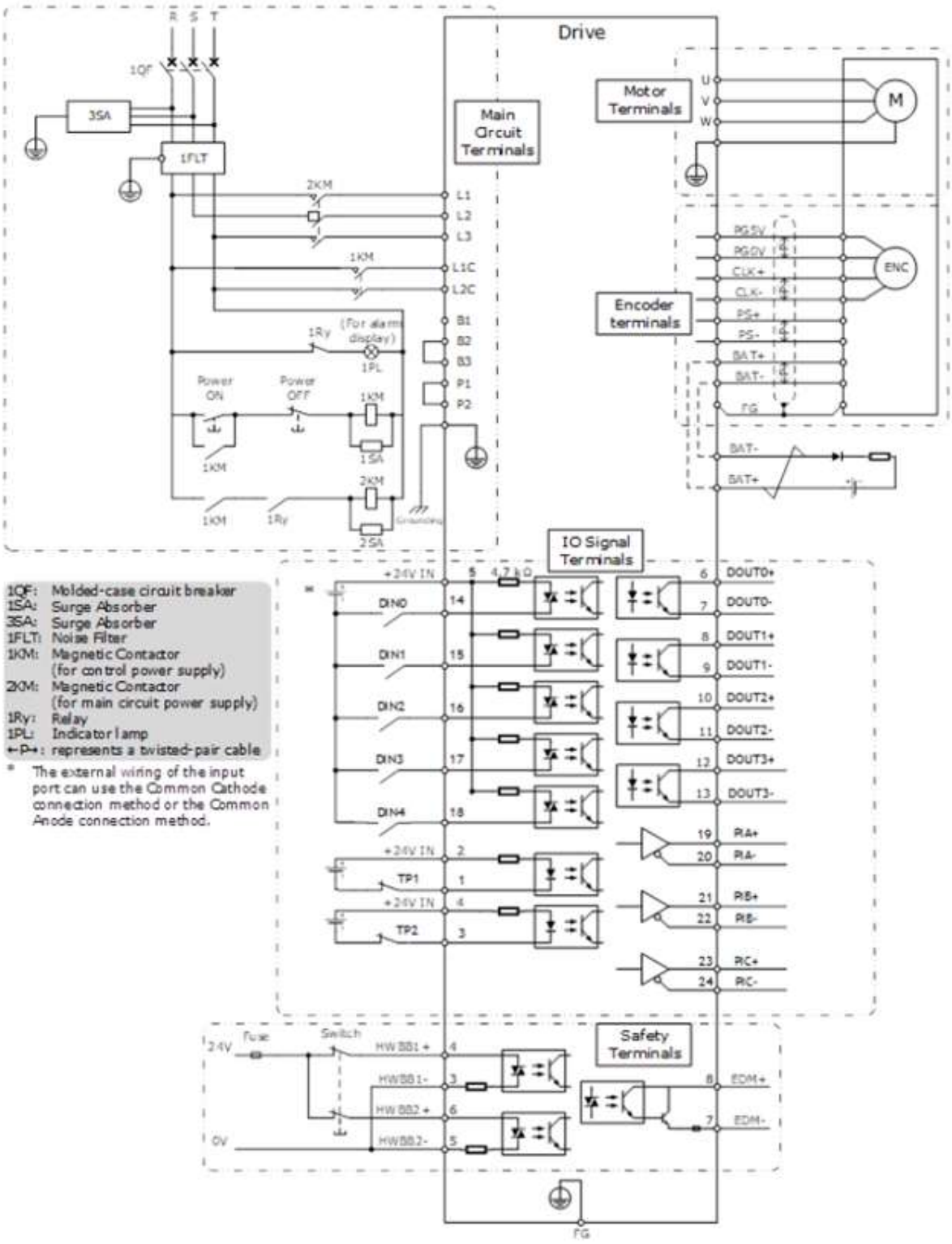
If placing cables in metal conduits, ensure the conduit is connected to ground.

For all grounding, use a single grounding point.

Ferrite Coils

While ferrite coils can be used to solve application specific EMC issues, they should not be necessary for applications.

3.2 Basic Wiring Diagrams

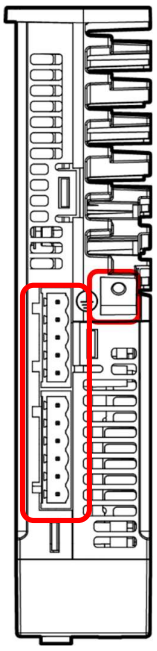


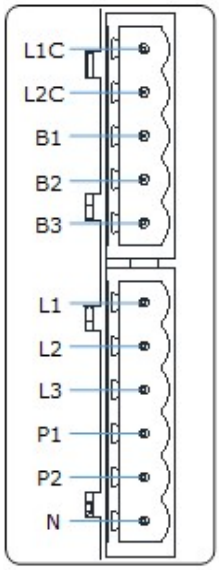
3.3 Power Supply (X1, X2)

3.3.1 Terminals Arrangement

The power supply to Drive includes main circuit terminals and control circuit terminals.

Signal Diagram





X1

X2

Pin Layout

Symbols	Name	Specifications and Reference
L1, L2, L3	Main circuit power supply input terminals	Three-phase, 200 V ac to 240 V ac, -15% to +10%, 50 Hz or 60 Hz
L1C, L2C	Control power supply terminals	Single-phase, 200 V ac to 240 V ac, -15% to +10%, 50 Hz or 60 Hz
B1, B2, B3	Regenerative Resistor terminal	There is a factory fit short between B2 and B3. When the busbar capacitance is insufficient, remove the short wiring, and connect an external regenerative resistor between B1 and B2.
P1, P2, N	DC terminals	There is a factory fit short between P1 and P2. When using an external DC power supply (270 V dc to 324 V dc), remove the factory fit short between P1 and P2, connect P2 to the positive pole, and connect N to negative pole.
	Ground terminal	Always connect this terminal to prevent electric shock.

3.3.2 Wiring Procedure

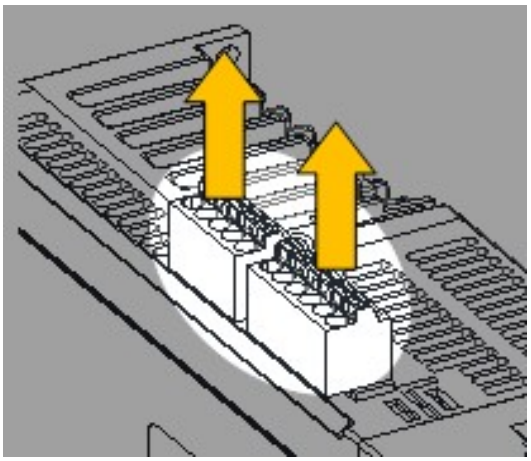
Prepare the following items before preparing the wiring for the Main Circuit Terminals and Control Circuit Terminals.

Required Item	Description
Flat-blade screwdriver	Commercially available screwdriver with tip width of 3.0 mm to 3.5 mm
Cold pressed terminals	Sleeve type ferrule with cross-section from 1.5 mm^2 to 2.5 mm^2 and a length of 10 mm
Wiring pliers	Commercially available pliers with crimping and stripping functions

Follow the procedure below to wire the Main Circuit Terminals and Control Circuit Terminals.

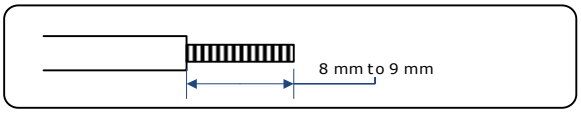
Step 1 Remove the Main Circuit Terminals and Control Circuit Terminals from the Drive.

Figure 3-2 Remove the terminals



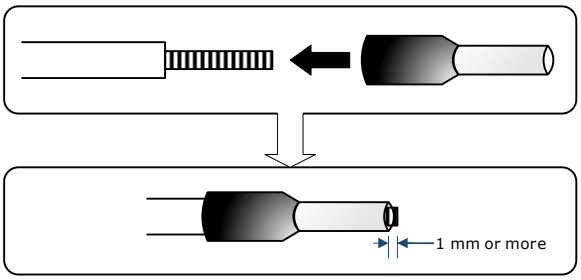
Step 2 Peel off the sheath so that the conductor portion of the cable will protrude from the tip of the ferrule.

Figure 3-3 Remove the sheath



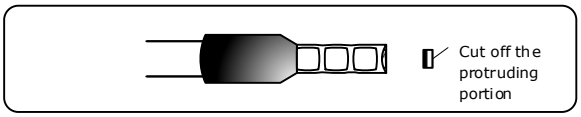
Step 3 Insert the cable into the ferrule (It should protrude 1 mm or more from the ferrule).

Figure 3-4 Insert the cable into the ferrule



Step 4 Crimp the cable that has been inserted into the ferrule and cut off the cable conductor portion protruding from the ferrule (The allowable protruding length after cutting should not be more than 0.5 mm).

Figure 3-5 Crimp the cable



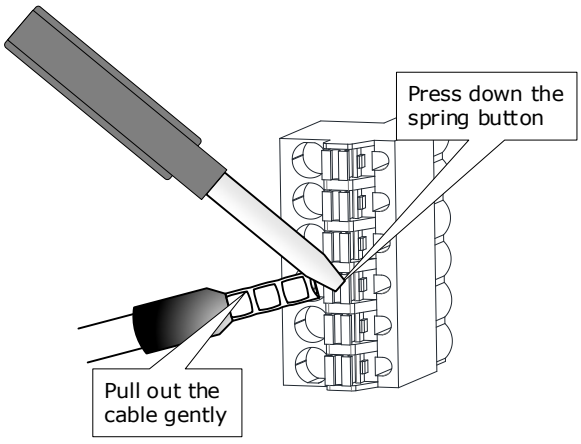
Step 5 Insert the crimped cable into the connection terminals directly until the cable is not easily pulled out (A slight pull is allowed).

Step 6 Make all other connections in the same way.

Step 7 To change the wiring, pull the cable out of the connection terminals.

Use the flat-blade screwdriver to press down the spring button corresponding to the terminal, and then gently pull out the cable.

Figure 3-6 Pull out the cable



Step 8 Once the wiring is completed, attach connection terminals to the Drive.

NOTE

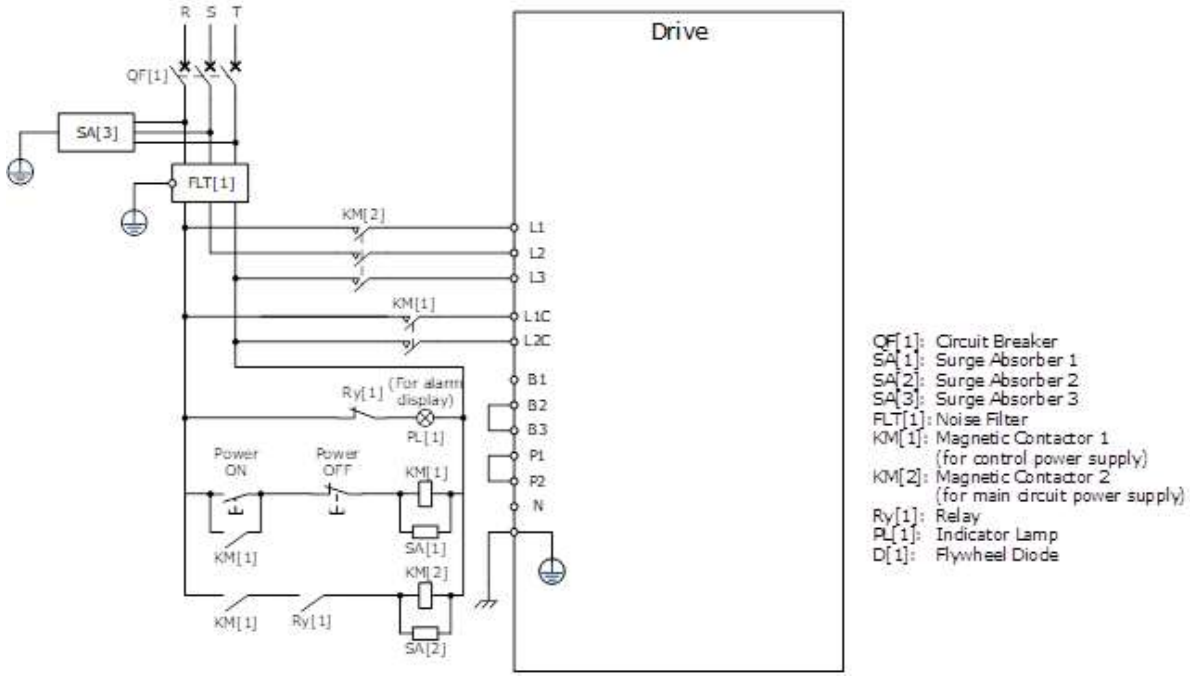
- The above wiring procedure is also applicable to the Motor Terminals.

3.3.3 Wiring Diagrams

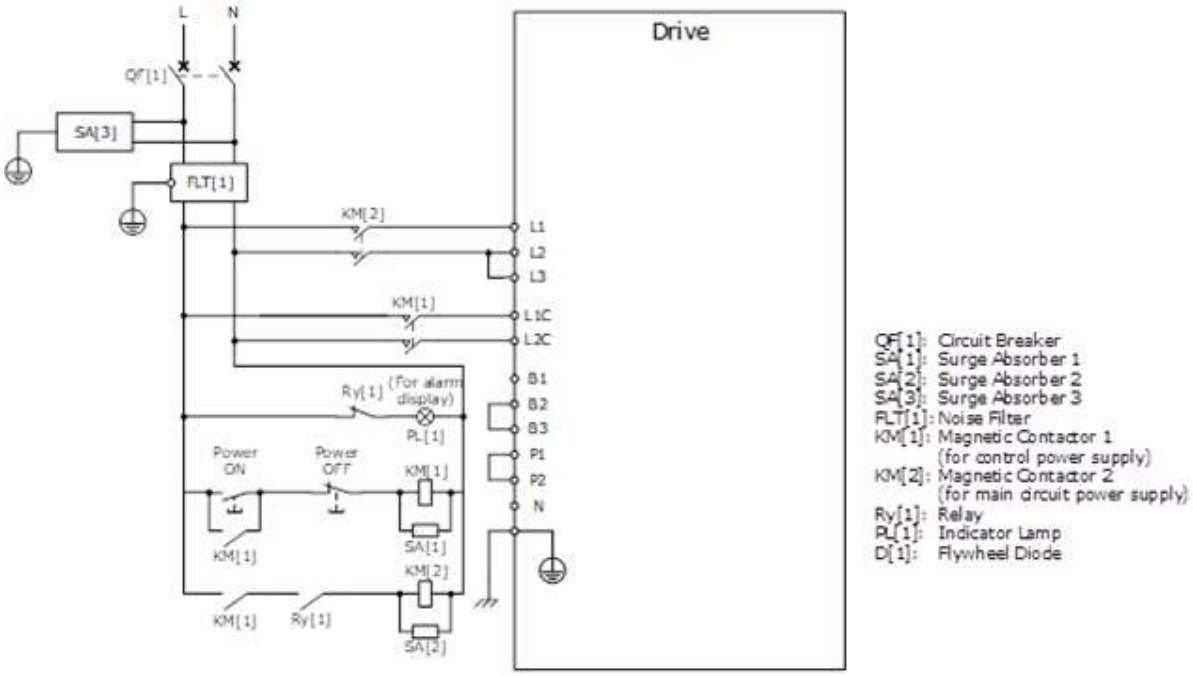
The wiring diameter of the power input is determined by the Drive model. The following table lists the recommended wire diameters for each Drive model.

Drive Model	Recommended Wire	
	Cross-sectional area (mm^2)	AWG
DX4-1A5A	2.075	14
DX4-101A	2.075	14
DX4-102A	2.075	14
DX4-104A	2.075	14
DX4-108A	2.627	13
DX4-110A	2.627	13
DX4-115A	3.332	12
DX4-120A	3.332	12
DX4-130A	3.332	12

Wiring Example for Three-phase Power Supply Input

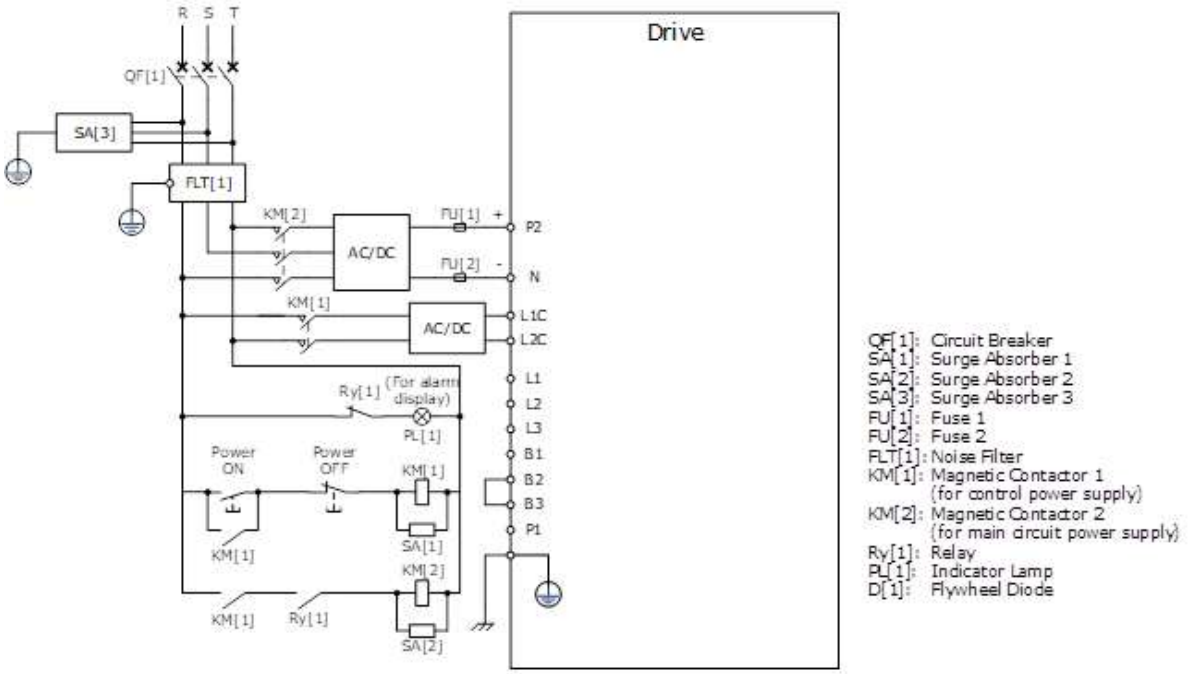


Wiring Example for Single-phase Power Supply Input



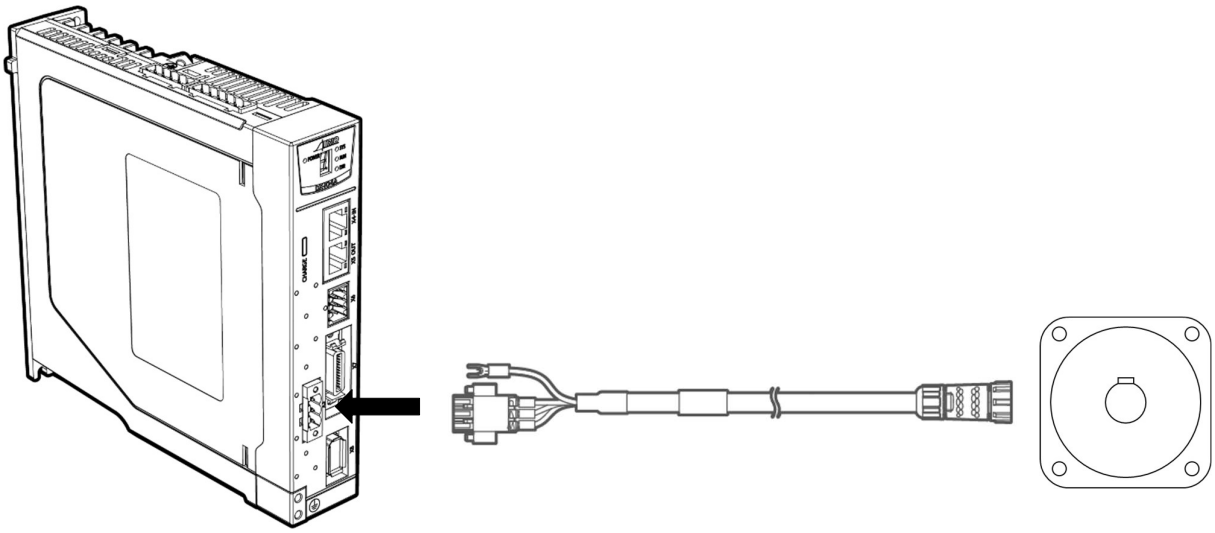
NOTE: for single phase wiring L or N can be wired into either L1 or L2

Wiring Example for DC Power Supply Input



3.4 Motor Power (X3)

Connection Diagram

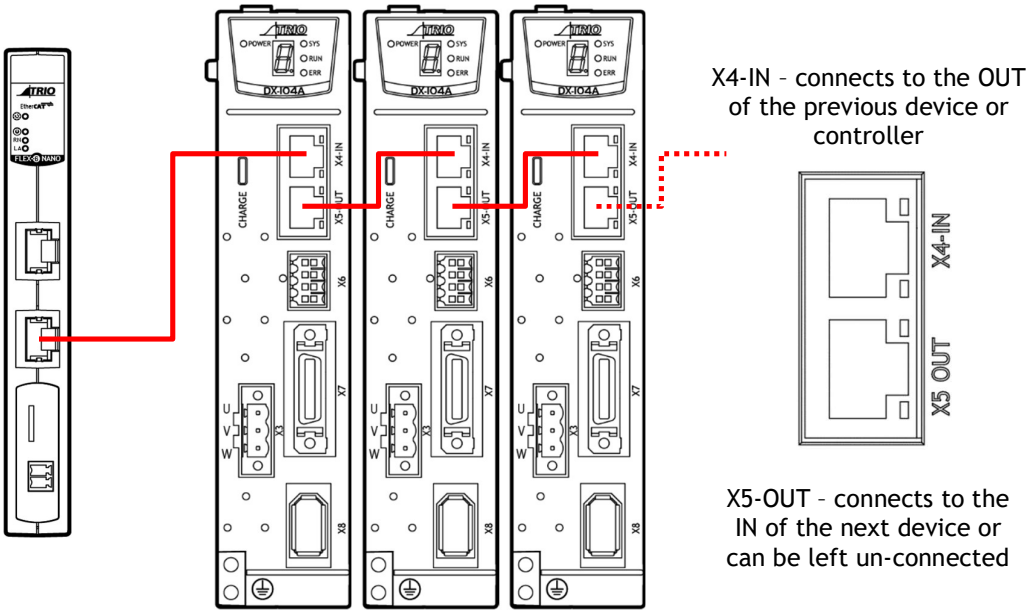


Terminals Arrangement

<table>
<tr><th colspan="2">Terminals</th><th>Pin Layout</th></tr>
<tr><td rowspan="2">Motor connection side</td><td>EC3P-B1718
  </td><td>
<table>
<tr><th>Pin</th><th>Symbols</th><th>Color</th></tr>
<tr><td>1</td><td>U</td><td>Brown</td></tr>
<tr><td>2</td><td>V</td><td>Gray</td></tr>
<tr><td>3</td><td>W</td><td>Black</td></tr>
<tr><td>4</td><td>FG</td><td>Yellow-Green</td></tr>
<tr><td>5</td><td>B1</td><td>White</td></tr>
<tr><td>6</td><td>B2</td><td>Green</td></tr>
</table>
</td></tr>
<tr><td>EC3P-N1718
  </td><td>
<table>
<tr><th>Pin</th><th>Symbols</th><th>Color</th></tr>
<tr><td>1</td><td>U</td><td>Brown</td></tr>
<tr><td>2</td><td>V</td><td>Gray</td></tr>
<tr><td>3</td><td>W</td><td>Black</td></tr>
<tr><td>4</td><td>FG</td><td>Yellow-Green</td></tr>
</table>
</td></tr>
<tr><td>Drive connection side</td><td>1 2 3</td><td>
<table>
<tr><th>Pin</th><th>Symbols</th><th>Color</th></tr>
<tr><td>1</td><td>U</td><td>Brown</td></tr>
<tr><td>2</td><td>V</td><td>Gray</td></tr>
<tr><td>3</td><td>W</td><td>Black</td></tr>
</table>
</td></tr>
</table>

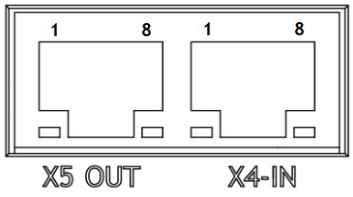
3.5 EtherCAT Communication (X4, X5)

Connection Diagram



Pin Layout

EtherCAT communication (X4-IN and X5-OUT) are RJ45 terminals. The communication cable from the network master or controller should be connected to X4-IN and X5-OUT should be connected to the X4-IN terminal of the next Drive (or network device).

Connectors	Pin	Name	Function
	1	TX+	Send data +
	2	TX-	Send data -
	3	RX+	Receive data +
	4	—	—
	5	—	—
	6	RX-	Receive data -
	7	—	—
	8	—	—
	Shell	PE	Protecting earthing (shield)

Cable Description

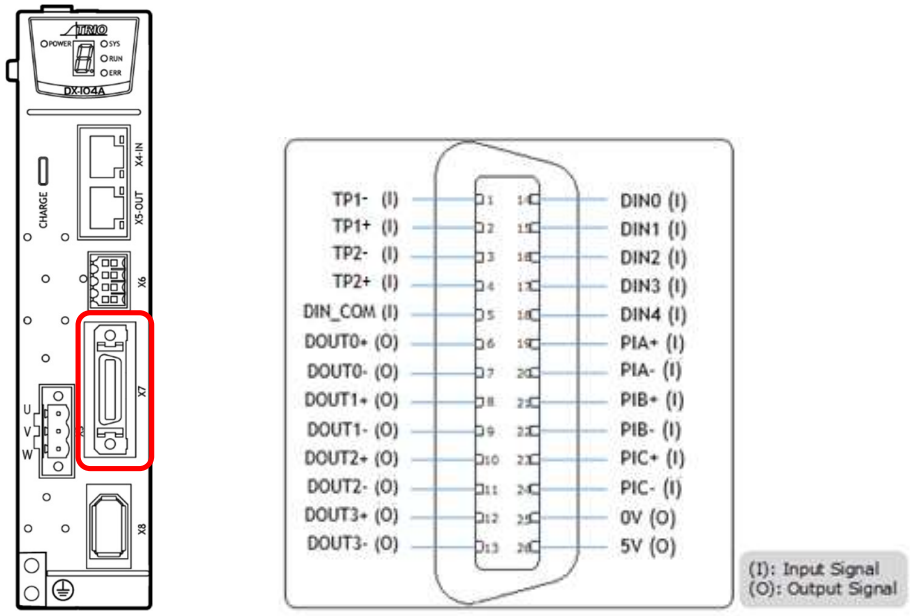
Use category 5 (CAT5e SF/UTP) Ethernet communications cables for network connections. Metal shielded connectors are recommended to prevent signal interference.

3.6 Connecting STO Function Signals (X6)

A Safety Function Device shall be connected for using the STO function. For the connection and usage, please refers to **Chapter 4 STO**.

3.7 I/O Connector (X7)

Signal Diagram

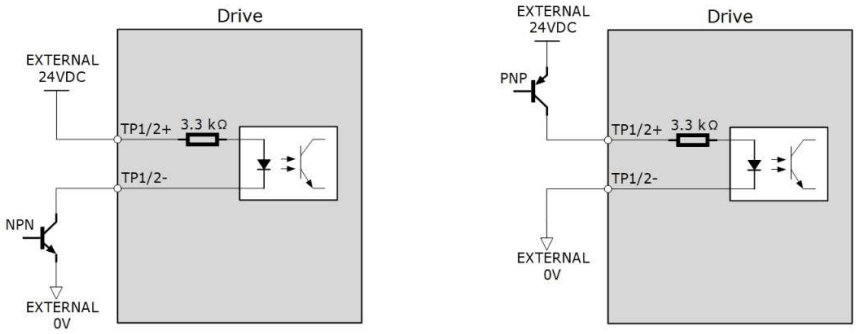


Pin Layout

Pin	Name	Type	Function
1	TP1-	Input	Touch Probe Input 1
2	TP1+	Input	
3	TP2-	Input	Touch Probe Input 2
4	TP2+	Input	
5	DIN_COM	Input	Power supply to DIN signals, connect to a 24 V dc power supply.
6	DOUT0+	Output	General purpose digital output 0 Rated current: 30mA / Max current: 150mA
7	DOUT0-	Output	
8	DOUT1+	Output	General purpose digital output 1 Rated current: 30mA / Max current: 150mA
9	DOUT1-	Output	
10	DOUT2+	Output	General purpose digital output 2 Rated current: 30mA / Max current: 150mA
11	DOUT2-	Output	
12	DOUT3+	Output	General purpose digital output 3 Rated current: 30mA / Max current: 150mA
13	DOUT3-	Output	
14	DIN0	Input	General purpose digital input 0.

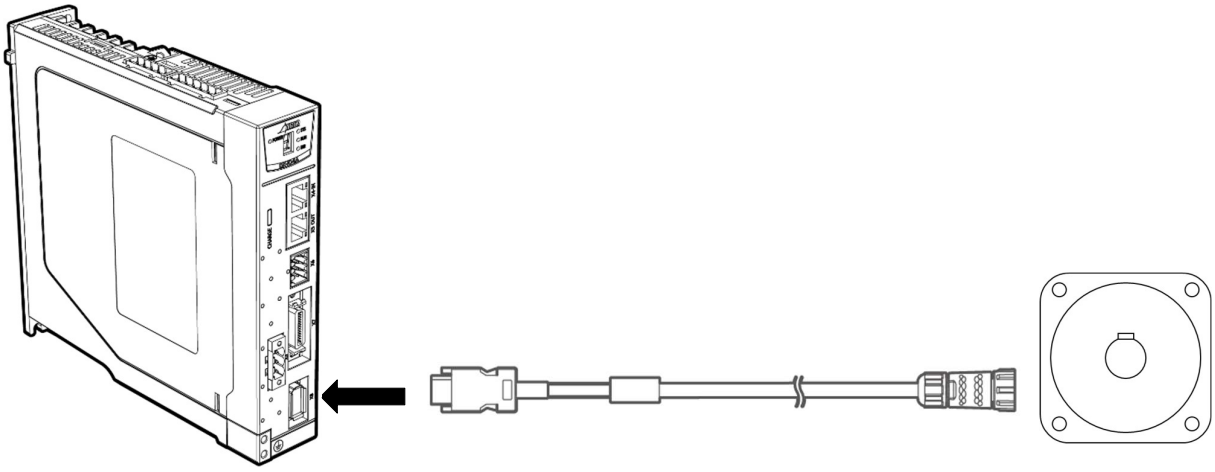
Pin	Name	Type	Function
15	DIN1	Input	General purpose digital input 1.
16	DIN2	Input	General purpose digital input 2.
17	DIN3	Input	General purpose digital input 3.
18	DIN4	Input	General purpose digital input 4.
19	PIA+	Input	External Encoder Input, channel A.
20	PIA-	Input	
21	PIB+	Input	External Encoder Input, channel B.
22	PIB-	Input	
23	PIC+	Input	External Encoder Input, channel C (index pulse).
24	PIC-	Input	
25	0V	Output	Supply voltage for external encoder. Max current: 500mA
26	+5V	Output	

The TP inputs can be connected to either an NPN or PNP sensor.



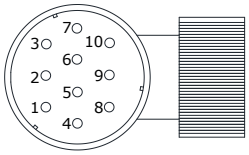
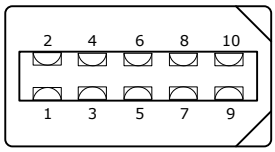
3.8 Encoder (X8)

Connection Diagram



Terminals Arrangement

<table>
<tr><th colspan="2">Terminals</th><th>Pin Layout</th></tr>
<tr><td>Motor connection side</td><td>ECS-I1724 / ECS-A1724
  </td><td>
<table>
<tr><th>Pin</th><th>Symbols</th><th>Color</th></tr>
<tr><td>1</td><td>S+</td><td>Blue</td></tr>
<tr><td>2</td><td>S-</td><td>Blue-Black</td></tr>
<tr><td>3</td><td>BAT+</td><td>Yellow</td></tr>
<tr><td>4</td><td>MA+</td><td>Green</td></tr>
<tr><td>5</td><td>MA-</td><td>Green-Black</td></tr>
<tr><td>6</td><td>PG5V</td><td>Red</td></tr>
<tr><td>7</td><td>PG0V</td><td>Black</td></tr>
<tr><td>8</td><td>BAT-</td><td>Yellow-Black</td></tr>
<tr><td>9</td><td>FG</td><td>Frame ground</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th colspan="2">Terminals</th><th>Pin Layout</th></tr>
<tr><td></td><td>EC3S-I1324 / EC3S-A1324
 
</td><td>
<table>
<tr><th>Pin</th><th>Symbols</th><th>Color</th></tr>
<tr><td>1</td><td>S+</td><td>Blue</td></tr>
<tr><td>2</td><td>S-</td><td>Blue-Black</td></tr>
<tr><td>3</td><td>BAT+</td><td>Yellow</td></tr>
<tr><td>4</td><td>BAT-</td><td>Green</td></tr>
<tr><td>5</td><td>MA+</td><td>Green-Black</td></tr>
<tr><td>6</td><td>MA-</td><td>Red</td></tr>
<tr><td>7</td><td>PG0V</td><td>Black</td></tr>
<tr><td>8</td><td>PG5V</td><td>Yellow-Black</td></tr>
<tr><td>9</td><td>—</td><td>—</td></tr>
<tr><td>10</td><td>FG</td><td>Frame ground</td></tr>
</table>
</td></tr>
<tr><td>Drive connection side</td><td> 
</td><td>
<table>
<tr><th>Pin</th><th>Symbols</th><th>Color</th></tr>
<tr><td>1</td><td>PG5V</td><td>Red</td></tr>
<tr><td>2</td><td>PG0V</td><td>Black</td></tr>
<tr><td>3</td><td>—</td><td>—</td></tr>
<tr><td>4</td><td>—</td><td>—</td></tr>
<tr><td>5</td><td>MA+</td><td>Green</td></tr>
<tr><td>6</td><td>MA-</td><td>Green-Black</td></tr>
<tr><td>7</td><td>S+</td><td>Blue</td></tr>
<tr><td>8</td><td>S-</td><td>Blue-Black</td></tr>
<tr><td>9</td><td>BAT+</td><td>Yellow</td></tr>
<tr><td>10</td><td>BAT-</td><td>Yellow-Black</td></tr>
<tr><td>Shell</td><td>FG</td><td>Frame ground</td></tr>
</table>
</td></tr>
</table>

3.8.1 Encoder Battery Connection

Absolute encoders are fitted on motors with an encoder type of L; e.g. MXL-02A0630**L**A222. These encoders require a battery supply to retain the absolute encoder data when the Drive power is removed.

This battery supply is provided by an in-line battery fitted into a battery box in the cable which allows the encoder supply to be retained when the Encoder Cable is removed from the Drive.

CAUTION

- To retain absolute encoder data, ensure that the Control power supply to the Drive is ON when the battery supply is removed.

Chapter 4 STO

4.1 Introduction

This product has the integrated safety function **Safe Torque Off** (STO) according to IEC 61800-5-2, which is equivalent to an uncontrolled stop in accordance with stop category 0 of IEC 60204-1, which can protect people from dangerous movements of the machine and reduce the risk to the operator.

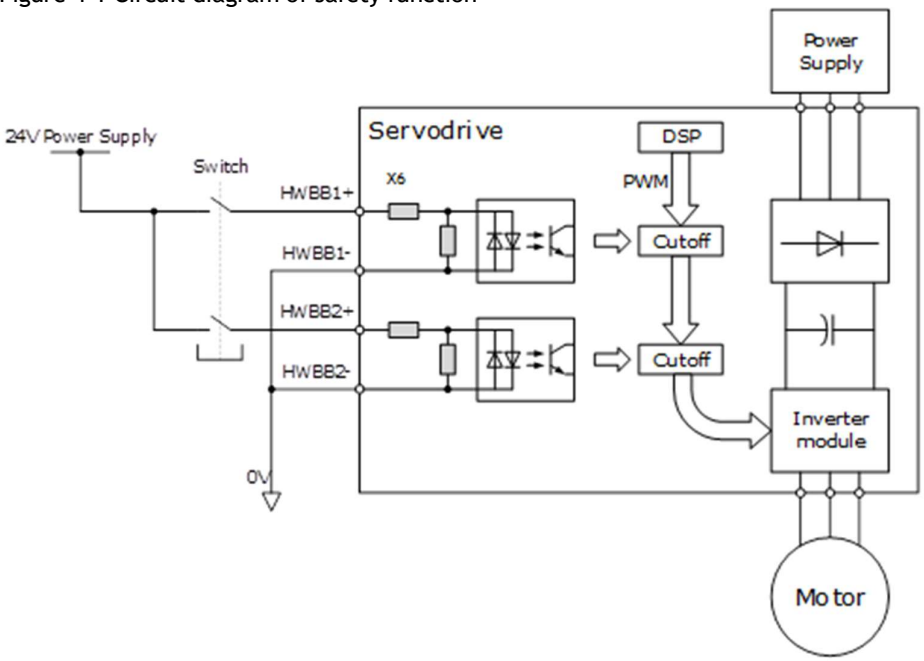
The Safe Torque Off (STO) function is a safety function that shuts the Motor current and turns off Motor output torque by turning off the driving signal of the Drive's internal power transistor when safety input signal is detected.

However, the safety function STO is not equivalent to the safety function **safe off** of IEC 60204-1, since it does not provide any galvanic insulation. This means that the Motor terminals can still have dangerous voltage when in STO state.

4.1.1 Block Diagram

The circuit diagram of safety function is as shown in Figure 4-1.

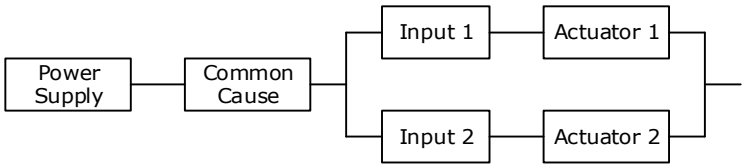
Figure 4-1 Circuit diagram of safety function



Close the Switch for turning ON HWBB1 and HWBB2, PWM signal can be allowed to pass by Cutoff circuit, which is, allowing the torque to output.
Open the Switch for turning OFF HWBB1 or HWBB2, PWM signal cannot be allowed to pass by Cutoff circuit, which is, forbidding the torque to output.

The reliability block diagram of safety function is as shown in Figure 4-2.

Figure 4-2 Reliability block diagram



4.1.2 Functions and Features

The functions or features of STO are as follows:

The safe state is a hardware disable of all PWM signals used to generate torque in the Motor.

The architecture of the system is 1oo1 + 1oo2.

The STO works in high demand mode of operation, and systematic capability is SC3.

The PFH may amount to 0.018% of the complete safety system, and it is $1.8*10^{-11}$.

MTTFd of each channel is 3184 years.

According to IEC 61508-6: 2010, MRT and MTTR are both 0.

Failure rates are: λ (total failures) = 355.80 fit; λ_S (safe failures) = 283.38 fit;
λ_{DD} (dangerous detected failures) = 71.69 fit;
λ_{DU} (dangerous undetected failures) = 0.73 fit.
[**NOTE**] The unit for failure rates is 1 **fit** (failures in time) = $1*10^{-9}$ h^{-1}, meaning one failure in 10^9 operation hours of the device.

The safety integrity level is SIL3 (IEC 62061: 2015), the performance level is PLe, the category is Cat.4 (ISO 13849-1: 2015).

According to IEC 61508:2010 and IEC62061:2015, the SFF is no less than 99% for dual channel part (1oo2) and is no less than 99% for signal channel part (1oo1).

According to ISO 13849-1: 2015, DC is no less than 99%.

(*) The response time of STO is no more than 30 ms.
Response time of STO is the time frame from the STO signal is triggered to the PWM signal is removed.

(*) The diagnose test interval is less than 20 ms for HFT=0 and is less than 1h for HFT>0.

(*) According to IEC61326-3-1 for the DS definition, the Motor will stop within 200 ms.

According to ISO 13849: 2015, the CCF score is better than 65.

(*) All detected faults will lead to safe state.

(*) In single channel, diagnostic test interval + fault reaction time < 30 ms.

(*) Input signal filtering time definition: when the input signal keeps low level more than 2 ms, turns HWBB1 and HWBB2 OFF and the system will enter safe state.

CAUTION

- In order to prevent the accumulation of faults, based on the risk assessment of the machine or device, it is confirmed at a fixed time whether the function is lost. Regardless of the system safety level, the safety confirmation test is performed at least once in 20 years. The inspection items mainly include the items (*) added to the above characteristics.

4.1.3 Risk Assessment

The device manufacturer is responsible for the residual risks associated with all risk assessments. The following are residual risks associated with STO functions. Trio is not responsible for any damage or injury caused by residual risks.

- Never touch the terminals while the power is on.
  Since the STO function only cuts off the torque output of the Motor and does not cut off the physical connection between the Drive and the Motor, there is a risk of electric shock.
- Use products that have been safety-confirmed or meet safety specifications for parts used on safety circuits.
- Since the STO function can cut off the torque output of the Motor, make sure that the Motor does not move due to external forces.
- Please confirm whether the new product and the previously used product are the same model when replacing the Drive.
  Always confirm the performance of the function before running the system.
- Please conduct a risk assessment of the entire machine or device.
- When the power module inside the Drive has a short-circuit fault, the Motor shaft may turn 0.5 rotations or less.
- Always supply power the STO input signals (HWBB1 and HWBB2) from a same source.
  If the power is supplied separately, the leakage current may cause the STO function to malfunction and unable to cuts off the torque output of the Motor.
- Please use the PELV/SELV switching power supplying to the IO signal of the STO function.

4.1.4 Alarms

If A30 (STO Disconnected) alarm or A31 (STO Circuit Failure) alarm occurs in the Drive, which means that the STO function circuit may be damaged. The user should troubleshoot to use the STO function again.

Alarm No.	Name	Description
A30	STO Disconnected	HWBB1 or HWBB2 is disconnected for more than 10 seconds. Check the wiring before using the STO function.
A31	STO Circuit Failure	The STO function circuit may be damaged. Please contact Trio or the Authorized Distributor.

4.1.5 Applicable Standards

The safety standards followed by STO are shown in the table below.

Item	Safety Specification
EMC Directive	• IEC 61800-3: 2017 • IEC 61000-4: 2017 • IEC 61326-3-1: 2017 • IEC 61800-5-2: 2016
Low Voltage Directive	• EN 61800-5-1: 2007 + AMD1:2017
Functional Safety	• IEC 61800-5-2: 2016 • IEC 60204-1: 2016 • IEC 61508: 2010 • IEC 62061: 2015 • ISO 13849-1: 2015

Item	Safety Specification
Environmental Requirements	• IEC 60068-2-1: 2007 • IEC 60068-2-2: 2007 • IEC 60068-2-6: 1995 • IEC 60068-2-14: 1984 • IEC 60068-2-27: 1987 • IEC 60068-2-78: 2001 • IEC 61800-2: 2015 • IEC 61800-5-1:2007 + AMD1:2016

4.2 Environmental Conditions

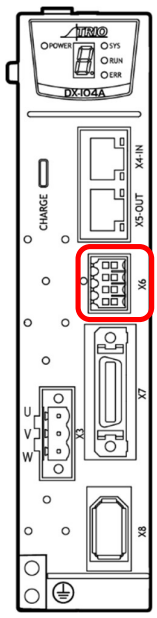
Item	Specification	
Operation	Temperature	Single drive: -5 ℃ to 55 ℃ Multiple drives, flush mounted: -5 ℃ to 40 ℃
	Humidity	5% to 95% RH (with no freezing or condensation)
Storage	Temperature	-20 ℃ to 85 ℃
	Humidity	5% to 95% RH (with no freezing or condensation)
Altitude	≤1000 m (Rated)	
IP	IP20	
Pollution Index	II	
Overvoltage Category	III	
Isolation Voltage	Input to Output: 2.7 kV; Input to Earth: 2.0 kV	
Insulation Resistance	50 MΩ or more	

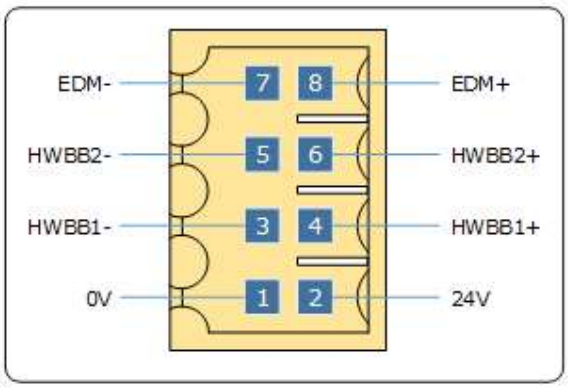
CAUTION

- To avoid the risk of crosstalk to signal cables, please segregate the power interface cable from signal cables or state alternative mitigation methods.
- The drive system is recommended for industrial cabinet installation and should not be permanently installed for use from a domestic single-phase plug-socket.

4.3 Terminals Arrangement (X6)

Signal Diagram





Pin Layout

WARNING

- Please use the PELV/SELV switching power supplying to the IO signal of the STO function.
- The external signal shall meet the Idle-current principle.

Pin	Signal	Name	Function
1	0 V	24 V Power Supply	— (Do not use these pins because they are connected to internal circuits)
2	24 V		
3	HWBB1-	HWBB1 Input	The STO function takes effect when the HWBB1 or the HWBB2 signals is turned OFF.
4	HWBB1+		
5	HWBB2-	HWBB2 Input	
6	HWBB2+		
7	EDM-	External Device Monitor Output	Turns ON when the HWBB1 signal or the HWBB2 signal is turned OFF.
8	EDM+		

Signal Specifications

The input specifications of the HWBB1 signal (X6-3, X6-4) and HWBB2 signal (X6-5, X6-6) are as follows.

Item	Characteristics	Description
Internal Impedance	3.3 kΩ	—
Operating Voltage Range	24V ± 20%	V_{H_min} = 17.6 V; V_{L_max} = 4 V

The electrical characteristics of the EDM (X6-7, X6-8) output signal are as follows:

Item	Characteristics	Description
Maximum Allowable Voltage	35 V dc	—
Maximum Allowable Current	80 mA dc	—
Maximum ON Voltage Drop	1.0 V	Voltage between EDM+ and EDM- when current is 80 mA
Maximum Delay Time	5 ms	Time from a change in HWBB1 or HWBB2 until a change in EDM

4.4 Function Description

4.4.1 EDM (External Device Monitor)

The EDM (External Device Monitor) signal is used to monitor failures in the STO. Connect the monitor signal as a feedback signal, e.g., to the Safety Function Device.

The relationship among the signals of EDM, HWBB1, and HWBB2 is shown in Table 4-1.

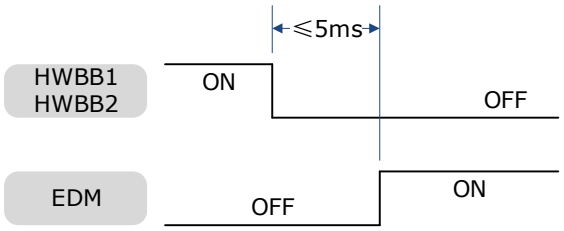
Table 4-1 The relationship among the signals of EDM, HWBB1, and HWBB2

Signal	Logic			
HWBB1	ON	ON	OFF	OFF
HWBB2	ON	OFF	ON	OFF
EDM	OFF	OFF	OFF	ON

WARNING

- The EDM signal is not a safety output. Use it only for monitoring for failures.

If an STO is requested by turning OFF input signals (HWBB1 and HWBB2) when the safety function is operating normally, the EDM output signal will be turned ON within 5 milliseconds.



4.4.2 Safe State

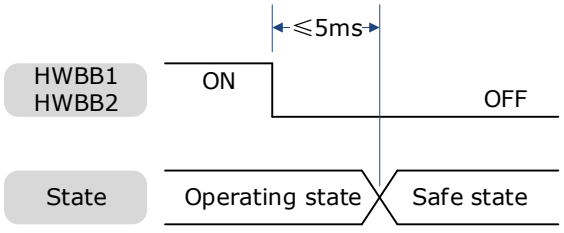
When the STO function takes effect, the Drive enters the safe state and the Panel Operator displays SAF, as is shown below.

The relationship between the State and the signals of HWBB1 and HWBB2 is shown in Table 4-2.

Table 4-2 The relationship between the State and the signals of HWBB1 and HWBB2

Item	Logic			
HWBB1	ON	ON	OFF	OFF
HWBB2	ON	OFF	ON	OFF
State	—	Alarm	Alarm	SAF

Turn OFF input signals (HWBB1 and HWBB2) for taking effect the STO function, the power supplied to the Motor will be cut off within 5 milliseconds.



Safety output signal from the safety controller and safety sensor may include L pulse for self-diagnosis. Make sure the off period of safety input signal less than 1 millisecond, and the safety input circuit does not detect this OFF event.

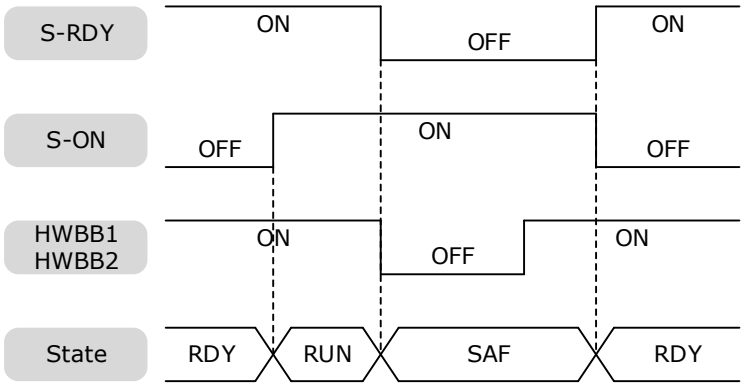
CAUTION

- Conditions for STO function reset is that both HWBB1 and HWBB2 are ON.

4.4.3 S-RDY (Servo Ready Output) Signal

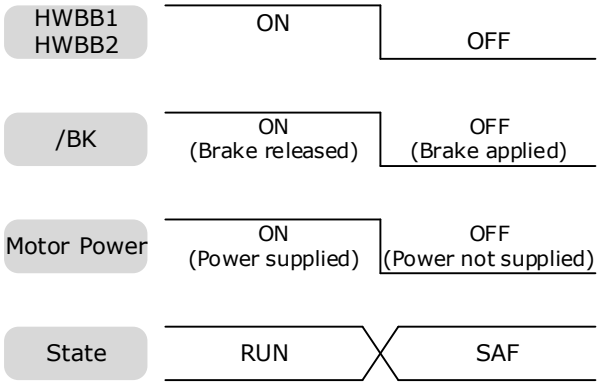
When the Drive is in Safe State, S-RDY (Servo Ready Output) signal is OFF.

When the HWBB1 and the HWBB2 signals are turned ON, and the Servo is OFF, the S-RDY signal will be turned ON, and the Drive will be in Ready State.



4.4.4 /BK (Brake Ouput) Signal

If the STO function takes effect when the HWBB1 or HWBB2 signal is OFF, the /BK (Brake) signal will turn OFF. At that time, the setting in Pn506 (Brake Reference-Servo OFF Delay Time) will be disabled.



4.4.5 Stopping Methods

The Drive will enter the safe state when the STO function takes effect, and the Motor will stop according to the setting of Pn003.0.

Parameter	Setting	Stopping Method	Status after Stopping	When Enabled
Pn003.0	0	Dynamic Brake	Coasting	After restart
	1	Dynamic Brake	Dynamic Brake	
	2	Coasting	Coasting	

4.4.6 Reset Method for Deviation Counter

The Drive will enter the safe state when the STO function takes effect, and the Deviation Counter will reset according to the setting of Pn004.1.

Parameter	Setting	Reset Method	When Enabled
Pn004.1	0	Reset to zero when Servo is OFF or STO function takes effect.	After restart
	2	Reset to zero when Servo is OFF, or STO function takes effect, or Overtravel is occurred.	

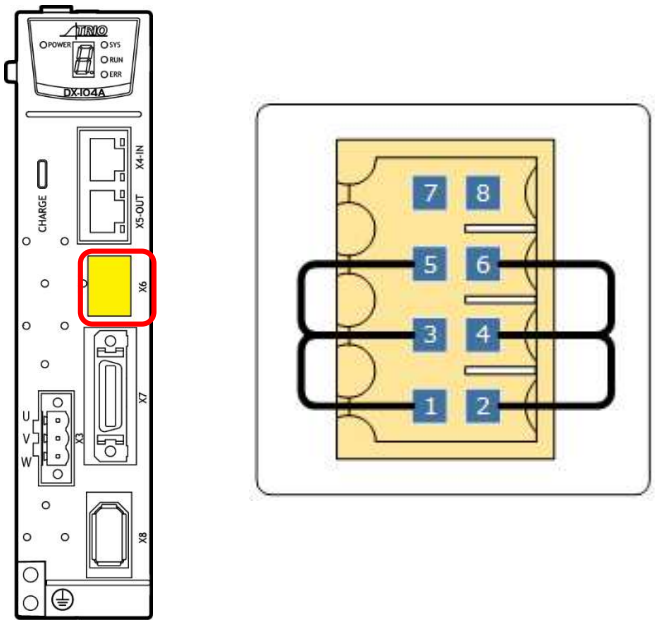
4.5 Safety Function Device Connection

4.5.1 Disconnecting a Safety Function Device

If a safety function device is not connected, keep the Safety Connector plugged into the X6 port, and the shorting pins on the connector remain in the default state.

WARNING

- In this case, the STO function will be disabled and the Drive will not be able to implement the safety function by the Safety Function Device.



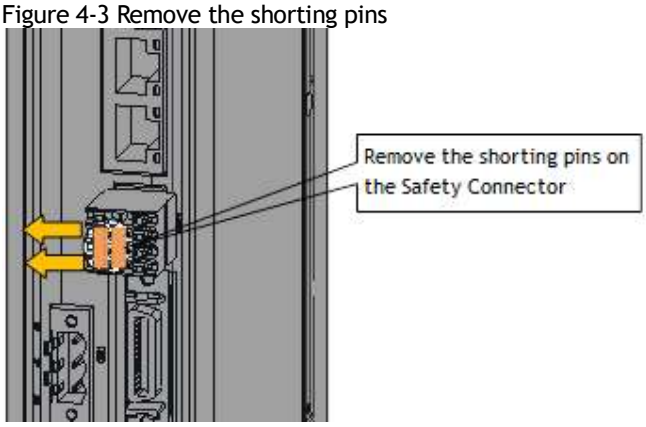
CAUTION

- If the shorting pins are removed and the Safety Function Device is not connected, the Drive will enter safe state and not supply the current to the Motor, so that the Motor cannot output torque. At that time, the Panel Operator will display **SAF**.

4.5.2 Connecting a Safety Function Device

Step 1 Remove the shorting pins on the Safety Connector as shown in Figure 4-3.

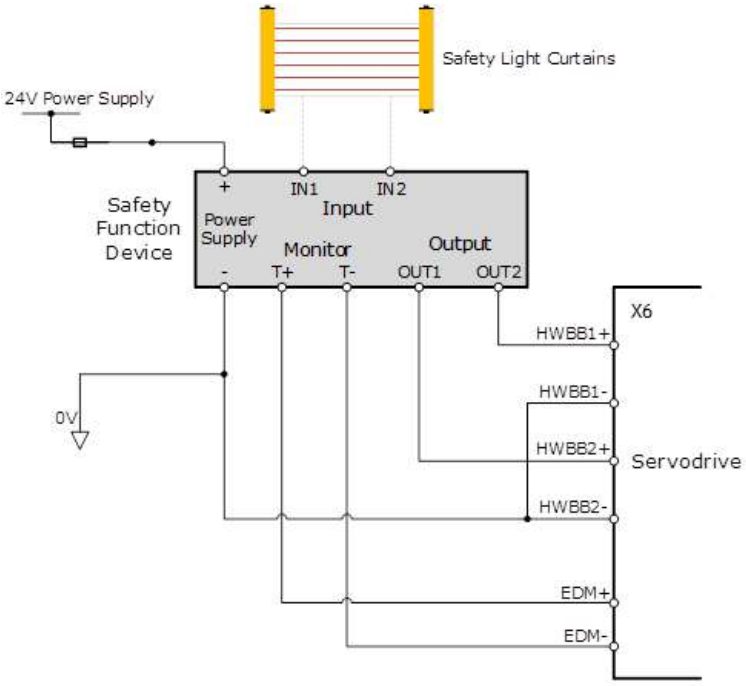
Figure 4-3 Remove the shorting pins



Step 2 Wiring the Safety Function Device

Connect the Safety Function Device to the X6 port according to the wiring example shown in Figure 4-4.

Figure 4-4 Wiring example for Safety Function Device



Use armored cables to protect the HWBB1+ and HWBB2+ from short circuits.
Use the EDM signal at the common emitter output, making sure that the current flows from EDM+ to EDM-.

When the safety grating is blocked, the HWBB1 and HWBB2 signals turn OFF, and the EDM signal is turned ON to enter the Safe State.

When the blocking of the safety grating is released, the HWBB1 and HWBB2 signals turn ON, and the Drive will enter the Operating State.

Step 3 Validating Safety Functions

When the system is commissioned, or maintenance operations are performed, or a Drive is replaced re-validation tests must be run to check the operation of the STO function. It is recommended that the results of any conformation testing are kept as a record for future reference.

- When the HWBB1 and HWBB2 signals turn OFF, confirm that the Panel Operator displays SAF and that the Motor does not operate.
- Monitor the ON/OFF status of the HWBB1 and HWBB2 signals.

If the ON/OFF status of the signals do not coincide with the display, the following must be considered:

- An error in the external device.
- Disconnection of the external wiring, short-circuiting in the external wiring.
- A failure in the Drive.

Find the cause and correct the problem.

Troubleshooting

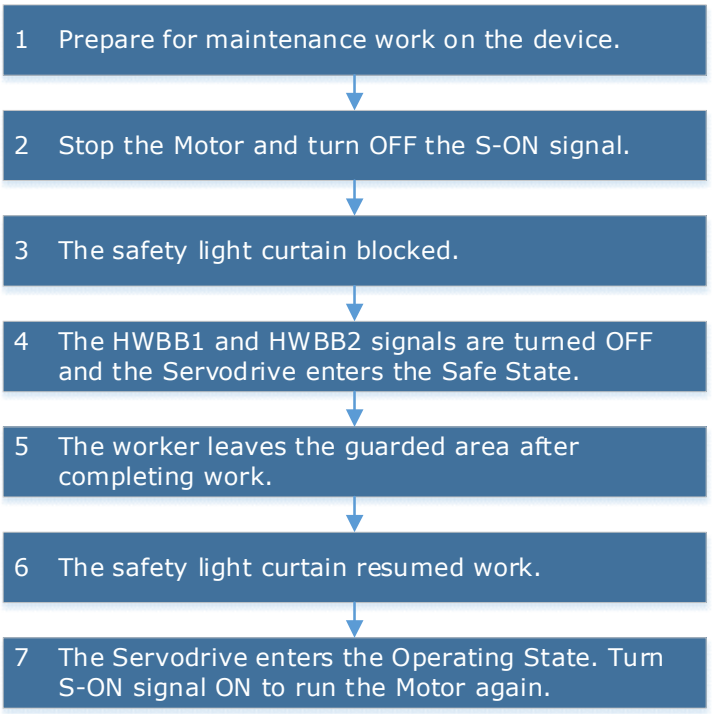
If any one of the input signal HWBB1 or HWBB2 turns OFF, the Drive will enter the Safe State. However, if other signal is still ON for more than 10 seconds, an alarm A30 (STO Disconnected) will occur. At that time, the following must be considered:

- The circuit or device used to input the HWBB1 and HWBB2 signals may be faulty.
- The cable for the input signal has been disconnected.

Find the cause and correct the problem.

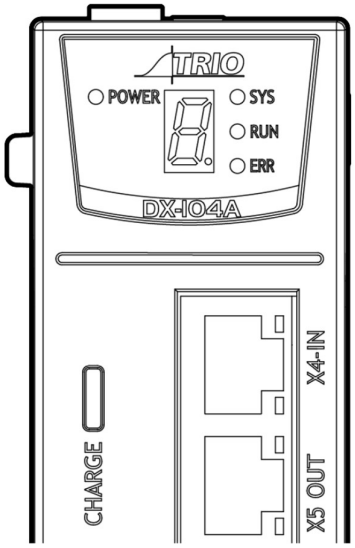
4.6 Procedure

Taking the wiring of the Safety Function Device shown in Figure 4-4 as an example, use the STO function as follows.



Chapter 5 Status Display

The Status indicators on the Drive show the status of the EtherCAT network and the servo control.



The POWER LED indicates power is present to the Control board.

The CHARGE LED indicates the voltage level on the Main circuit.

The seven-segment display shows the status of the motor control.

The LEDs integrated into the RJ45 connectors and the LEDs labeled SYS, RUN and ERR are network status indicators.

5.1 Motor Control Status Display

When the Drive is powered on the seven-segment display will show the Servo Status.

The display will cycle through a multi-digit code. The start of the sequence is the display separator, a hyphen and the decimal point. This is followed by a 2 or 3 digit code, each digit is displayed for 1 second and this sequence will continually cycle. For example, if the status is showing:

Then the sequence would be:

Some states have additional information; for example, if the drive has an active alarm, the sequence would be:

This shows the state as Servo Alarm State (FLt) and the alarm code (A01) each separated by the display separator.

5.1.1 Code

The table below described the different Code sequences shown on the Drive.

Table 5-1 Display meanings of Code

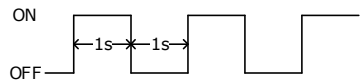
Code	Meaning
	Servo initialization failed (check the encoder connection)
	Servo OFF (Motor Power OFF)
	Servo Ready
	Run Servo ON (Motor Power ON)
	Quick Stop State
	Servo Alarm State
	Safe State
	Forward Drive Prohibited
	Reverse Drive Prohibited
	(Forward and Reverse) Overtravel State
	Alarm Number Display

5.2 Network Status Indicators

There are 3 indicator lamps on the panel Operator of the Drive to indicate the communication status of EtherCAT: SYS, RUN and ERR.

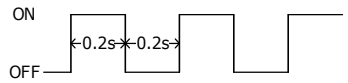
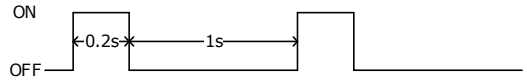
SYS Indicator

The SYS indicator shows the system status of EtherCAT communications.

Indicator		Description
Status	Pattern	
Off	Never lit	No power supplied or EtherCAT is resetting
Blinking		EtherCAT is booting
On	Always lit	Initialization is complete and EtherCAT is operating normally

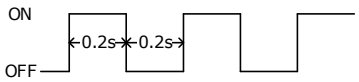
RUN Indicator

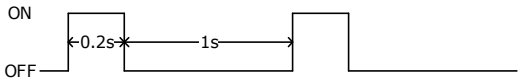
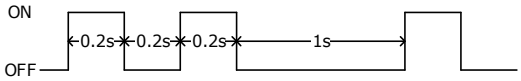
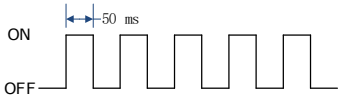
The RUN indicator shows the status of EtherCAT communications.

Indicator		Description
Status	Pattern	
Off	Never lit	EtherCAT is in Init state
Blinking		EtherCAT is in Pre-Operational state
Single flash		EtherCAT is in Safe-Operational state
On	Always lit	EtherCAT is in Operational state

ERR Indicator

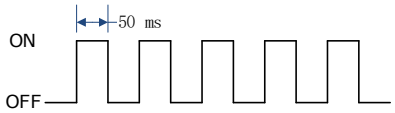
The ERR indicator shows the error status of EtherCAT communications.

Indicator		Description
Status	Pattern	
Off	Never lit	No error
Blinking		A change in state requested by the master could not be made due to register or object settings.

Indicator		Description
Status	Pattern	
Single flash		A synchronization error occurred and EtherCAT automatically went to Safe-Operational state
Double flash		An application (Sync Manager) watchdog timeout error occurred
Flickering		A boot error occurred
On	Always lit	A PDI watchdog timeout error occurred

5.2.1 RJ45 LEDs

The Link/Activity indicators show whether Communications Cables are connected to the X4-IN and X5-OUT connectors and whether communications are active.

Indicator		Description
Status	Pattern	
Off	Never lit	A Communications Cable is not connected and the EtherCAT controller is not running
Flickering		Data communications are in progress
On	Always lit	A Communications Cable is connected, but data communications are not being performed

Chapter 6 Commissioning

All configuration and commissioning of DX4 is performed using Motion Perfect v5.0 (or above).

6.1 Motion Perfect

Motion Perfect is a Microsoft Windows™ based application for the PC, designed to be used in conjunction with Trio Motion Technology's range of multi-tasking motion controllers, servo drives, HMI and IO expansion products.

A PC with the following specifications is required to run Motion Perfect:

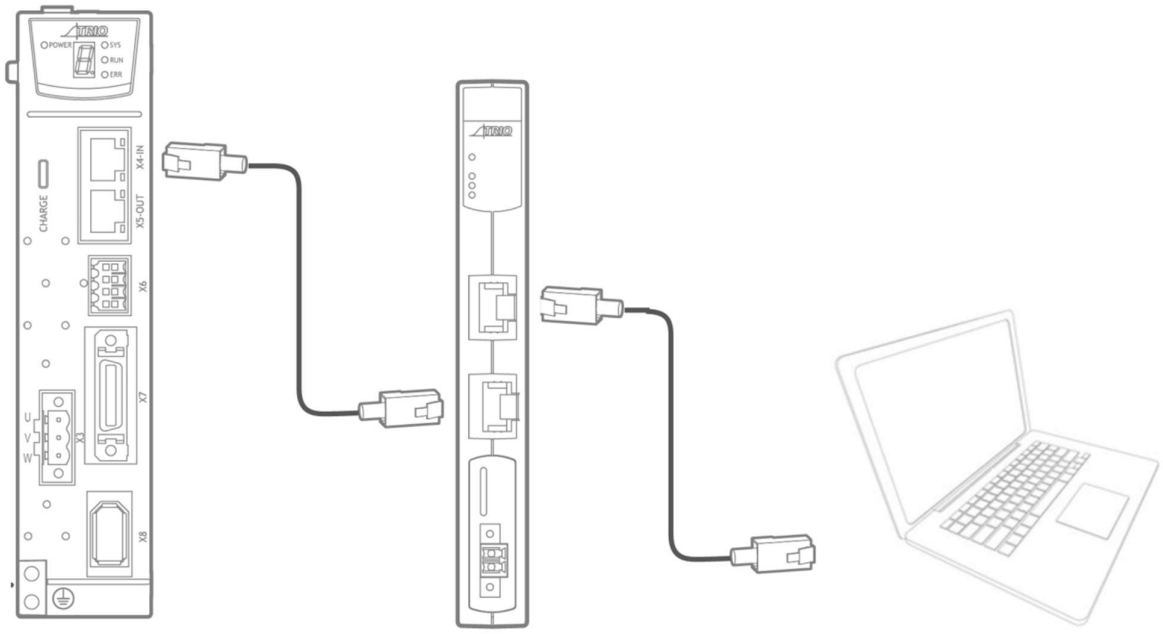
	Minimum	Recommended
Operating System	Windows XP, SP 3[1], Windows Vista[1], Windows 7	Windows 10
.NET Library	4.6.2	
Processor	Dual core	2 or more cores
RAM	2GBytes	4GBytes+
Hard Disk Space	200MBytes + space for projects	500MBytes
3D Graphics	DirectX 9	DirectX 11
Communications	Ethernet	Ethernet

[1] As of 11th April 2017 Microsoft has dropped support for Windows Vista. The main consequence of this is that PCs running Windows Vista or older will be more open to malware infection as security related patches will no longer be available. Although we will continue to test basic functionality on Windows XP and Windows Vista and will continue to support it as long as possible, there is no guarantee that all functionality will work.

Motion Perfect is a free download and is available to from the Trio web site (www.triomotion.com).

6.2 Setup

To communicate with DX4 the drive must be connected to a Trio controller via EtherCAT and the Trio controller needs to be connected to a PC via Ethernet and the PC needs to be running Motion Perfect.



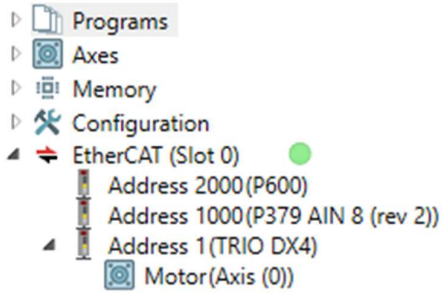
6.2.1 Initial Connection

To make the initial connection to a controller:

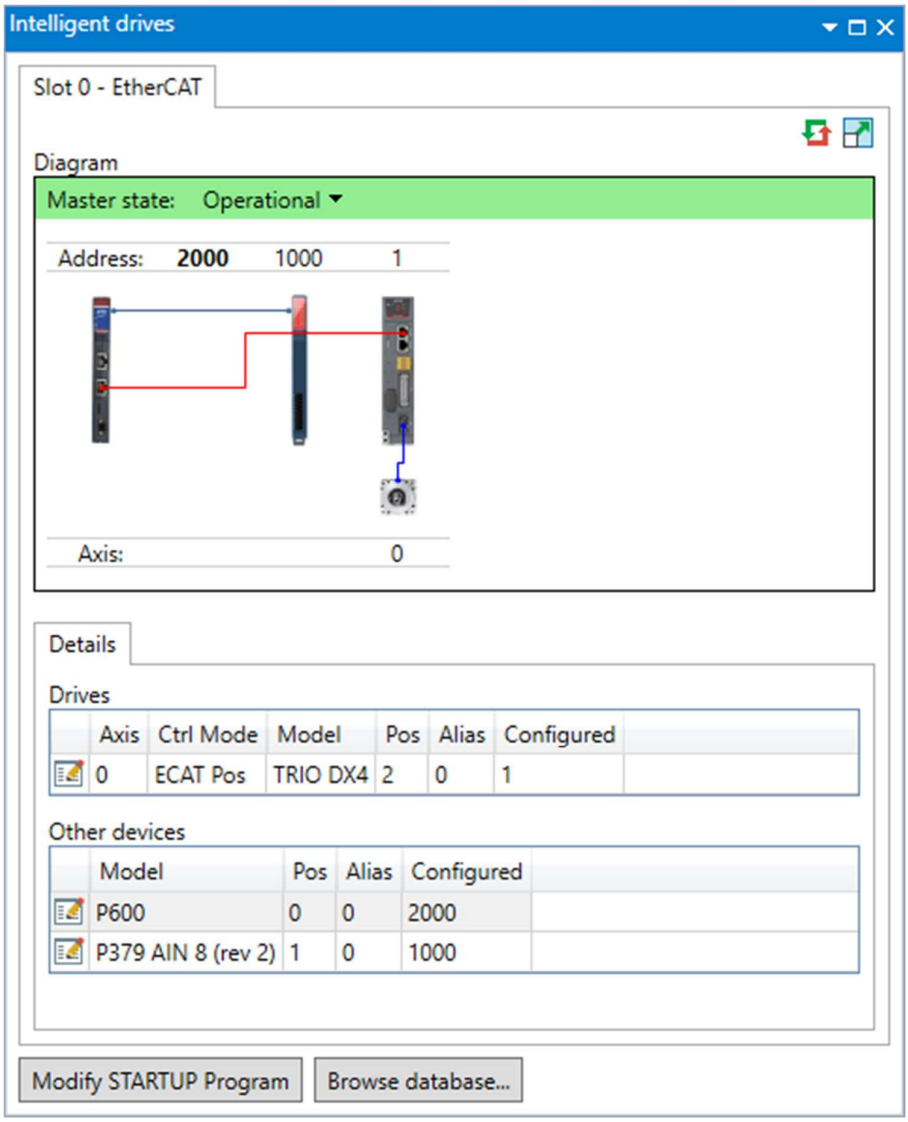
- Make sure that your controller is powered up and connected to the computer
- Start *Motion* Perfect. Once it has started up the initial screen should be displayed.
- Select "Connect in Sync mode" from the "Controller" menu. As *Motion* Perfect has not been connected before the "Connection" dialog will be displayed.
- Select the ‘Ethernet’ as the communications interface used by your controller. Then enter the IP address of the controller (default 192.168.0.250) and the TCP port (default 23).
- Click on the "Apply & Connect" button. The "Connect" will close and *Motion* Perfect will go into Sync Mode showing the the Controller Tree on the left.

The drive will be automatically detected by the Trio controller and appear as an EtherCAT node. This can be seen in either the controller tree, or the intelligent drives tool

Controller Tree example



Intelligent Drives tool example



EtherCAT State

If the EtherCAT state is not operational (green indicator in the controller tree, and green banner in Intelligent Drives), it may be necessary to re-start the EtherCAT network.

A re-start of the EtherCAT network can be issued from either the controller tree by right clicking on the EtherCAT root node, or from the Intelligent Drives tool by right clicking on the controller.

This will force the Controller to re-scan for devices on the EtherCAT network.

Axis Assignment

To operate correctly the controller must assign the drive an axis number. The rules for axis assignment are:

- If there is a NODE_AXIS entry in MC_CONFIG for the node number (based on network position) use axis number specified by NODE_AXIS.
- If the Drive has a non-zero device node number (Pn704) and this node number is unique on the network, then the axis number will be the node number -1. Node number 13 would be axis number 12.
- Otherwise the axis number is allocated based on the network position and AXIS_OFFSET. If AXIS_OFFSET is 0, the first EtherCAT drive would be axis 0, then second axis 1, etc.

By default, Drives are allocated axis numbers based on network position.

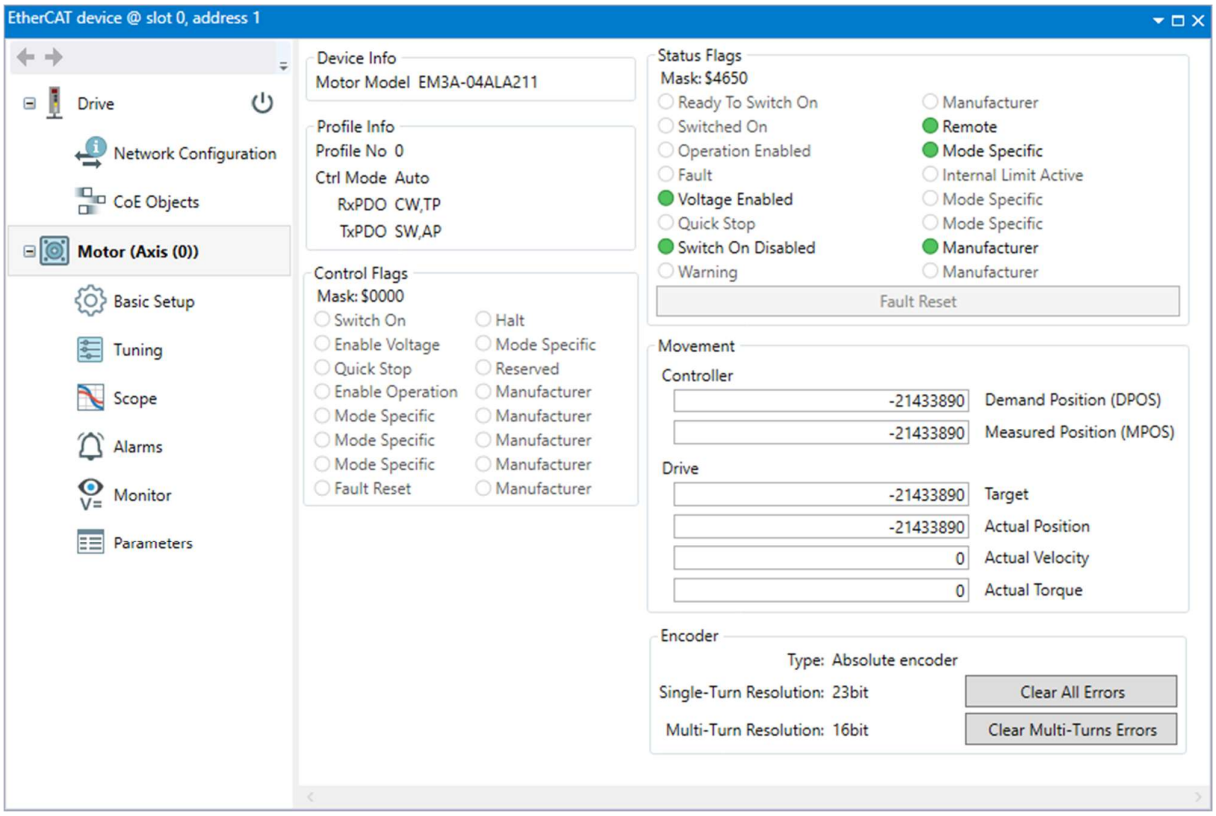
If there is a conflict during the axis allocation process, and the drive cannot be allocated a node number the EtherCAT network will not achieve an operational state.

Typical reasons for this are:

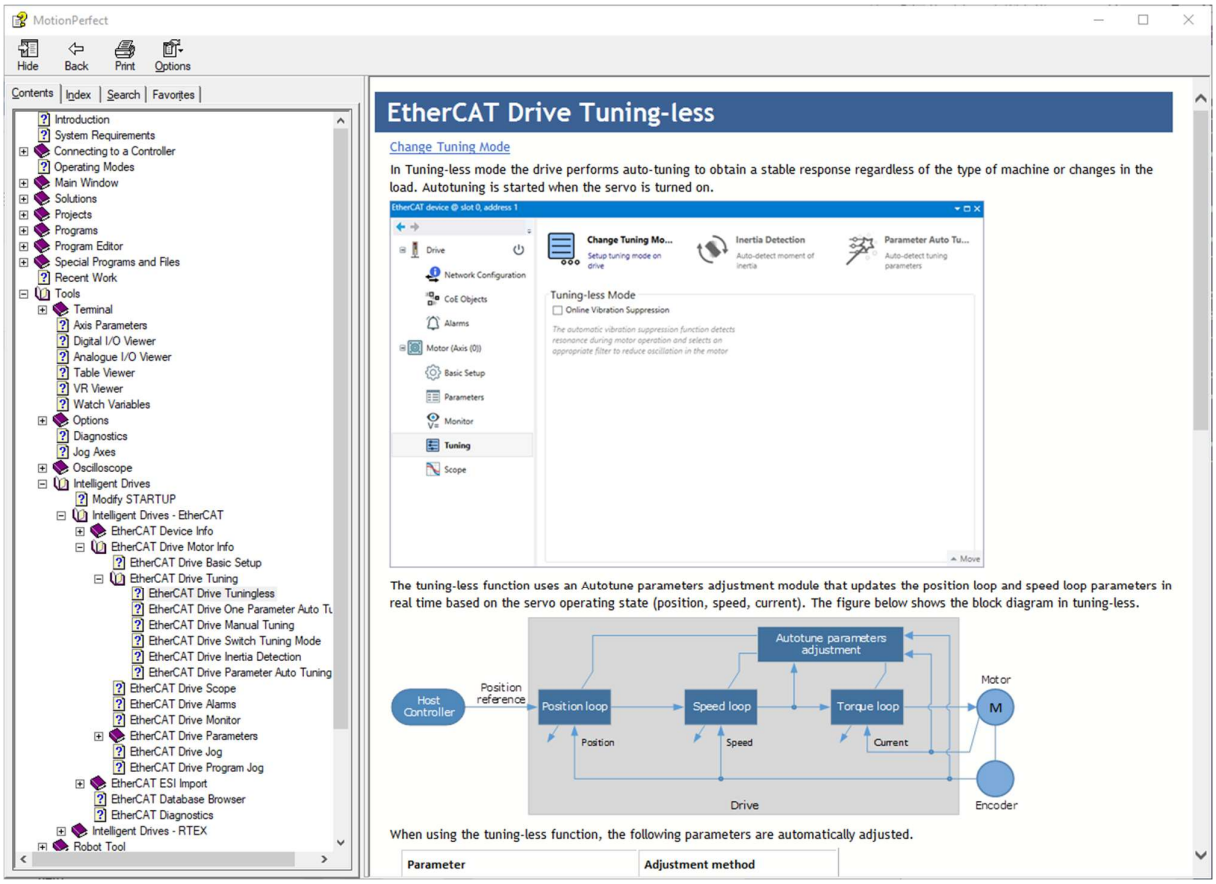
- Duplicate axis number allocation in MC_CONFIG. To resolve this, change the NODE_AXIS command in MC_CONFIG to avoid the duplication
- Conflict with local hardware. If the Controller has a local axis hardware, this will use axis 0 (zero), which may cause a conflict with the EtherCAT network. To change the base number of axis allocation of either the local hardware or the EtherCAT network, use the AXIS_OFFSET command in MC_CONFIG. The command AXIS_OFFSET(-1) = 32 will force the local hardware axis allocation to start at axis 32, leaving the lower axis numbers free for EtherCAT.

6.3 Drive Commissioning Screens

In either case, double clicking on the drive or motor in either the Controller Tree or the Intelligent Drives tool will open the device configuration screen. This is where all drive configuration and commissioning tools can be found.



From any of the device configuration screens, for help or more information, pressing F1 will launch the Motion Perfect help based on the screen in view.



The commissioning screens for the Drive are listed below. The menu is split into 2 groups, Drive and Motor. The Drive screens are for status and operations that are not necessarily axis specific. The Motor screens show detail that is axis specific.

Drive

- EtherCAT information
- Device information
- Update firmware (DSP and FPGA)
- Drive status

Network Configuration

- Flexible process data mapping

CoE Objects

- Read / Write access to all objects
- Create custom object lists
- Display values in decimal or hexadecimal

Motor

- Motor model detected
- Live monitor of key parameters used by controller

    - Control word, Status word
    - DPOS, MPOS
    - Target
    - Actual Position, Actual Velocity, Actual Torque
    - Status of motor feedback device

Basic Setup

- Allows easy access to basic drive configuration
- Parameters that define the physical operation of the drive
    - Power supply type
    - Motor Direction and Abs. Encoder Usage
    - Behavior in case of alarm
    - Internal torque limit
    - Brake control

Tuning

- Selection of tuning mode
- Access to tuning tools
- Access to control law parameters though graphical interface
- Generate test move without using the command line

Scope

- Select up to 8 drive parameters to capture
- Data capture performed on the drive
- Zoom / Cursors on graph
- Save and Load graph data
- Generate test move without using the command line

Alarms

- View active alarm and historical alarm log
- Trouble shooting tips for all alarm codes

Monitor

- Read only access to drive status
- Items in logical groups for viewability
- Show / Hide option to customize view
- Import / Export monitor item set

Parameters

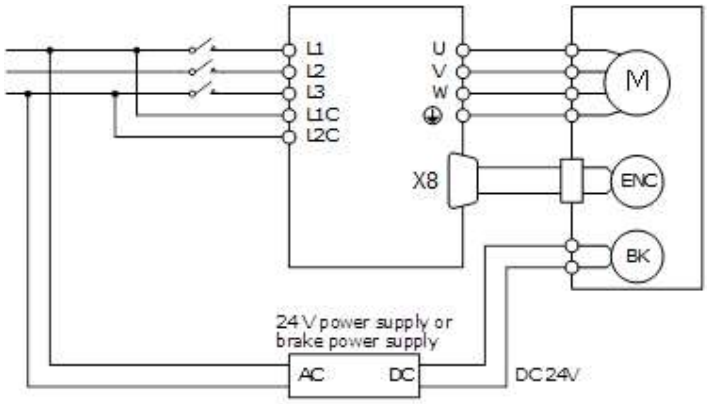
- Read / Write access to all drive parameters
- Folding tree structure for easy navigation
- Text search for easy location based on name

- Filters to identify changes
- Import and export of full or partial parameter set
- Create STARTUP program based on full or partial parameter set

6.4 Basic Operation

To ensure safe and correct operation, check the following items before you start.

- Make sure that the Drive and Motor are installed, wired, and connected correctly.
- Make sure that the correct power supply voltage is supplied to the Drive.
- Make sure that there are no loose parts in the Motor mounting.
- If you are using a Motor with an Oil Seal, make sure that the oil seal is not damaged. Also make sure that oil has been applied.
- If you are performing trial operation on a Motor that has been stored for a long period of time, make sure that all Motor inspection and maintenance procedures have been completed.
- If you are using a Motor with a Holding Brake, make sure that the brake is released in advance. To release the brake, you must apply the specified voltage of 24 VDC to the brake.



Once connected to a motor, when the Drive is powered up it will auto detect the motor and perform an auto setup which will allow operation of the motor.

The default power supply selection for the main circuit is Three Phase, 200 VAC, 50Hz. If the supply in use is different to this the drive will generate an alarm. The correct supply type can be selected from the Basic Setup page in the drive commissioning screens or by directly writing to parameter Pn007.1 and Pn007.3

Parameter	Setting	Meaning
Pn007.1	0	Single-phase AC for 1.5kW drive will apply an 80% de-rate for 2.0kW and 3.0kW single-phase is not supported
	1 [Default]	Three-phase AC
	2	DC
Pn007.3	0 [Default]	50 Hz
	1	60 Hz

Once the supply type has been changed the drive will require a re-start for the new selection to apply.

If using an absolute encoder, the drive will generate an alarm if it detects a low battery voltage at the encoder. If a battery is fitted and the voltage is correct, this alarm can be cleared from the Motor page in the drive commissioning screens. If there is no battery fitted, then the usage of the encoder will need to be changed to incremental. Changing the encoder usage from absolute to incremental will not change the encoder resolution but will ignore multi-turn information from the encoder and inhibit the low battery voltage alarm. The correct encoder usage can be selected from the Basic Setup page in the drive commissioning screen or by writing directly to parameter Pn002.2.

Parameter	Setting	Meaning
Pn002.2	0 [Default]	Use the encoder as an absolute encoder (requires encoder battery)
	1	Use the encoder as an incremental encoder

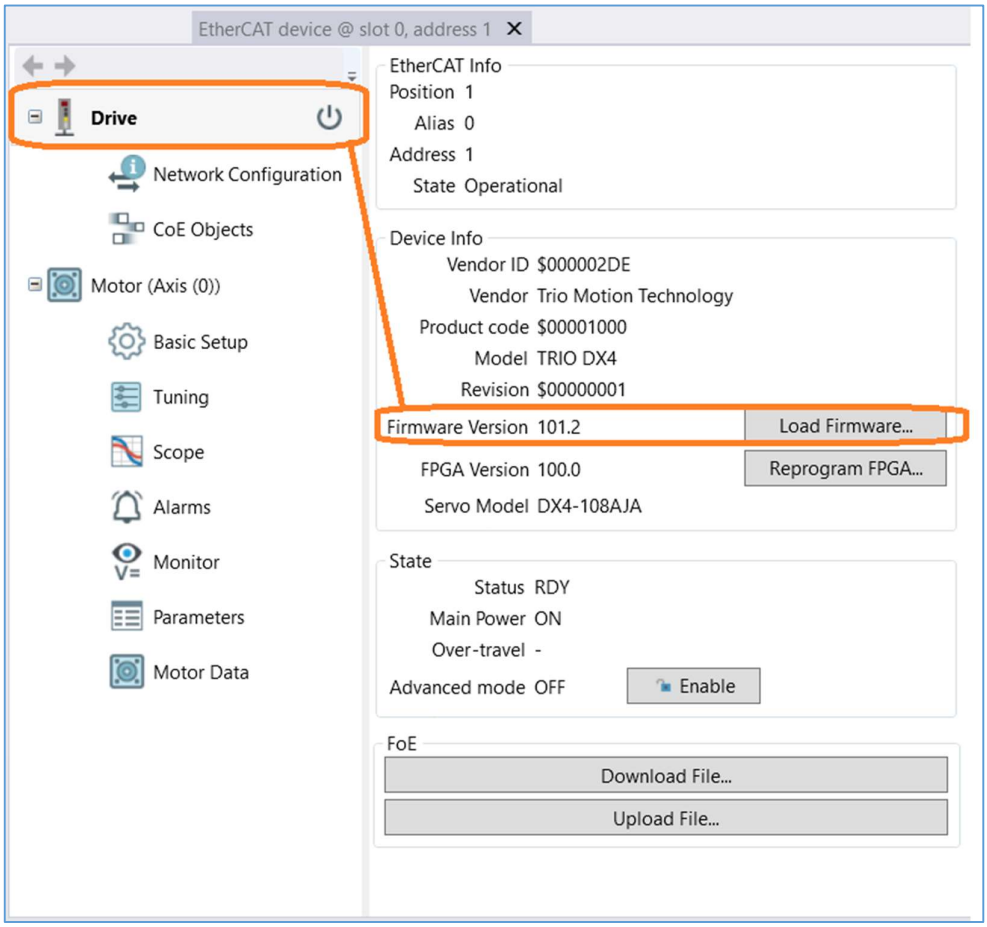
Once the encoder usage has been changed the drive will require a re-start for the new selection to apply.

To perform simple motion the Move panel in the Scope page (or Tuning page) in the drive commissioning screens can be used. This offers either Jog or Program Jog motion.

6.4.1 Drive Firmware – Checking and Updating

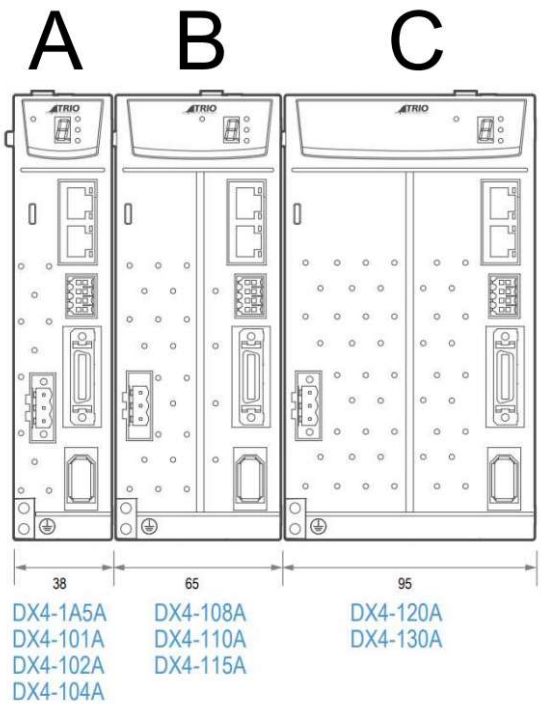
The version of firmware installed on the DX4 drive may not always be the current recommended type.

The current version can be checked by going on line to the drive via Motion Perfect and looking at the Drive section of the DX4's properties. An example of this is shown below. To initiate the update of firmware to the drive select the **Load Firmware** button and follow the on screen instructions when prompted.



Firmware versions are always available for download from the Trio website on the DX4 Product page - Software section.

The correct firmware to download is based on the frame size of the DX4. Using the information below is also an easy to use indication on the file name type to use.



Product	Output Power	Height (mm)	Width (mm)	Depth (mm)
DX4-1A5A	50W	172	38	180
DX4-101A	100W	172	38	180
DX4-102A	200W	172	38	180
DX4-104A	400W	172	38	180
DX4-108A	750W	172	65	180
DX4-110A	1kW	172	65	180
DX4-115A	1.5kW	172	65	180
DX4-120A	2kW	172	95	180
DX4-130A	3kW	172	95	180
All Models : Voltage = 200V ac				

The firmware files have the .bin file extension.

Example:

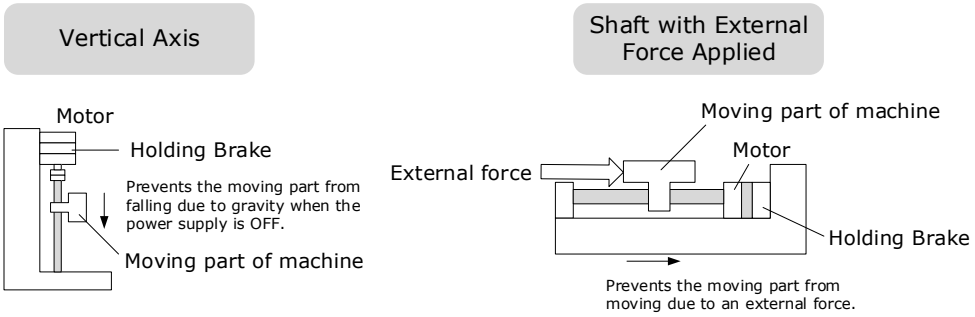
DX4_DSP_APP_A_A000_V101B4.bin	A frame size firmware version
DX4_DSP_APP_A_B000_V101B4.bin	B frame size firmware version
DX4_DSP_APP_A_C000_V101B4.bin	C frame size firmware version

6.4.2 Holding Brake

A holding brake is used to hold the position of the moving part of the machine when the drive is turned off, so that moving part does not move due to gravity or an external force.

This brake can be either built into a motor or can be provided as a separate component.

The holding brake is used in the following cases.



IMPORTANT

The brake integrated into the motor is a de-energization brake. It is used only to hold the motor once stationary and cannot be used for braking.

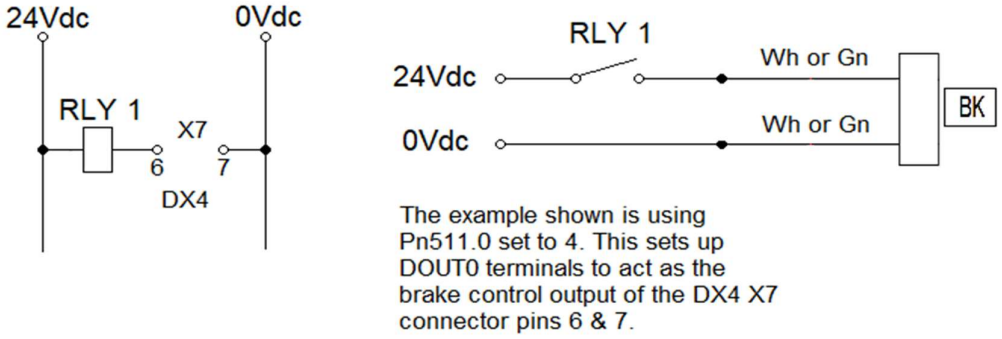
Use the holding brake only to hold a motor that is stationary.

If the motor has a holding brake a digital output on the drive can be assigned for brake control. Any of the digital outputs on the drive can be configured as the brake control output.

The assignment is made by selecting from the Basic Setup page in the drive commissioning screens or by writing directly to parameter Pn511.

Parameter	Setting	+ Pin	- Pin	Meaning
Pn511.0	4	X7-6	X7-7	The /BK signal is output from X7-6 and X7-7.
Pn511.1	4	X7-8	X7-9	The /BK signal is output from X7-8 and X7-9.
Pn511.2	4	X7-10	X7-11	The /BK signal is output from X7-10 and X7-11.
Pn511.3	4	X7-12	X7-13	The /BK signal is output from X7-12 and X7-13.

An Interposing relay must be used to control the supply to the motor brake coil. The motor power cable with the brake option selected will have two spare coloured cores ready for external holding brake control. The two cores are White and Green and connection to the brake is not polarity sensitive, both cores may be connected to either +24Vdc or 0V.



Contact current rating for suitable interposing relay type when controlling the motor brake coil is listed in the tables below.

MXL Range Motors

All Brake Voltage Rated at 24Vdc ±10%

Motor Size	Brake Rated Power (W)	Brake Operating Current (A)	Brake Rated Torque (Nm)
50W	4.0	0.17	0.32
100W	4.0	0.17	0.32
200W	7.4	0.31	1.5
400W	7.4	0.31	1.5
750W	9.6	0.40	3.2
1KW	9.6	0.40	3.2

MXM Range Motors

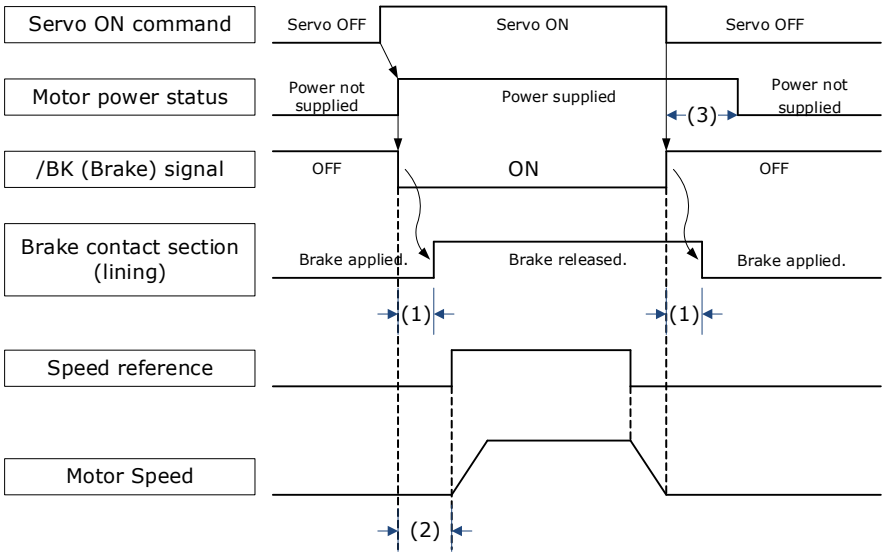
All Brake Voltage Rated at 24Vdc ±10%

Motor Size	Brake Rated Power (W)	Brake Operating Current (A)	Brake Rated Torque (Nm)
1KW	19.5	0.82	12
1.5KW	19.5	0.82	12
2KW	19.5	0.82	12
3KW	35	1.67	40

Selecting a digital output in the Basic Setup screen will enable the brake control timing parameters.

Brake Operating Sequence

The time required to release the brake and the time required to brake should be considered to determine the brake operation timing, as described below.



(1): The brake delay times for motors with Holding Brakes.
(2): Before you output a reference from the host controller to the drive, wait for at least 50 ms plus the time required to release the brake after you send the S-ON command.
(3): Use Pn506 (Brake Engage Delay Time), Pn507 (Brake Engage Speed Threshold), and Pn508 (Brake Engage Timeout) to set the timing of brake operation.

NOTE	Time required to release brake: The time from when the brake signal is turned ON until the brake is actually released. Time required to brake: The time from when the brake signal is turned OFF until the brake actually operates.

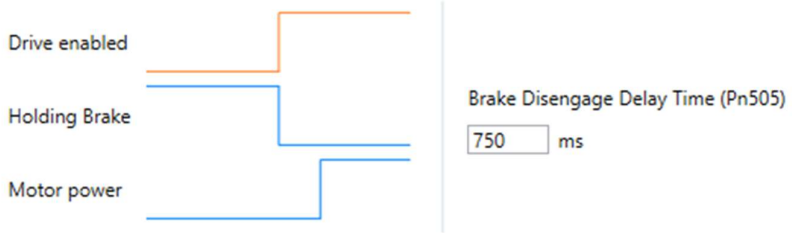
Brake Control when Motor is Stationary

Disabled -> Enabled

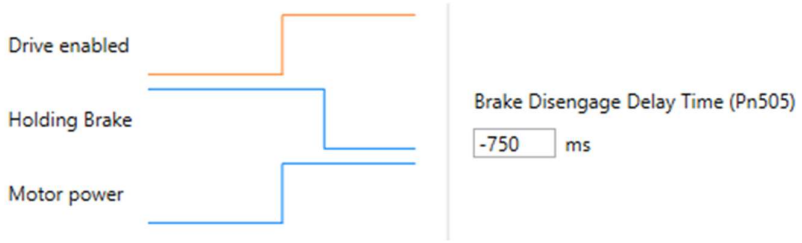
The brake disengage delay time controls the sequence and delay of brake signal when the drive changes from disabled to enabled when the motor is stationary.

Parameter	Name	Range	Unit	Default
Pn505	Brake Disengage Delay Time	-2000 to 2000	ms	0

If Pn505 is a positive value, when the Servo ON command is received, the brake signal will change first, and then power will be supplied to the motor after the delay time.



If Pn505 is a negative value, when the Servo ON command is received, the power will be supplied to the motor immediately, then the brake signal will change after the delay time.



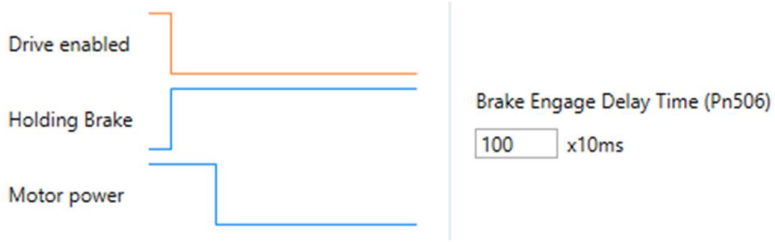
Enabled -> Disabled

The brake engage delay time controls the delay between the brake signal and motor power when the drive changes from enabled to disabled when the motor is stationary.

Parameter	Name	Range	Unit	Default
Pn506	Brake Engage Delay Time	0 to 500	10ms	0

When the motor is used to control a vertical axis, the machine moving part may move slightly due to gravity or an external force.

This slight motion can be eliminated by setting the Brake Engage Delay Time (Pn506) so that power supply to the motor is stopped after the brake is applied.



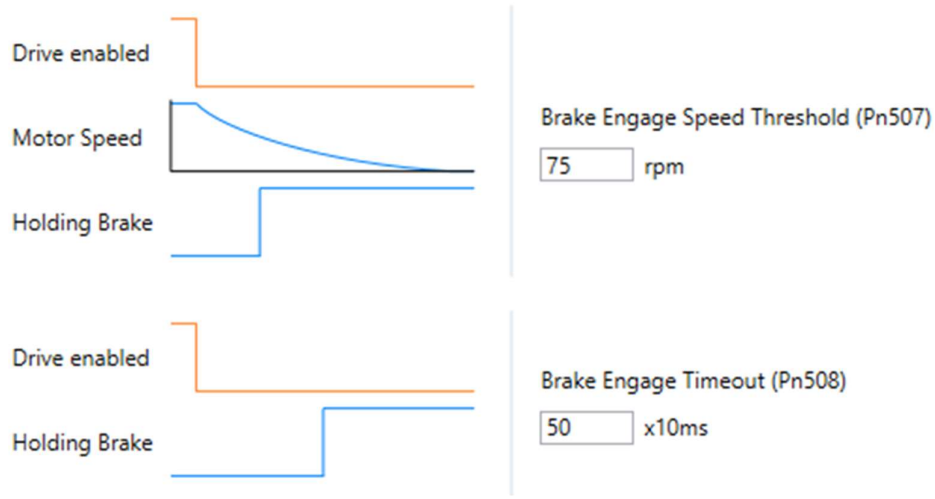
IMPORTANT

Power supply to the Motor will be stopped immediately when an alarm occurs, regardless of the setting of this parameter. The machine moving part may move due to gravity or an external force before the brake is applied.

Brake Control when Motor is In Motion

If an alarm occurs or the Servo OFF command is received while the motor is operating, the motor will start stopping and the brake signal will be turned OFF. You can adjust the timing of brake signal output by setting the Brake Engage Timeout (Pn508).

Parameter	Name	Range	Unit	Default
Pn507	Brake Enable Speed Threshold	10 to 100	1rpm	100
Pn508	Brake Enable Waiting Time	10 to 100	10ms	50



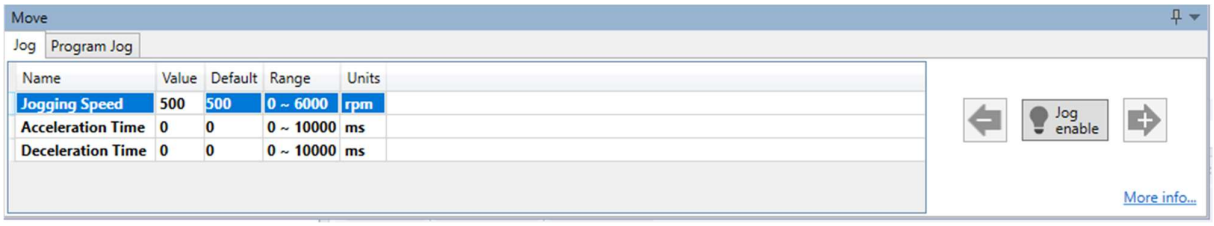
The brake signal changes when either of the following conditions is satisfied:

- When the motor speed falls below the level set in Pn507 after the power to the motor is turned OFF.
- When the time set in Pn508 is exceeded after the power to the motor is turned OFF.

6.4.3 Jog Motion

The 'jog' motion is a velocity profiled move. It has no end point so will generate continuous motion in a specific direction. The velocity profile is defined by acceleration, speed and deceleration value and will generate a trapezoidal velocity profile. Motion is commanded when the mouse button is clicked and halted when the button is released.

The Jog control is shown below:



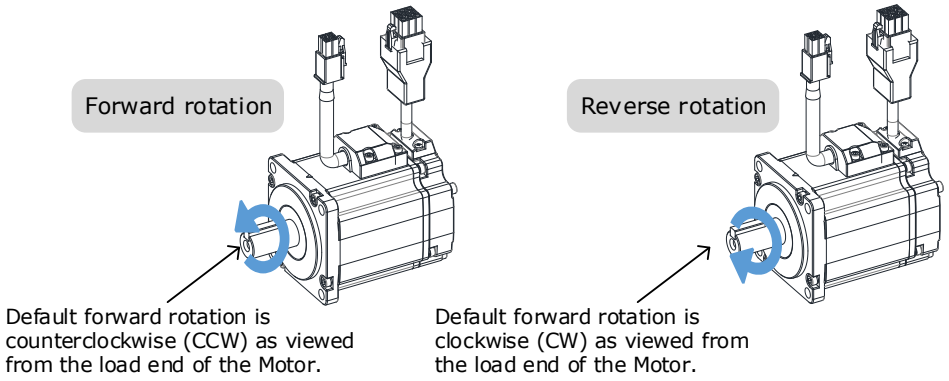
The motion profile is controlled three parameters:

- Jogging Speed: the maximum speed the jog profile will demand in revs per minute (RPM)
- Acceleration Time: the time to accelerate from rest to 1000 RPM in milliseconds (ms)
- Deceleration Time: the time to decelerate from 1000 RPM to rest in milliseconds (ms)

To initiate motion, first the drive must be enabled by clicking the 'Motor enable' button. This will enable the motion arrows.

Click and hold the arrow buttons to run the motor. The jog motion is continuous; while the button is pressed the motor will run in the direction of the arrow. The motor will stop when the button is released.

The '+' arrow will cause forward rotation, the '-' arrow will cause reserve rotation.



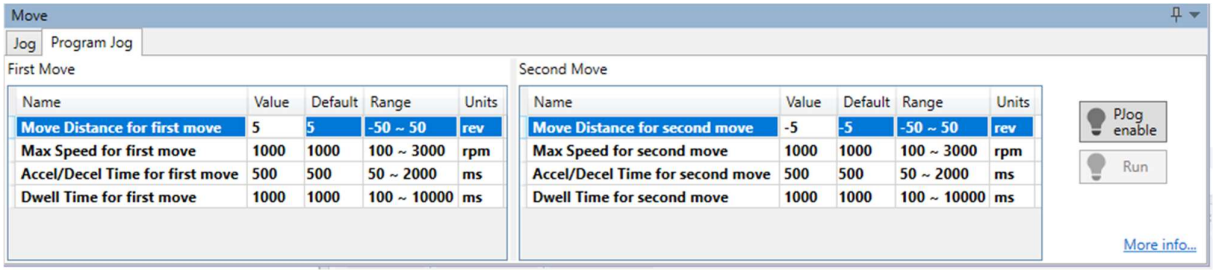
The rotation direction of the Motor can be changed by setting the Motor Direction from the Basic Setup page in the drive commissioning screens. The figure above shows the default setting.

When the drive is enabled via the 'Jog enable' button, the drive switches to a local control mode. While in this mode the position change is not sent to the controller. The controller values of MPOS and DPOS will not change during a jog. When the drive is disabled, the update of MPOS and DPOS on the controller resume.

6.4.4 Program Jog Motion

The 'program jog' motion is a sequence of two profiled moves of a specific distance with a programmable dwell time between moves. Each move has an independent move distance, acceleration, deceleration and speed. Both are profiled using a trapezoidal velocity profile. Once started, the motion will repeat until stopped by the user.

The Program Jog control is shown below:



The parameters controlling the program jog are:

- Move Distance: the distance to move, this is a signed value where a positive value represents forward motion and a negative value represents reverse motion. The distance is specified in revolutions (revs)
- Max Speed: the maximum speed of the profiled velocity in revs per minuite (RPM)
- Accel/Decel Time: the time to accelerate from rest to Max Speed in milliseconds (ms). The deceleration value is the same as acceleration.
- Dwell Time: the delay time before starting the next move in milliseconds (ms)

To initiate motion, first the drive must be enabled by clicking the 'PJog enable' button. This will enable the 'Run' button.

Clicking the 'Run' button will start the motion.

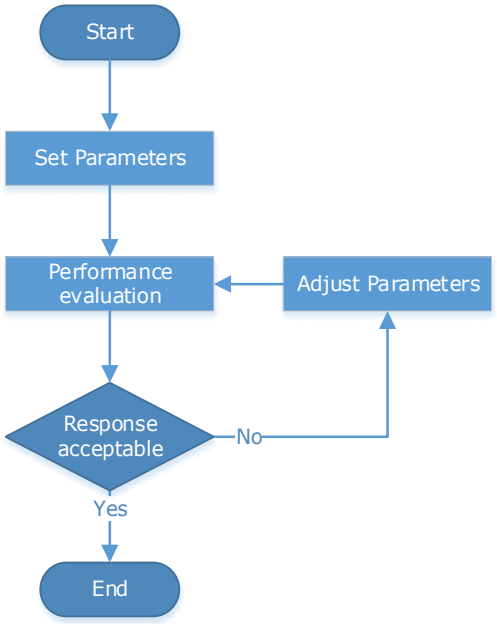
The sequence will run repeatedly until stopped by either clicking the 'Run' button or the 'PJog enable' – during motion clicking either will disable the axis.

When the drive is enabled via the 'PJog enable' button, the drive switches to a local control mode. While in this mode the position change is not sent to the controller. The controller values of MPOS and DPOS will not change during a jog. When the drive is disabled, the update of MPOS and DPOS will resume.

Chapter 7 Tuning

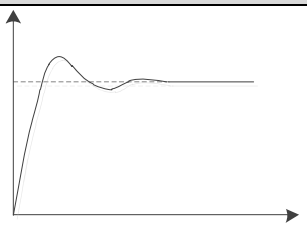
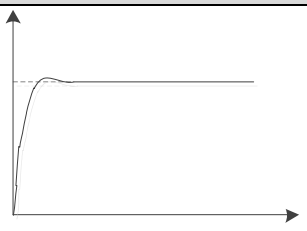
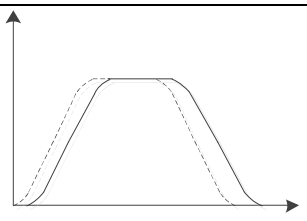
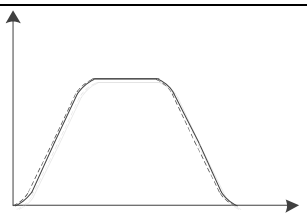
Tuning is the process of satisfying the servo performance by adjusting the parameters involved in the control law.

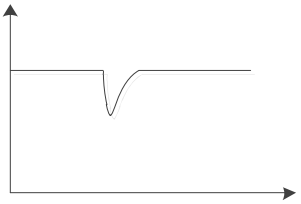
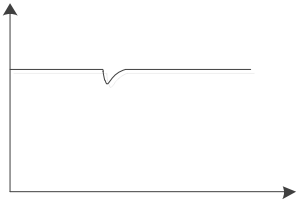
The process of tuning is usually an iterative process; the figure below shows the general flow



There are various indicators used to evaluate servo performance including bandwidth, response time, overshoot, steady state error, anti-load disturbance, speed ripple fluctuation, torque ripple, etc. The importance of these will depending on the application.

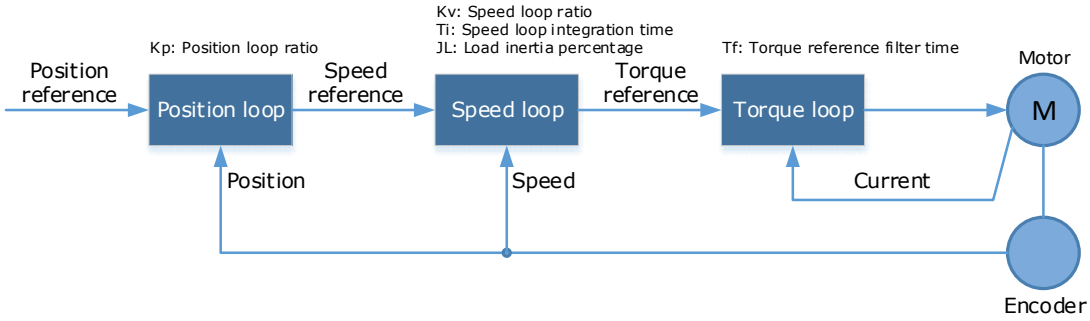
The table below shows examples of speed vs time graphs showing the comparison of before and after tuning.

Indicator	Before tuning	After tuning
Speed step response		
Position following		

Indicator	Before tuning	After tuning
Anti-load disturbance		

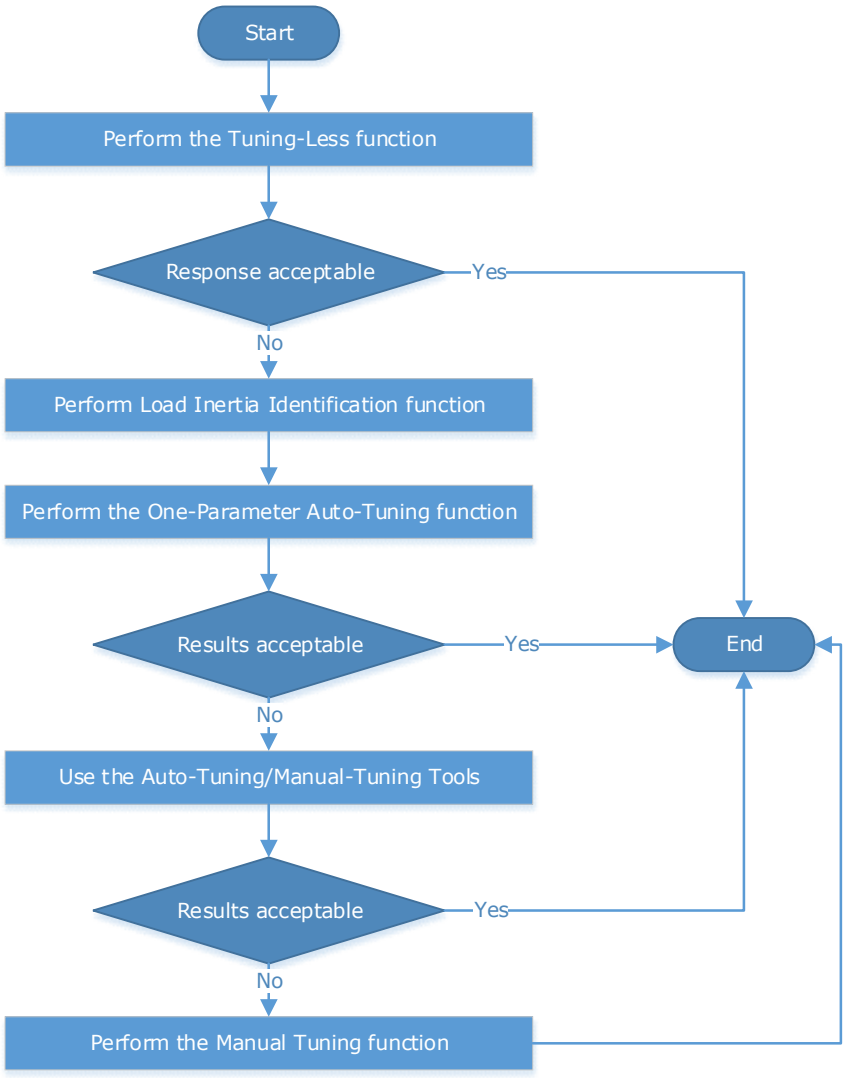
7.1 Tuning Process

When tuning a servo drive is if helpful to understand the servo control principle used. The figure below shows the servo control block diagram. The position loop, the speed loop and the torque loop are cascaded structures, corresponding to the position control mode, the speed control mode and the torque control mode respectively.



NOTE: only the basic tuning parameters during the tuning are shown in the figure.

Generally, for tuning the drive follow the process below.



IMPORTANT

It will be necessary to perform the tuning operation again if the motor has been disassembled or the load device had been replaced.

WARNING

Before performing the tuning operation, make sure the limit function is available.

Before performing the tuning operation, make sure that an emergency stop can be performed at any time.

Before performing the tuning operation, you shall set the torque limit according to actual condition.

Never touch the moving parts during the tuning operation.

7.2 Tuning Modes

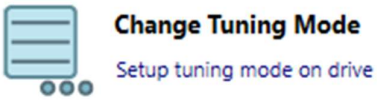
The drive supports 3 different tuning modes and different features are available in each mode.

Tuning-less: the drive performs auto-tuning to obtain a stable response regardless of the type of machine or changes in the load.

One-Parameter Auto-Tuning: similar to the tuning-less function but requires an inertia measurement of the load and uses a rigidity parameter to control the system bandwidth.

Manual Tuning: all gain terms are manually adjusted

The tuning mode can be changed from the Tuning page in the drive commissioning screens. Click on the 'Change Tuning Mode' button.



This will launch a wizard to guide the change of tuning mode.

Alternatively, the tuning mode can be changed by directly writing to parameter Pn100.0.

Parameter	Setting	Meaning
Pn100.0	1 [Default]	Tuning-less
	2	*Reserved*
	3	One-Parameter Auto-Tuning
	4	*Reserved*
	5	Manual tuning

Once the tuning mode has been changed the drive will require a re-start for the new selection to apply.

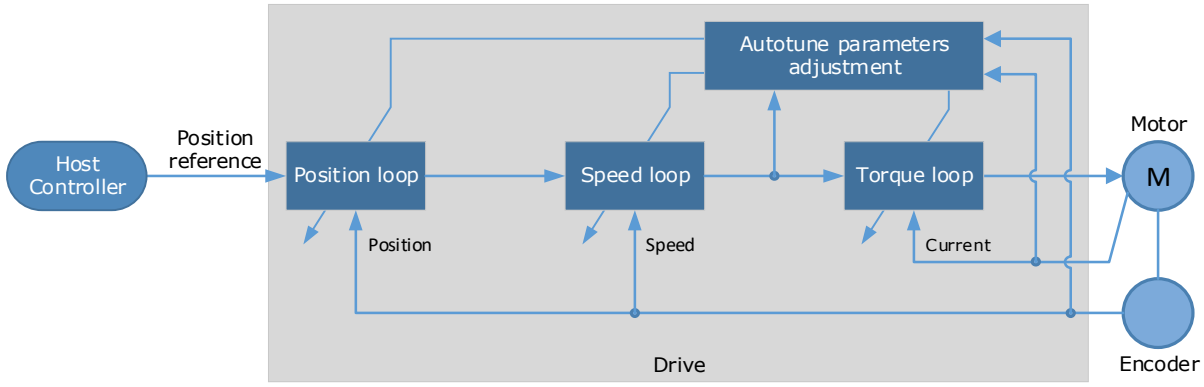
The table below show a summary functions available in each mode:

Function	Tuning-less	One-Parameter	Manual
Feedforward (Velocity and Torque)	Yes	Yes	Yes
Friction Compensation	Yes	Yes	Yes
Feedback Speed Selection	No	Yes	Yes
Load Torque Compensation	No	Yes	Yes
Damping Selection	No	Yes	No
Automatic Vibration Suppression	Yes	Yes	Yes
Intermediate Frequency Vibration Suppression	Yes	Yes	Yes
Notch Filter	Yes	Yes	Yes
Load Oscillation Suppression	No	No	Yes
P / PI Switching	No	Yes	Yes
Gain Switching	No	No	Yes
Model Following Control	No	No	Yes

7.2.1 Tuningless

In Tuning-less mode the drive performs auto-tuning to obtain a stable response regardless of the type of machine or changes in the load. Autotuning is started when the servo is turned on.

The tuning-less function uses an Autotune parameters adjustment module that updates the position loop and speed loop parameters in real time based on the servo operating state (position, speed, current). The figure below shows the block diagram in tuning-less.



When using the tuning-less function, the following parameters are automatically adjusted.

Parameter	Adjustment method
Speed Loop Gain	Auto-tuning
Speed Loop Integral Time	Auto-tuning
Position Loop Gain	Auto-tuning
Torque Command Filter Time	Auto-tuning
Load Inertia Percentage	Auto-tuning

NOTE: The gain terms used by the tuning-less model are not shown in the drive parameters.

Use Case

Applicable for applications where the motor / load inertia mismatch is no more than 30 times.

Applicable for applications of any motor speed.

Parameters

Parameter	Setting	Description
Pn100.0	1 [Default]	Set the **Tuning Mode** as **Tuning-less**.

Changing the tuning mode will require the drive to be restarted.

Restrictions

The following table shows a summary of functions available in tuning-less mode

Function	Tuning-less
Feedforward (Velocity and Torque)	Yes

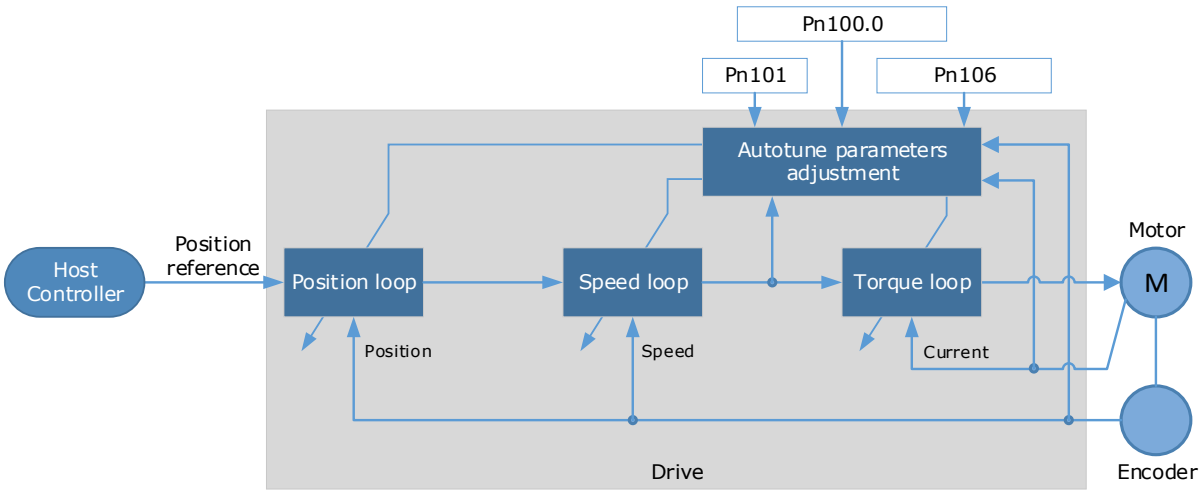
Function	Tuning-less
Friction Compensation	Yes
Automatic Vibration Suppression	Yes
Intermediate Frequency Vibration Suppression	Yes
Notch Filter	Yes

7.2.2 One-Parameter Auto Tuning

This tuning function is similar to the tuning-less function, using an Autotune parameters adjustment module that updates the position loop and speed loop parameters in real time based on the servo operating state (position, speed, current).

One-Parameter Auto Tuning may offer some advantages over Tuning-less mode due to:

- Tuning is based on a proper load inertia percentage so tends to offer improved performance.
- The user selection of rigidity means that the tuning mode can be applied to more operating conditions.



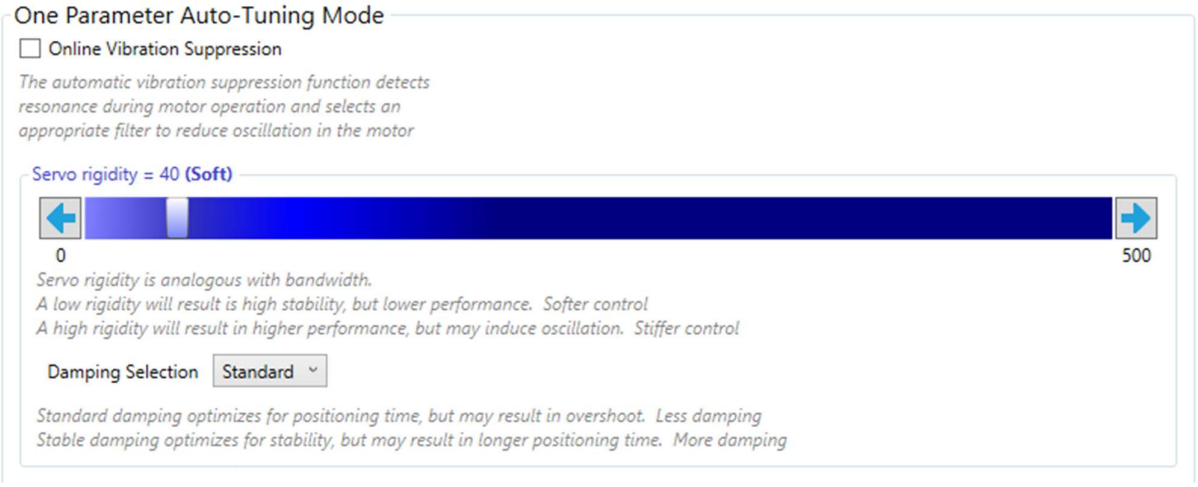
One-Parameter Auto Tuning requires an inertia measurement of the load. The drive can measure the load inertia using the Inertia Detection tool, which can be launched from the Tuning page in the drive commissioning screens

This will launch a wizard to guide the process of inertia detection.

Alternatively, the inertia can be entered by directly writing to parameter Pn106.

Parameter	Name	Description
Pn106	Load Inertia Percentage	Ratio of Motor inertia to load inertia

The stiffness of the control is selected by a rigidity parameter. This can be adjusted by a slider on the Tuning page in the drive commissioning screens.

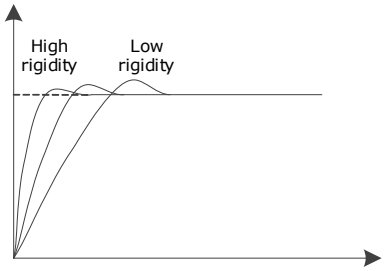


Alternatively, the rigidity can be entered by directly writing to parameter Pn101.

Parameter	Name	Description
Pn101	Servo Rigidity	Determines the response characteristic of the position loop or speed loop.

A lower number corresponds to a lower rigidity, less stiff. This will provide a slower response.

A higher number corresponds to a higher rigidity, more stiff. This will provide a faster response but taken too far may result in oscillation.



When using the One-Parameter Auto-Tuning function, the following parameters are automatically adjusted.

Parameter	Adjustment method
Speed Loop Gain	Auto-tuning
Speed Loop Integral Time	Auto-tuning
Position Loop Gain	Auto-tuning
Torque Command Filter Time	Auto-tuning

NOTE: The gain terms used by the tuning-less model are not shown in the drive parameters.

Use Case

Applicable for applications where the motor / load inertia mismatch is no more than 50 times.

Applicable for applications of any motor speed.

Parameters

Parameter	Setting	Meaning
Pn100.0	3	Set the Tuning Mode as One-Parameter Auto-Tuning.
Pn100.3	0 [Default]	Set the damping method in One-Parameter Auto-Tuning as Standard.
	1	Set the damping method in One-Parameter Auto-Tuning as Stable.
Pn101	—	Servo Rigidity (setting depends on application)
Pn106	—	Load Inertia Percentage (setting depends on application)

Changing the tuning mode will require the drive to be restarted.

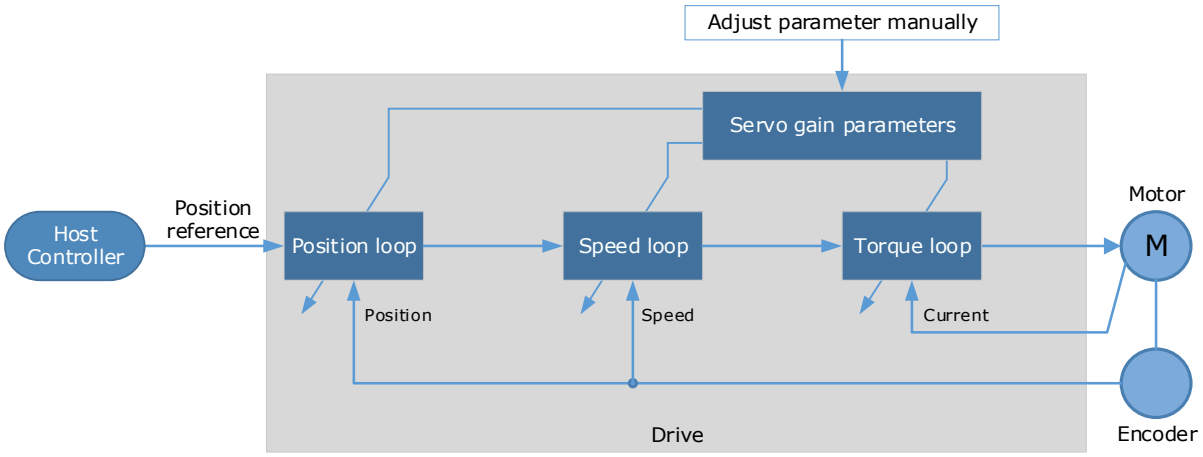
Restrictions

The following table shows a summary of functions available in one-parameter auto-tuning mode

Function	One-Parameter
Feedforward (Velocity and Torque)	Yes
Friction Compensation	Yes
Feedback Speed Selection	Yes
Load Torque Compensation	Yes
Damping Selection	Yes
Automatic Vibration Suppression	Yes
Intermediate Frequency Vibration Suppression	Yes
Notch Filter	Yes
P / PI Switching	Yes

7.2.3 Manual Tuning

In the Manual Tuning, the gain parameters are manually adjusted without using the autotune parameter adjustment module, until the desired performance is achieved.



It is necessary to adjust the three-loop control parameters of the Servo from the inside out, that is, the adjustment sequence is Torque loop → Speed loop → Position loop. In order to maintain stability, the bandwidth setting should be the largest in the torque loop, then the speed loop, and the position loop should be smallest.

The following parameters need to be adjusted in each loop when performing Manual Tuning.

Torque loop (Torque Control Mode)

- Torque Reference Filter Time (Tf):

  The torque reference filter applies to the torque reference to remove the high frequency components, which can effectively reduce the torque ripple of the motor output, eliminate signal noise and reduce the temperature rise of the motor.

The larger the Torque Reference Filter Time, the better the filtering effect on the torque reference. However, the greater the phase lag, and the slower the torque response. Therefore, the smallest acceptable value should be set to obtain a larger torque loop bandwidth in the actual tuning.

Speed loop (Speed Control Mode)

- Relevant parameter in torque loop (Tf)
- Load Inertia Percentage (JL)

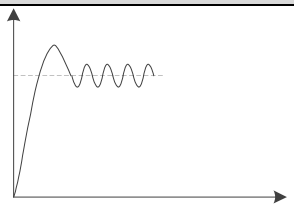
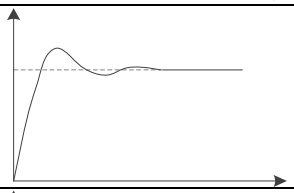
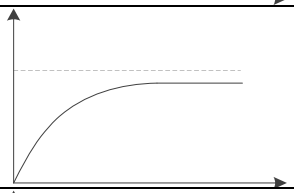
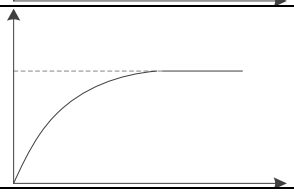
  Properly setting the Load Inertia Percentage is a prerequisite for the tuning to obtain the best performance. This can be calculated manually or measured using the Inertia Detection tool which is accessible from the Tuning page in the drive commissioning screens.

- Speed Loop Gain (Kv), Speed Loop Integral Time (Ti)

  The speed loop is controlled using a Proportional-Integral Controller that contains Speed Loop Gain and Speed Loop Integral Time. Both determine the speed loop bandwidth and anti-disturbance performance of the Servo.

  In general, increasing the setting of the Speed Loop Gain will increase the speed loop bandwidth, and the anti-load disturbance performance will be better. Decreasing the setting of the Speed Loop Integral Time will strengthen the integral action, the speed loop bandwidth will be increased, and the anti-load disturbance performance will be better. In addition, the integral action may reduce the steady-state error to zero.

The table below lists several commonly used adjustment methods based on the characteristics of the speed step response.

Response Curve	Description	Adjustment method
	Speed loop bandwidth is high	Properly decrease the Speed Loop Gain or increase the Speed Loop Integral Time.
	Speed loop damping ratio is low	Properly increase the Speed Loop Integral Time.
	Steady-state error is existed	Properly decrease the Speed Loop Integral Time.
	Speed loop bandwidth is low	Properly increase the Speed Loop Gain or decrease the Speed Loop Integral Time.

It is recommended to increase the Speed Loop Gain and decrease the Speed Loop Integral Time to obtain a larger speed loop bandwidth.

Position loop (Position Control Mode)

- Relevant parameters in speed loop (Kv, Ti, Tf, and JL)
- Position Loop Gain (Kp)

  The position loop is controlled using a Proportional Controller that only contains the Position Loop Gain. This parameter determines the position loop bandwidth. Increasing the Position Loop Gain will increase the position loop bandwidth, and the anti-load disturbance performance will be better. If the Position Loop Gain is too high this will cause overshooting and vibration.

It is recommended to set the Position Loop Gain to a quarter of the Speed Loop Gain, and make appropriate adjustments based on this.

Access to all control law parameters is available from the Tuning page or the Parameter page in the drive commissioning screens.

Use Case

Applicable for applications where the motor / load inertia mismatch is no more than 50 times.

Applicable for applications of any motor speed.

Parameters

The parameters for manual tuning are:

Block	Parameter	Name
Position Control	Pn104	Position Loop Gain
Position Control	Pn109	Second Position Loop Gain
Speed Feedforward	Pn112	Speed Feedforward
Speed Feedforward	Pn113	Speed Feedforward Filter Time
Speed Control	Pn102	Speed Loop Gain
Speed Control	Pn107	Second Speed Loop Gain
Speed Control	Pn103	Speed Loop Integral Time
Speed Control	Pn108	Second Speed Loop Integral Time
Speed Control	Pn106	Load Inertia Percentage
Torque Feedforward	Pn114	Torque Feedforward
Torque Feedforward	Pn115	Torque Feedforward Filter Time
Anti-resonance Filter	Pn173	Frequency of Vibration Suppression Filter
Anti-resonance Filter	Pn175	Vibration Suppression
Speed Filter	Pn135	Encoder Speed Filter Time
Notch Filter	Pn181	Frequency of Notch Filter 1
Notch Filter	Pn182	Depth of Notch Filter 1
Notch Filter	Pn183	Width of Notch Filter 1
Notch Filter	Pn184	Frequency of Notch Filter 2
Notch Filter	Pn185	Depth of Notch Filter 2
Notch Filter	Pn186	Width of Notch Filter 2
Notch Filter	Pn187	Frequency of Notch Filter 3
Notch Filter	Pn188	Depth of Notch Filter 3
Notch Filter	Pn189	Width of Notch Filter 3
Torque Filter	Pn105	Torque Reference Filter Time
Torque Filter	Pn110	Second Torque Reference Filter Time
Torque Limit	Pn401	Forward Internal Torque Limit
Torque Limit	Pn402	Reverse Internal Torque Limit

Restrictions

The following table shows a summary of functions available in manual tuning mode

Function	Manual
Feedforward (Velocity and Torque)	Yes
Friction Compensation	Yes
Feedback Speed Selection	Yes
Load Torque Compensation	Yes
Automatic Vibration Suppression	Yes

Function	Manual
Intermediate Frequency Vibration Suppression	Yes
Notch Filter	Yes
Load Oscillation Suppression	Yes
P / PI Switching	Yes
Gain Switching	Yes
Model Following Control	Yes

7.3 Compensation

The Drive offers several compensation techniques which can be used in various tuning modes to improve performance.

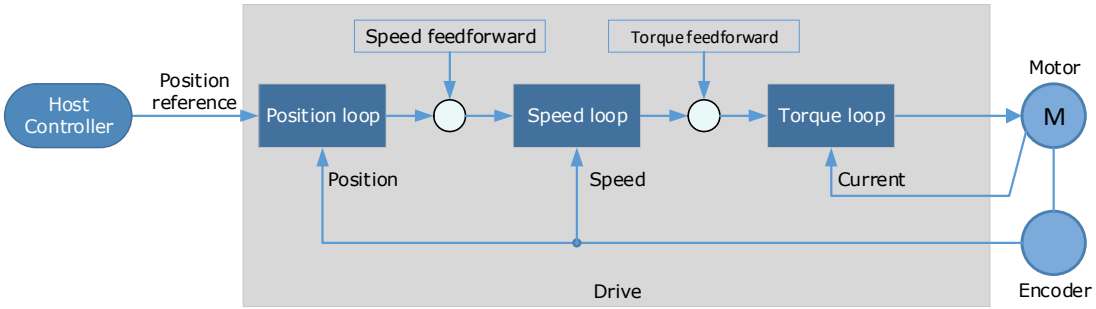
7.3.1 Feedforward

The table below shows the tuning modes where the feed forward function can be used.

Feedforward function	Available
Tuning-less	Yes
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

Feedforward includes both speed feedforward and torque feedforward.

- Speed feedforward can improve position response and reduce position following error
- Torque feedforward can improve the speed response and reduce the speed following error



In general, the differential of the position reference is used as the feedforward. This is known as an internal feedforward reference and is the default mode of operation. Other options are available for generating the feedforward reference.

- Internal Feedforward (default)
- Model Following Feedforward, available when Model Following Control is selected
- Cubic feedforward

Internal Feedforward

When using internal feedforward the reference is calculated using:

- Internal Speed Feedforward =

Differential of position reference × Speed Feedforward

- Internal Torque Feedforward ＝

  Differential of speed reference × Load Inertia Percentage × Torque Feedforward

Increasing the feedforward term will tend to reduce error during periods where the reference is constant. i.e. during periods of constant speed, the speed feed forward will allow to the control scheme to reduce following error, however the feedforward can introduce overshoot.

In addition, it may be required to filter the noise caused by the differential for the feedforward. Increasing the filter time will reduce the noise but may increase the overshoot.

In the case of high rotation speed, it may be necessary to use the high-speed torque feed forward function, this is selected by setting parameters:

- Pn005.0 to 2 (select high-speed internal torque feedforward)
- Pn005.2 to 0 (use internal torque feedforward)

Model Following Control Feedforward

This is only available when the Model Following Control function has been enabled.

For details on this method, refer to the section 7.6 Model Control Following.

Cubic Interpolation

Uses a cubic algorithm for interpolation of the reference

Parameters

Parameter	Setting	Meaning
Pn005.0	0	Use the general internal torque feedforward.
	2	Use the high-speed internal torque feedforward.
Pn005.2	0	Use the internal torque feedforward.
	1	Use the model following control torque feedforward, which is available when Model Following Control Selection is enabled.
	2	*Reserved*
	3	Use the torque feedforward generated by Cubic interpolation algorithm.
Pn005.3	0	Use the internal speed feedforward.
	1	Use the model following control speed feedforward, which is available when Model Following Control Selection is enabled.
	2	*Reserved*
	3	Use the speed feedforward generated by Cubic interpolation algorithm.
Pn112	—	Speed Feedforward
Pn113	—	Speed Feedforward Filter Time
Pn114	—	Torque Feedforward
Pn115	—	Torque Feedforward Filter Time

7.3.2 Friction Compensation

The table below shows the tuning modes where the friction compensation function can be used.

Friction Compensation function	Available
Tuning-less	Yes
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

Load friction will exist in the transmission system. However, severe load friction may cause low-speed crawling, waveform distortion at speed zero-crossing, positioning lag, etc. This can affect the dynamic and static performance of the system. The friction compensation function allows the drive to compensate for this and may be a requirement in applications with frequent forward and reverse motion, and high speed-stability requirements.

Friction compensation is used to compensate for both viscous friction fluctuations and coulomb friction fluctuations.

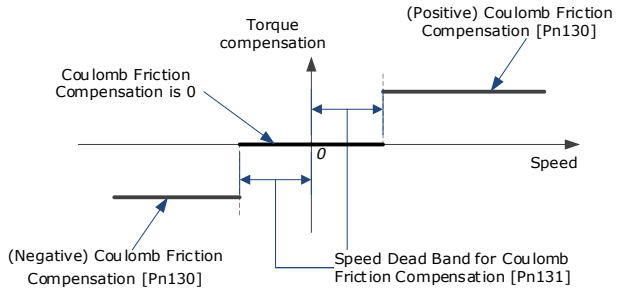
Coulomb Friction Compensation

Coulomb friction compensation is controlled though parameters Pn130 and Pn131.

Parameter	Setting	Meaning
Pn130	—	Coulomb Friction Compensation in 0.1% units of rated torque
Pn131	—	Speed Dead Band for Coulomb Friction Compensation in rpm

The application of coulomb friction compensation is symmetrical around zero speed. It is advisable to set a dead band for the friction compensation to avoid the system changing the compensation direction frequently near zero speed.

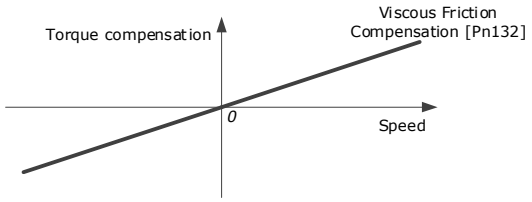
The diagram below shows the application of coulomb friction compensation.



Viscous friction compensation is controlled though parameter Pn132.

Parameter	Setting	Meaning
Pn132	—	Viscous Friction Compensation in 0.1% per 1000rpm

The application of viscous friction compensation is a linear relationship with the actual speed, as is shown below.



As the speed increase, so the viscous friction compensation increases with a rate defined by the Viscous Friction Compensation parameter.

7.3.3 Speed Feedback Selection

The table below shows the tuning modes where the speed feedback function can be used.

Speed Feedback function	Available
Tuning-less	No
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

By default, the speed feedback is calculated from by differentiating the positional value read from the encoder.

In the case of low speed or low encoder resolution, the method of position differentiation to calculate speed can introduce a large amount of noise in speed feedback which can affect the control performance.

To reduce the noise, a low pass filter can be applied to eliminate the noise and high-frequency components from the speed signal. The speed filter is controller though the Encoder Speed Filter Time parameter.

Parameter	Setting	Meaning
Pn135	—	Encoder Speed Filter Time in 0.01ms

Increase the time constant of the filter will have a stronger effect on the noise resulting in a smoother speed signal. But a strong filter will introduce phase lag, which can reduce the servo performance.

An alternative to using encoder position to calculate speed is to use a speed observer, this can provide a less noisy speed. The observed speed can be tuned to match actual speed using the Load Torque Observer Gain; however, this may introduce overshoot.

Parameter	Setting	Meaning
Pn161	—	Load Torque Observer Gain
Pn162	0 [Default]	Use encoder speed as the feedback speed.
	1	Use observed speed as the feedback speed.

7.3.4 Load Torque Compensation

The table below shows the tuning modes where the load torque compensation function can be used.

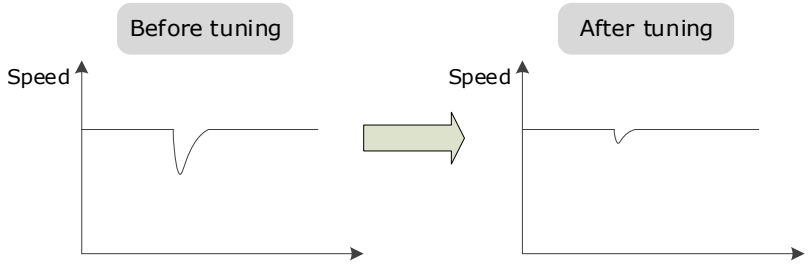
Load Torque Comp. function	Available
Tuning-less	No

Load Torque Comp. function	Available
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

Sudden changes in load torque can significantly affect the speed control during operation. A step change in load torque will generally introduce a decrease in speed which will take some time for the control to rectify.

In applications with continuously changing load torque it is necessary to improve the anti-load disturbance performance of the servo.

The figure below shows the speed drop caused by a sudden load torque. The load torque compensation function can be used to reduce the effect of the load torque change.



Tuning the load torque compensation function can be used to improve the anti-load disturbance performance, considering that the reference response performance and the load disturbance resistance cannot be balanced.

The Load Torque Compensation function adjusts compensation to the torque reference via an observer function. To reduce the overshoot caused by Load Torque Compensation, use the load torque compensation percentage to adjust the compensation value:

$$\text{Load Torque Compensation} = \text{Load Torque Observer} \times \text{Load Torque Compensation Percentage}$$

Parameter	Setting	Meaning
Pn160	—	Load Torque Compensation Percentage

Increasing this value can improve the load disturbance rejection performance. Too much may cause vibration and overshoot.

In addition, the bandwidth of the load torque observer can be changed via Load Torque Observer Gain. Increasing this will make the observed torque closer to the actual torque but may generate overshoot.

Parameter	Setting	Meaning
Pn161	—	Load Torque Observer Gain

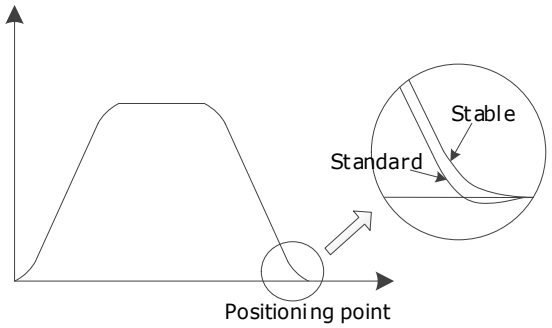
7.3.5 Damping Selection

The table below shows the tuning modes where the damping selection function can be used.

Damping Selection function	Available
Tuning-less	No
One-Parameter Auto Tuning	Yes
Manual Tuning	No

The Damping Selection selects between 2 damping options.

- [0] Standard: Short positioning time, but prone to overshoot.
- [1] Stable: Longer positioning time, but stable.



The damping selection can be made from the Tuning page in the drive commissioning screens.

Alternatively, the damping selection can be changed by directly writing to parameter Pn100.3.

Parameter	Setting	Meaning
Pn100.3	0 [Default]	Shorter positioning time, but prone to overshoot
	1	Longer positioning time, but stable

7.4 Vibration Suppression

The Drive offers several vibration suppression techniques which can be used in various tuning modes to improve performance.

7.4.1 Automatic Vibration Suppression

The table below shows the tuning modes where the automatic vibration suppression function can be used.

Automatic Vibration Suppression	Available
Tuning-less	Yes
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

The automatic vibration suppression function determines the vibration state of the Motor during operation and identifies the resonant frequency. It then selects either the Notch Filter or the IF Vibration Suppression according to the characteristics of the vibration. It will set the parameters for IF Vibration Suppression or Notch Filter 2, depending on what is required.

Automatic Vibration Suppression can be enabled from the Tuning screen in the drive parameter pages.

Alternatively, the this can be controlled by directly writing to parameter Pn100.2.

Parameter	Setting	Meaning
Pn100.2	0 [Default]	Automatic Vibration Suppression is disabled.
	1	Automatic Vibration Suppression is enabled.

Parameter	Setting	Meaning
Pn179	—	Amplitude Threshold for Vibration Detection

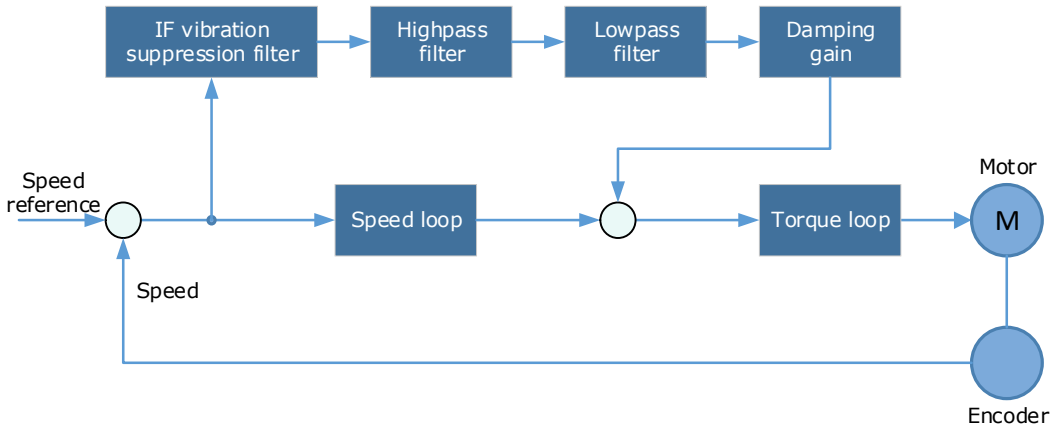
To prevent the automatic vibration suppression acting on incorrect vibrations an amplitude threshold can be applied can. This will prevent the vibration suppression acting on any detected frequency unless it exceeds the threshold.

7.4.2 IF (Intermediate Frequency) Vibration Suppression

The table below shows the tuning modes where the IF vibration suppression function can be used.

IF Vibration Suppression	Available
Tuning-less	Yes
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

The IF vibration suppression filter is used to process the speed deviation and provide compensation to the torque reference. It is applied for the frequency range 100 Hz to 2000 Hz.



Parameter	Setting	Meaning
Pn173	—	Frequency centre at which vibration suppression is performed
Pn174	—	Bandwidth of the vibration suppression filter. Indicates the range of the adjustment filter around the centre frequency. Increasing this setting can increase the range of vibration suppression, but it will affect the phase of the frequency near the centre
Pn175	—	Vibration Suppression
Pn176	—	Low pass Filter Time for Vibration Suppression
Pn177	—	High pass Filter Time for Vibration Suppression
Pn178	—	Level of the final compensated IF vibration suppression

NOTE: Set Pn173 to 2000, indicating the notch filter is unavailable

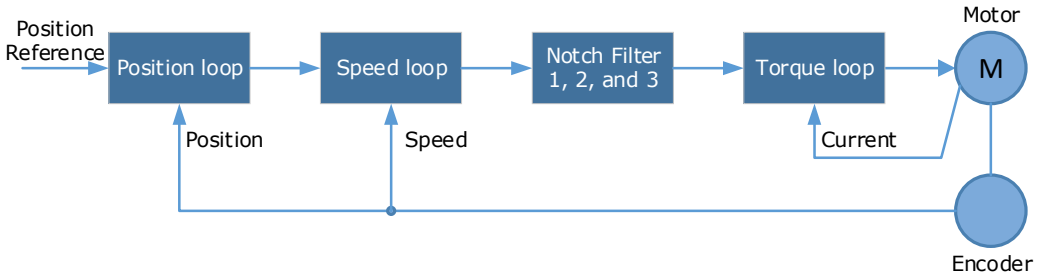
7.4.3 Notch Filter

The table below shows the tuning modes where the notch filter function can be used.

Notch Filter	Available
Tuning-less	Yes
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

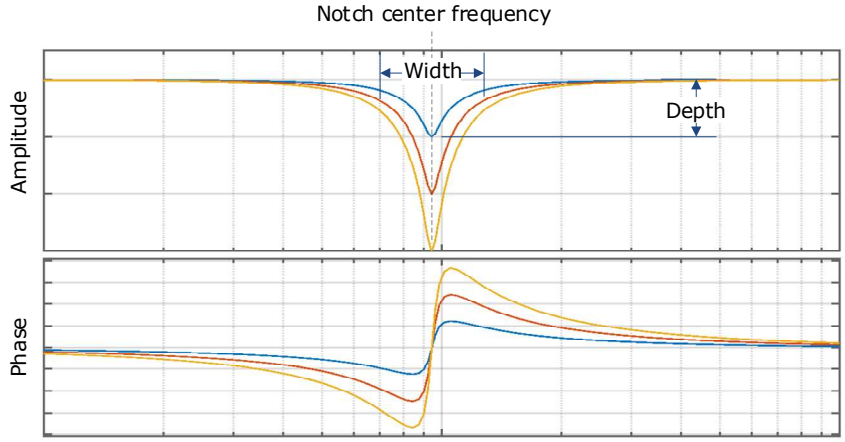
The notch filter is used to eliminate vibration caused by mechanical resonance.

There are three notch filters in the Drive, those who can used independently or in combination.



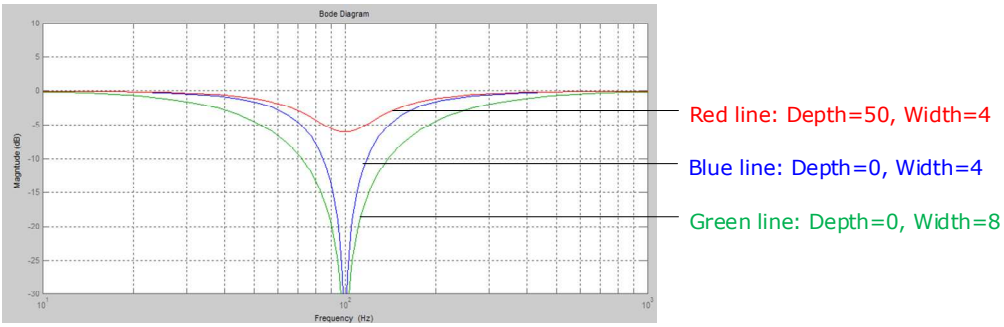
The diagram below shows the relevant parameters for the notch filter.

Notch filter can attenuate the signal at a specific frequency so can be very useful in removing resonance. Setting a correct frequency and width the vibration signal in the torque reference can be filtered out.



Parameters controlling the operation of notch filter are:

- Frequency, setting the frequency of notch filter to 5000 will disable the notch filter.
- Depth, the range of depth is from 0 to 23.
- Width, the range of width is from 0 to 15.



The notch filter parameters can be set from the Tuning page in the drive commissioning screens.

Alternatively, the filters can be configured by directly writing to the parameters.

Parameter	Setting	Meaning
Pn181	—	Frequency of Notch Filter 1
Pn182	—	Depth of Notch Filter 1
Pn183	—	Width of Notch Filter 1
Pn184	—	Frequency of Notch Filter 2
Pn185	—	Depth of Notch Filter 2
Pn186	—	Width of Notch Filter 2
Pn187	—	Frequency of Notch Filter 3
Pn188	—	Depth of Notch Filter 3
Pn189	—	Width of Notch Filter 3

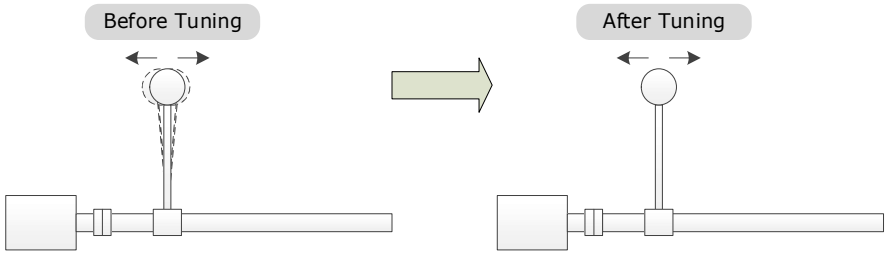
7.4.4 Load Oscillation Suppression

The table below shows the tuning modes where the load oscillation suppression function can be used.

Load Oscillation Suppression	Available
Tuning-less	No
One-Parameter Auto Tuning	No
Manual Tuning	Yes

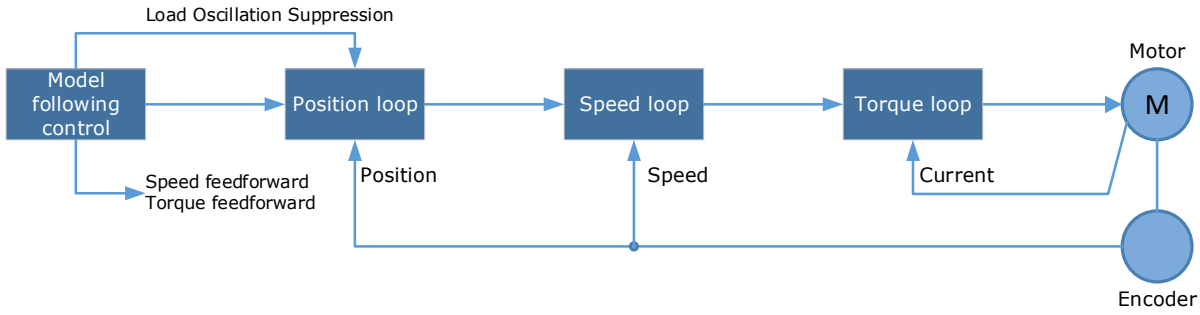
NOTE: This cannot be used in fully-closed loop control (dual encoder feedback).

The Load Oscillation Suppression function is used for suppressing low frequency jitter at the end of the load during position control.



The aim of the Model Following Control is to maintain the stability of the load position based on a relationship between load position and Motor position. This is done by correcting the position reference and generating new speed and torque feedforward values.

The block diagram below shows Load Oscillation Suppression.



This function is based on the Model Following Control (7.6) and enabled via Pn150.

Parameter	Setting	Meaning
Pn150.0	2	Use the model following control and load oscillation suppression.

NOTE: Changing the model following control mode will require the drive to be restarted.

Parameters controlling the operation of load oscillation suppression are:

- Frequency, which specifies the frequency at which Load Oscillation Suppression is to be performed.
- Filter Time, increasing this setting will strengthen the filter. However, it may reduce the suppression effect due to lag.
- Limit, which will clip the output of the Load Oscillation Suppression, helping to reduce overshooting during starting and stopping.

Parameter	Setting	Meaning
Pn155	—	Load Oscillation Frequency in Hz
Pn156	—	Filter Time for Load Oscillation Suppression
Pn157	—	Limit for Load Oscillation Suppression

7.5 Gain Scheduling

The Drive offers several gain scheduling techniques which can be used in various tuning modes to improve performance.

7.5.1 P/PI Switching

The table below shows the tuning modes where the P/PI switching function can be used.

P/PI Switching	Available
Tuning-less	No
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

By default, the Drive uses a Proportional-Integral (PI) Controller for the speed loop. This can be changed from PI to P control based on some reference condition using parameter Pn116.

Parameter	Setting	Meaning
Pn116	0 [Default]	Use torque reference as the condition (threshold setting: Pn117).
	1	Use position deviation counter as the condition (threshold setting: Pn118).
	2	Use acceleration reference as the condition (threshold setting: Pn119)
	3	Use the speed reference as the condition (threshold setting: Pn120).
	4	Fixed to PI Control.

NOTE: Changing the P/PI switching condition will require the drive to be restarted.

The relevant threshold parameters are shown in the table below.

Parameter	Setting	Meaning
Pn117	—	Torque Reference threshold
Pn118	—	Deviation Counter threshold
Pn119	—	Acceleration Reference threshold
Pn120	—	Speed Reference threshold

Consider the default settings as an example. The default setting is to use torque reference as the condition, and the default Torque Reference threshold (Pn117) is 200.

- When the torque reference percentage is less than 200, the speed loop adjustment will be PI control
- When the torque reference percentage is greater than 200, the speed loop adjustment will be P control

7.5.2 Gain Switching

The table below shows the tuning modes where the gain switching function can be used.

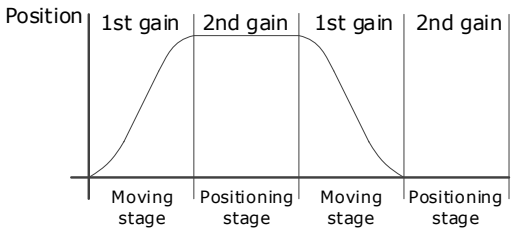
Gain Switching function	Available
Tuning-less	No
One-Parameter Auto Tuning	No
Manual Tuning	Yes

In manual tuning mode a gain switching function can be used which allows the drive to swap between two sets of gain parameters based on operating conditions.

The figure below shows an example:

- The ‘positioning’ gain terms focus on the performance such as position ripples and positional rigidity
- The ‘moving’ gain terms focus on the performance such as following error.

In this case, two switchable groups of gain parameters are required to meet the servo performance.

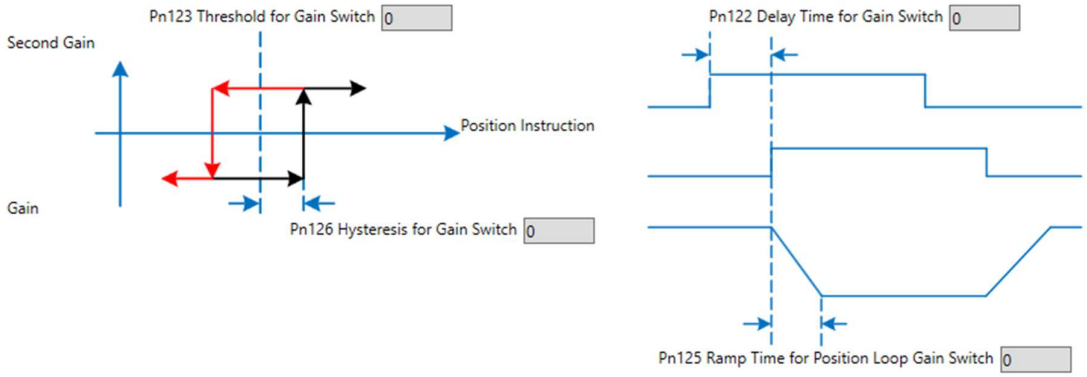


Gain switching can be enabled from the Tuning page in the drive commissioning screens. The conditions for gain switching are selected from a drop down.

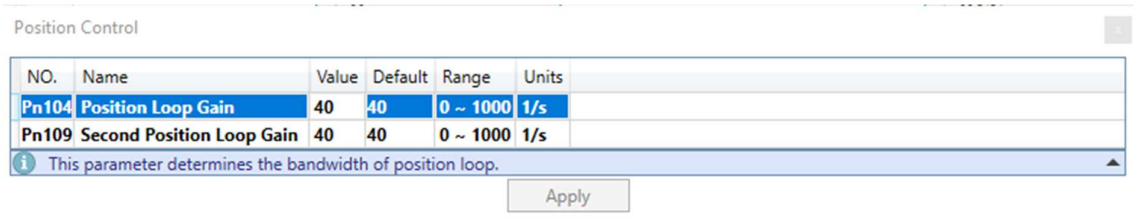
Options are:

- Fixed to first group gains.
- Use digital input (G-SEL) as the condition.
- Use torque reference as the condition.
- Use position deviation counter as the condition.
- Use acceleration as the condition.
- Use speed reference as the condition.
- Use position reference as the condition.
- Use actual speed as the condition.
- Use position reference and actual speed as the condition.
- Fixed to second group gains.
- Use positioning completed flag as the condition.

Once gain switching is selected the switch conditions will be shown.



And any additional gain terms parameters will be available from the control law block diagram



Alternatively, gain switching can be enabled by directly to the parameters.

Parameter	Setting	Meaning
Pn121	0 [Default]	Fixed to first group gains.

Parameter	Setting	Meaning
	1	Use digital input (G-SEL) as the condition.
	2	Use torque reference as the condition (threshold setting: Pn123).
	3	Use position deviation counter as the condition (threshold setting: Pn123).
	4	Use acceleration as the condition (threshold setting: Pn123).
	5	Use speed reference as the condition (threshold setting: Pn123).
	6	Use position reference as the condition (threshold setting: Pn123).
	7	Use actual speed as the condition (threshold setting: Pn123).
	8	Use position reference (Pn123) and actual speed (Pn124) as the condition.
	9	Fixed to second group gains.
	10	Use positioning completed flag as the condition.

NOTE: Changing the gain switching condition will require the drive to be restarted.

The parameters for the first gain and the second gain terms are as follows.

Parameter	First Gain	Second Gain
Speed Loop Gain	Pn102	Pn107
Speed Loop Integral Time	Pn103	Pn108
Position Loop Gain	Pn104	Pn109
Torque Command Filter Time	Pn105	Pn110

7.6 Model Control Following

The table below shows the tuning modes where the model control following function can be used.

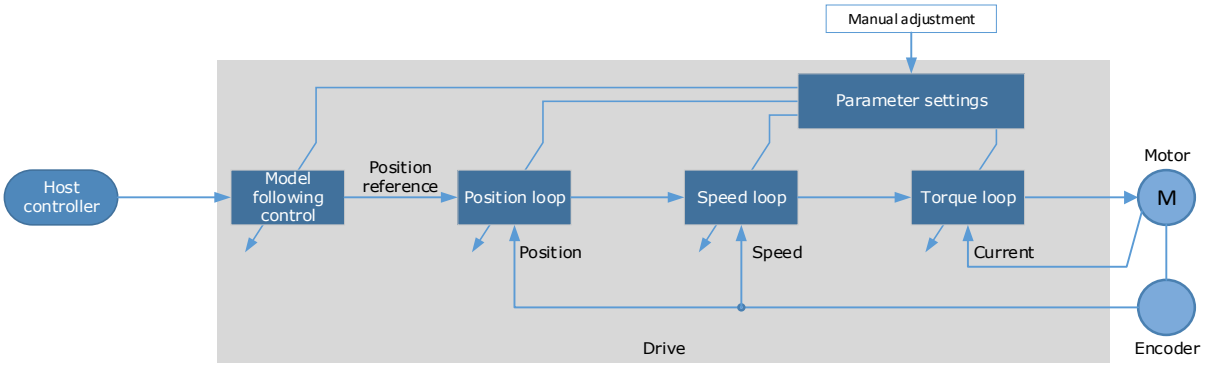
Model Control Following	Available
Tuning-less	No
One-Parameter Auto Tuning	No
Manual Tuning	Yes

NOTE: This cannot be used in fully-closed loop control (dual encoder feedback).

The Model Following Control is a function which sits before the position loop. In Model Following Control, new position references are generated based on the theoretical Motor control model, and relevant speed feedforward and torque feedforward are generated.

Applying these controls to the actual control loop can significantly improve the response performance and positioning performance of the position control.

The block diagram below shows the implementation of model following control.



The Model Following Control function is enabled via Pn150.

Parameter	Setting	Meaning
Pn150.0	0 [Default]	Do not use Model Following Control.
	1	Use the model following control.
	2	Use the model following control and load oscillation suppression.

NOTE: Changing the model following control mode will require the drive to be restarted.

To use the Model Following Control properly, the system should be setup in the following order:

Torque Loop → Speed Loop → Position Loop → Model Following Control.

For details on the relevant parameter of Torque Loop, Speed Loop and Position Loop, refers to the section 7.2.3 Manual Tuning.

The relevant parameters for Model Following Control are as follows.

Parameter	Setting	Meaning
Pn151	—	Model Following Control Gain
Pn152	—	Model Following Control Gain Correction
Pn153	—	Model Following Control Speed Feedforward (conditional on Pn005.3=1)
Pn154	—	Model Following Control Torque Feedforward (conditional on Pn005.2=1)

The gain determines the position response performance. Increasing this setting can improve speed of response, but overshooting is likely to occur.

The gain correction determines the damping ratio.

The (speed/torque) feedforward is a percentage factor that is used to adjust the feedforward value.

7.7 Load Identification

There are several tools which can be used help the tuning process.

7.7.1 Load Inertia Identification

The table below shows the tuning modes where the load inertia identification function can be used.

Load Inertia Identification	Available
Tuning-less	No

Load Inertia Identification	Available
One-Parameter Auto Tuning	Yes
Manual Tuning	Yes

The Load Inertia Identification function is used to calculate the load inertia relative to the Motor rotor inertia (percentage of load inertia).

The Load Inertia Identification function can be started from the Tuning page in the drive commissioning screens. Click on the 'Inertia Detection' button.

This will launch a wizard to guide the inertia detection sequence.

The identification routine will rotate the Motor back and forth either 4 or 8 times, during this movement the inertia is calculated. At the end of the identification routine, the result is displayed with the option to update the inertia value in Pn106.

To perform this function the Drive must be disabled.

WARNING

Ensure the movable parts have sufficient travel in the forward and reverse directions, as the Motor will run for up to 8 rotations during this operation.

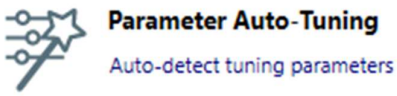
7.7.2 Auto-Tuning Tool

The table below shows the tuning modes where the auto tuning function can be used.

Auto-Tuning function	Available
Tuning-less	No
One-Parameter Auto Tuning	No
Manual Tuning	Yes

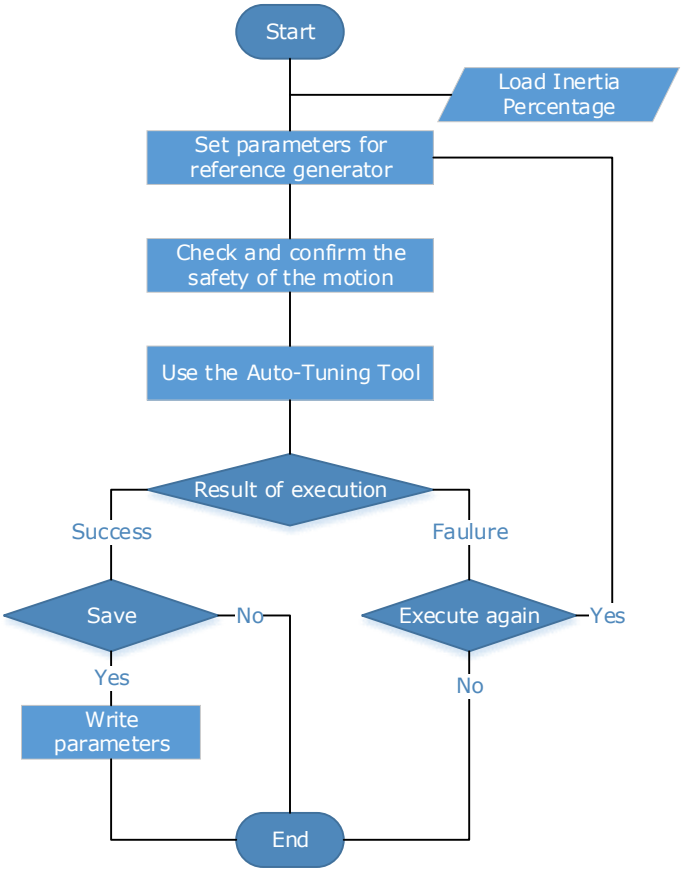
The Auto-Tuning Tool uses the drives internal position reference generator to exercise the Drive while iteratively changing the control parameters to achieve a tuned system.

The Auto-Tuning Tool can be started from the Tuning page in the drive commissioning screens. Click on the 'Parameter Auto Tuning' button.



This will launch a wizard to guide the parameter auto-tuning sequence.

The sequence is described in the flow chart below.



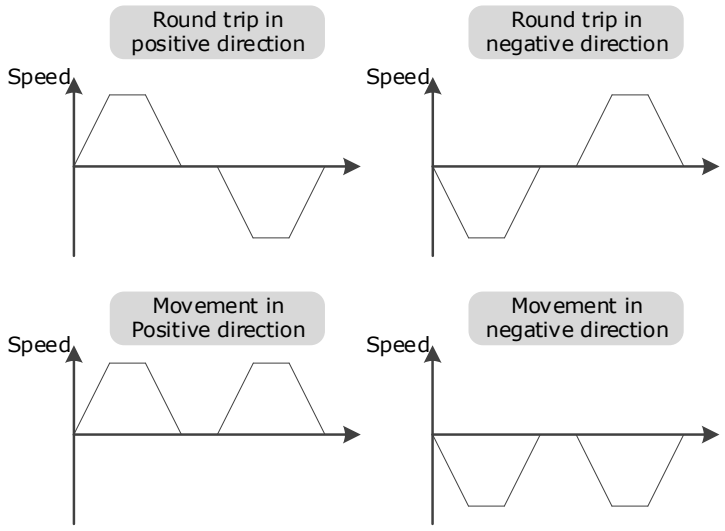
The steps in the wizard are:

- Detect Inertia
- Setup
- Motion Trajectory
- Tuning
- Results

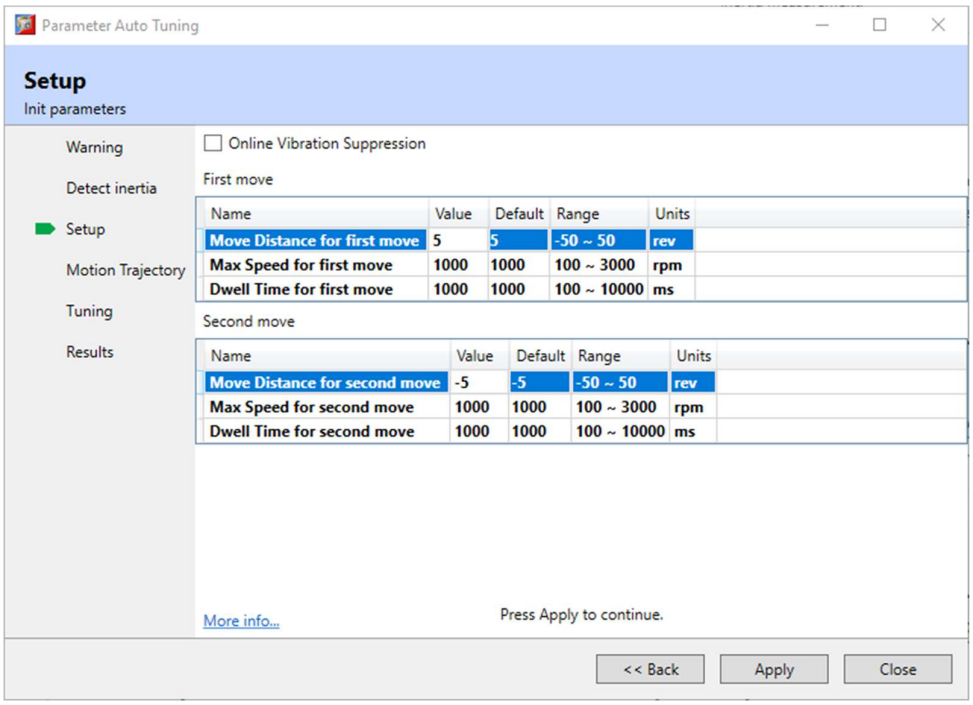
Detect Inertia: A pre-request for the Parameter-Auto Tuning is an accurate measurement of inertia. This can be entered manually or measured using the Inertia Detection tool. For more details on inertia detection see 0There are several tools which can be used help the tuning process.

Load Inertia Identification.

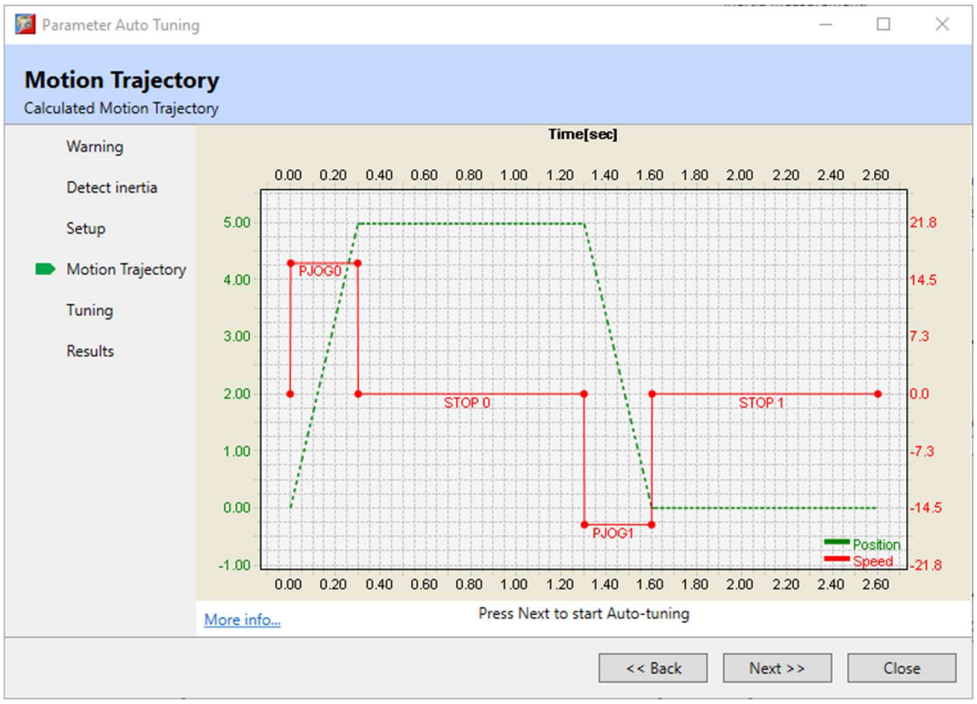
Setup: The drive will repeatedly run two moves during the Parameter Auto-Tuning, these are described by Distance, Speed and Dwell Time. The sequence can be either position/negative or negative/positive.



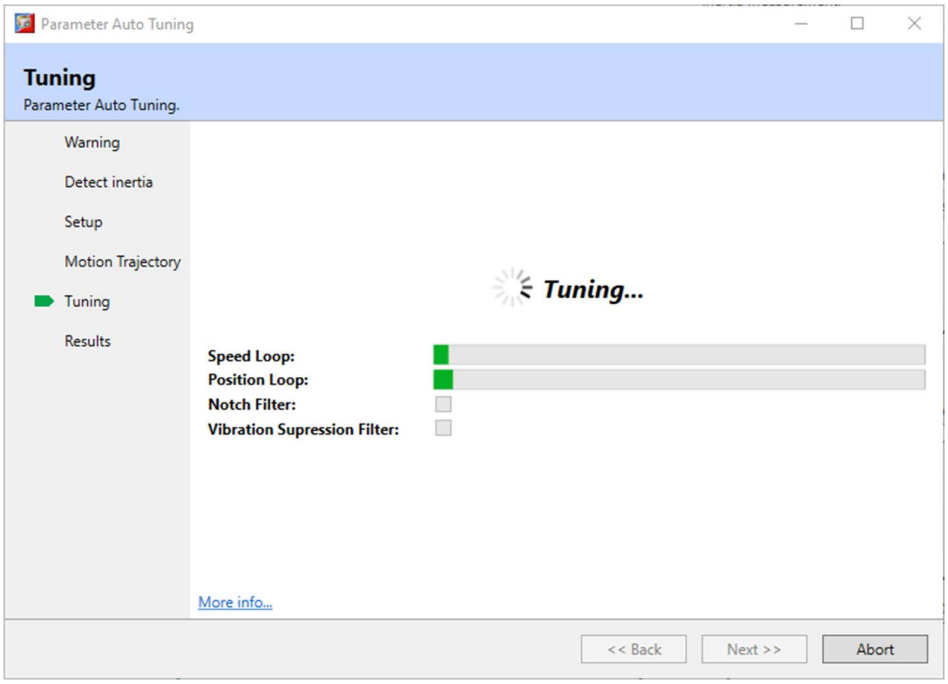
The Setup screen allows entry of the parameters which describe the motion.



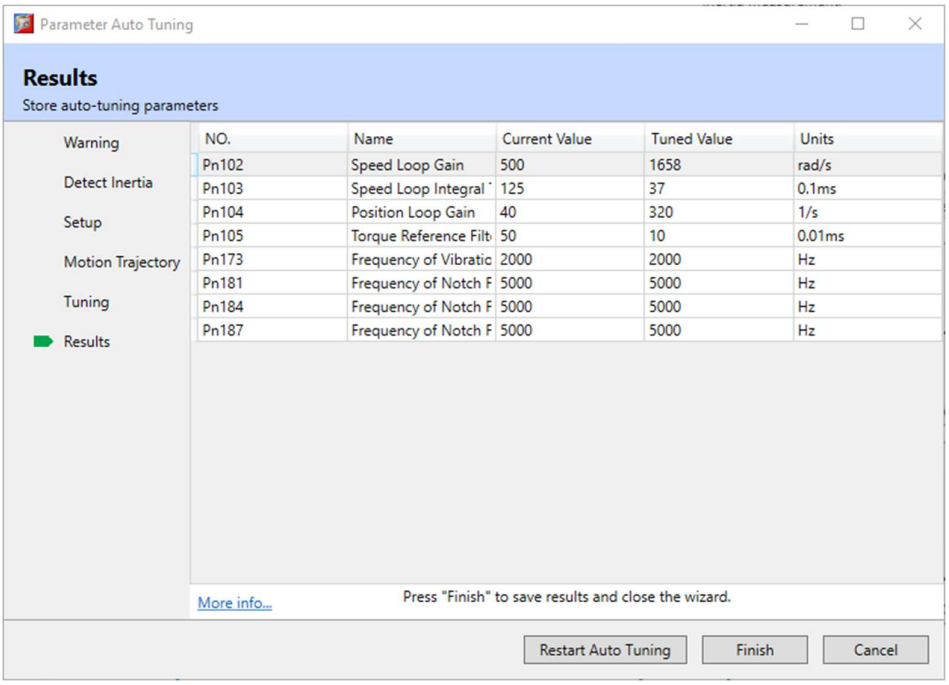
Motion Trajectory: This is an opportunity to review the defined motion sequence before starting the tuning sequence.



Tuning: During the internal tuning process, the progress is displayed on screen.



Results: Once the tuning process has completed, the calculated gain terms will be displayed with an option to save them to the drive.



7.8 Motor Overload Duration & Cycle Times

MXL Motors

Overload %	Overload Time (Secs)				
	50/100W	200W	400W	750W	1KW
150	88.7	184.8	50.4	652.3	115.2
200	12.7	26.4	16.4	93.0	24.0
250	4.3	10.3	8.9	31.8	11.4
300	2.2	6.6	5.7	15.9	7.5
350	1.6	4.6	4.0	11.2	5.3

MXM Motors

Overload %	Overload Time (Secs)			
	1KW	1.5KW	2KW	3KW
150	216.0	120.0	120.0	216.0
200	90.0	50.0	50.0	90.0
250	15.0	12.5	12.5	15.0
300	6.1	5.7	5.7	6.1
350	-	-	-	-

Care must be taken to ensure that the duty cycle is not exceeded when using high percentage overload durations.

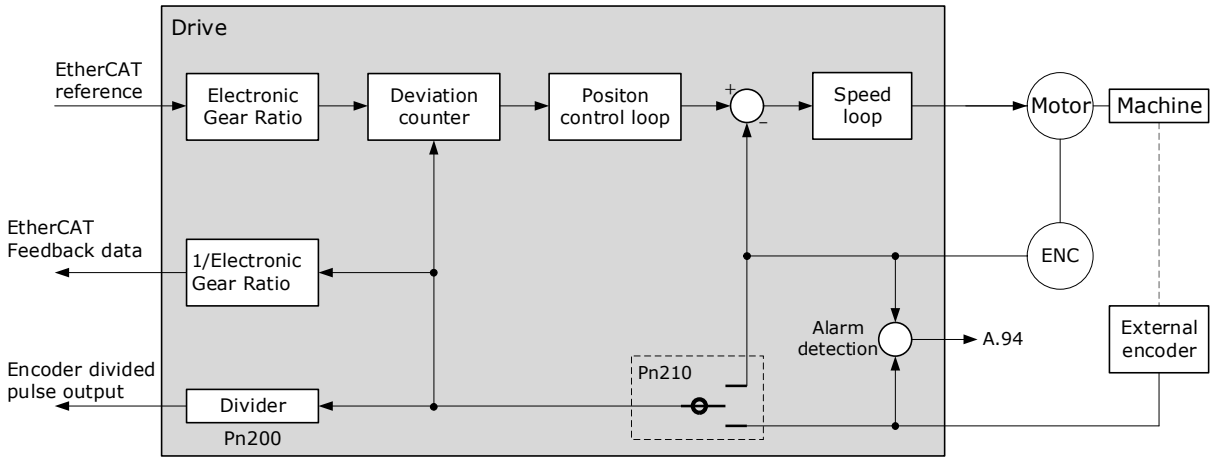
For example:
Using a 400W motor at 350% the maximum time at this level must not exceed 4.0 secs.

The motor will now have to wait 45 secs before it is safe to run again at a higher level of percentage overload.

Off Time = (Overload % Factor^2 * Overload Time) - Overload Time
Off Time = (3.5 ² x 4.0) – 4.0 = 45.0s

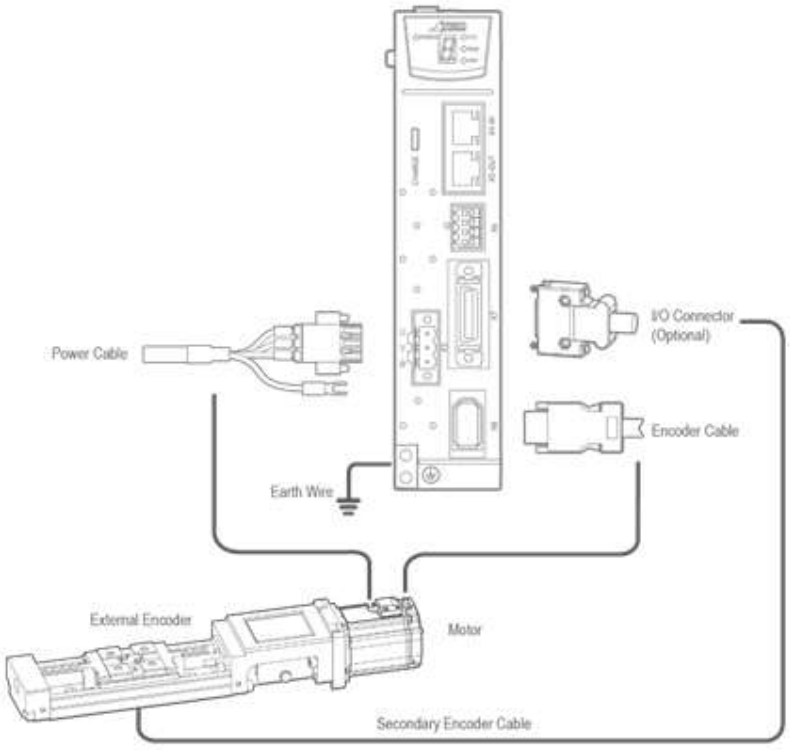
Chapter 8 Fully Closed Loop Operation

With a fully-closed system, the encoder on the motor is used in conjunction with an external encoder (external to the motor) is used to detect the position of the load. This is also known as dual encoder feedback. Below is a block diagram of Fully-Closed Loop Operation.



This setup can be useful in some high-precision positioning applications where there is compliance or backlash between the motor and the load.

However, due to the separation of encoders the system may suffer from looseness or twisting of mechanical parts which can cause vibration or oscillation, resulting in unstable positioning.



Careful commissioning of fully-closed loop setup is essential for good performance.

8.1 Commissioning Procedure

The commissioning procedure for the Drive for fully-closed loop control is given below.

Step 1 Complete the wiring and connection of the Drive and Motor and connect to the machine.

Step 2 Ensure Pn210.0 is set to 0 to use the encoder on the motor (semi-closed loop control).

Step 3 Using the Jog operation, move the movable part on the machine side to an appropriate position, and then confirm the Motor's motion in forward rotation and reverse rotation. For details on Jog operation, refer to the section 6.4.3 Jog Motion.

Step 4 Change Pn210.0 to 1 to include the external encoder in the control (fully-closed loop control).

Step 5 Using the Jog operation again to confirm the Motor's motion in forward rotation and reverse rotation.

Step 6 Resolve the following alarms and reset the system.

- If alarms A90 (Phase A Disconnected), A91 (Phase B Disconnected), A92 (Phase C Disconnected) alarms occur, check the wiring of the external encoder.
- If alarm A93 (Encoder Communications Error) occurs, contact Trio or the Authorized Distributor.
- If alarm A94 (Position Deviation Overflow) occurs, check the settings of Pn210, Pn212, Pn213 and Pn214. Also, check the wiring of the external encoder, and check if the mechanical connection structure is loose, slippery or has a large gap

Step 7 Check the settings of parameters Pn210.3, Pn212, and Pn213

- Check count direction of external encoder is the same as the main encoder. Pn210.3 can be used to change the count direction of the external encoder.
- Set Pn212 to change the resolution of the external encoder.
- Set Pn213 to change Position Deviation Threshold between main encoder and external encoder

Step 8 Try to use the Program Jog operation to confirm the Motor’s motion. For more detail on Program Jog refer to section 6-15 Program Jog Motion.

Step 9 Refer to Step 6 to resolve possible alarms until the alarm no longer occurs.

Step 10 Once the servo can operate using the Program Jog function the system is ready for use.

8.2 Enable External Encoder

Set Pn210.0=1 or 2 to enable the external encoder:

- Set Pn210.0 to 1, representing that the external encoder is enabled for the fully-closed loop control.
- Set Pn210.0 to 2, representing that the external encoder is enabled for the counting only.

In addition, set the parameter Pn212 (Resolution of External Encoder) to specify the resolution of the external encoder, indicating the numbers of AB quadrature pulse edges emitted by the external encoder after one rotation of the Motor (one quadrature pulse has four edges, that is, the pulse numbers × 4).

Parameter	Name	Range	Unit	Default
Pn210.0	External Encoder Selection	0 to 2	—	0
Pn212	Resolution of External Encoder	1 to 1048576	1 pulse	10000

8.3 Motor Direction and Machine Movement

For fully-closed loop operation the Motor direction and the machine movement direction must configured. The table below shows the relationship between Pn001.0, Pn210.3 and direction.

Pn001.0 (CCW, CW) (1)		Pn210.3 (Direction of External Encoder)			
		0 (Not invert)		1 (Invert)	
0 (CCW)	Reference direction	Forward reference	Reverse reference	Forward reference	Reverse reference
	Motor direction	CCW	CW	CCW	CW
	External encoder (2)	Forward movement	Reverse movement	Reverse movement	Forward movement
1 (CW)	Reference direction	Forward reference	Reverse reference	Forward reference	Reverse reference
	Motor direction	CW	CCW	CW	CCW
	External encoder	Reverse movement	Forward movement	Forward movement	Reverse movement

(1): Phase B leads in the divided pulses for a forward reference regardless of the setting of Pn001.0.
(2): Forward direction: The direction in which the pulses are counted up. Reverse direction: The direction in which the pulses are counted down.

8.4 Alarm Detection Settings

This setting is used to detect the difference between the feedback position of the Motor encoder and the feedback load position of the external encoder for fully-closed loop control.

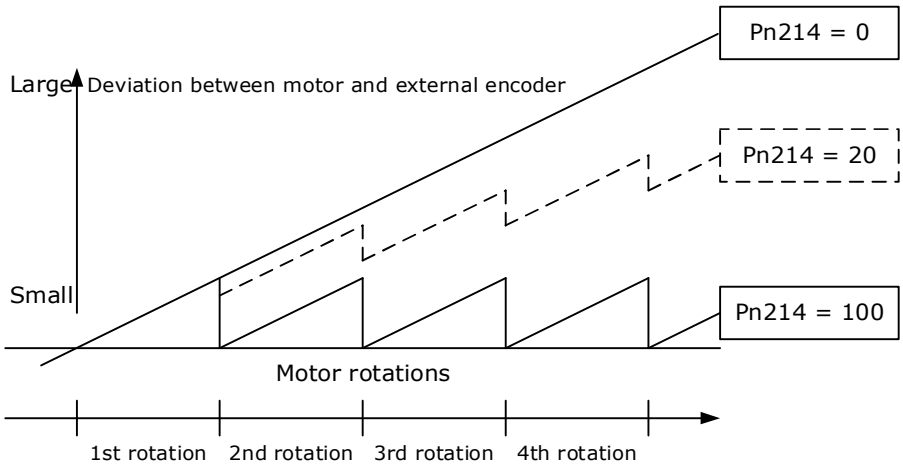
If the detected difference exceeds the threshold, an A94 alarm (Position Deviation Overflow) will be generated.

In addition, a coefficient of deviation between the Motor and the external encoder per Motor rotation can be set (Pn214). This setting can be used to prevent the Motor from running out of control due to damage to the external encoder or to detect belt slippage.

Parameter	Name	Range	Unit	Default
Pn213	Position Deviation Threshold between Encoder and External Encoder	0 to 134217728	1 Pulse	1000
Pn214	Position Deviation Clear between Encoder and External Encoder	0 to 100	1%	0

If Pn214 is set to 0, the external encoder value will be read as it is.

If Pn214 is set to to 20, the second rotation will start with the deviation for the first Motor rotation multiplied by 0.8.



Chapter 9 Appendix

9.1 EtherCAT Communications

9.1.1 Introduction

EtherCAT is a real-time Industrial Ethernet technology originally developed by Beckhoff Automation. The EtherCAT protocol which is disclosed in the IEC standard IEC61158 is suitable for hard and soft real-time requirements in automation technology, in test and measurement and many other applications.

The EtherCAT master sends a telegram that passes through each node. Each EtherCAT slave device reads the data addressed to it “on the fly” and inserts its data in the frame as the frame is moving downstream. The frame is delayed only by hardware propagation delay times. The last node in a segment (or drop line) detects an open port and sends the message back to the master using Ethernet technology’s full duplex feature.

9.1.2 Specification

The specifications for EtherCAT communication are as follows.

Item	Specifications
Applicable Communications Standards	IEC 61158 Type12, IEC 61800-7 CiA402 Drive Profile
Protocol	100BASE-TX (IEEE802.3)
Communications Connectors	X4-IN (RJ45): EtherCAT signal input connector X5-OUT (RJ45): EtherCAT signal output connector
Cable	Category 5 (CAT5e SF/UTP)
Sync Manager	SM0: Mailbox output, SM1: Mailbox input, SM2: Process data output, and SM3: Process data input
FMMU	FMMU 0: Mapped in process data output (RxPDO) area FMMU 1: Mapped in process data input (TxPDO) area FMMU 2: Mapped to mailbox status
EtherCAT Commands (Data Link Layer)	APRD, FPRD, BRD, LRD, APWR, FPWR, BWR, LWR, ARMW, FRMW (APRW, FPRW, BRW, and LRW commands are not supported)
Process Data	Assignments can be changed with PDO mapping.
MailBox (CoE)	Emergency messages, SDO requests, SDO responses (TxPDO/RxPDO and remote TxPDO/RxPDO are not supported.)
Distributed Clocks	Free-Run Mode and DC Mode (Can be switched) Applicable DC cycles: 125µs to 8ms
Slave Information Interface	256 bytes (read-only)

9.1.3 EtherCAT Slave Information

The drive publishes network accessible properties via an EtherCAT Slave Information (ESI) file. This is an XML based file which is used by the network master. For the DX4 this information is already built into Motion Perfect and the Trio controllers.

The ESI file for the DX4 is available on the Trio website and has the name:

*TRIO_DX4_V***.xml*

NOTE: The asterisks (***) indicate the version number.

9.1.4 EtherCAT State Machine

A state machine is used to manage the communications states between the master and slave applications, shown in Figure 9-1. Normally, the state of the slave responds based on requests from the master.

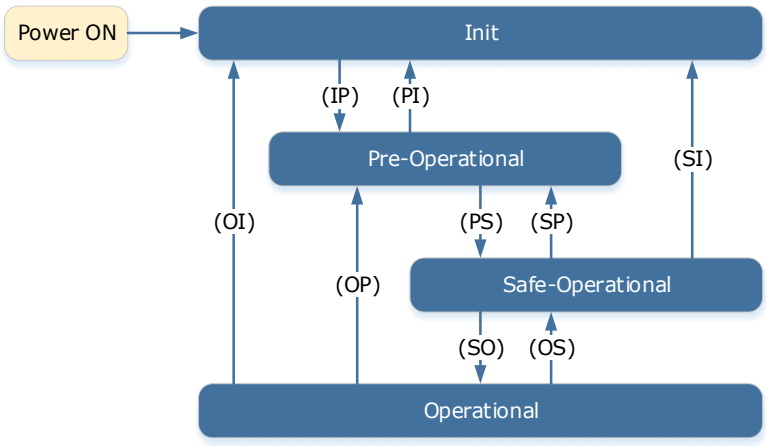


Figure 9-1 EtherCAT state machine

Table 9-1 lists the state transition and initialization process.

State or Transition	Operation
Init (I)	• Mailbox communications are not available. • Process data communications are not available.
Init to Pre-Operational (IP)	• The master sets the DL address and Sync Manager Channels for mailbox communications. • The master initializes DC clock synchronization. • The master requests the Pre-Operational state. • The master sets the AL control register. • The slaves check whether the mailbox was initialized correctly.
Pre-Operational (P)	• Mailbox communications are available. • Process data communications are not available.
Pre-Operational to Safe-Operational (PS)	• The master sets the Sync Manager Channels and FMMU channels for process data. • The master uses SDOs to set the PDO mappings and the Sync Manager PDO Assignment parameters. • The master requests the Safe-Operational state. • The slaves check whether the Sync Manager channels for process data communications and, if required, the distributed clock settings are correct.
Safe-Operational (S)	Process data communications are possible. However, only the input data is available. The output data is still unavailable.

State or Transition	Operation
Safe-Operational to Operational (SO)	• The master sends available output data. • The master requests the Operational state.
Operational (O)	Process data communications are available.

Table 9-1 Description of state or transition

The state of the drive can be seen in the EtherCAT Info frame in the device configuration screen within Motion Perfect. The image below shows a drive in the 'Operational' state.

Figure 9-2 Motion Perfect Device Configuration, Drive screen

9.1.5 Communications between master and slave

Process Data Object (PDO)

PDO is used to transfer cyclic data. This is data that is transferred between the master and slave every network cycle. Typically, this is data required for operation of the drive; Control Word, Status Word, Set Point, etc…

Service Data Object (SDO)

SDO is used to transfer non-cyclic data, such as communication parameter configuration, and Servo running parameter configuration. The CoE service type includes Emergency Message, SDO request and SDO response.

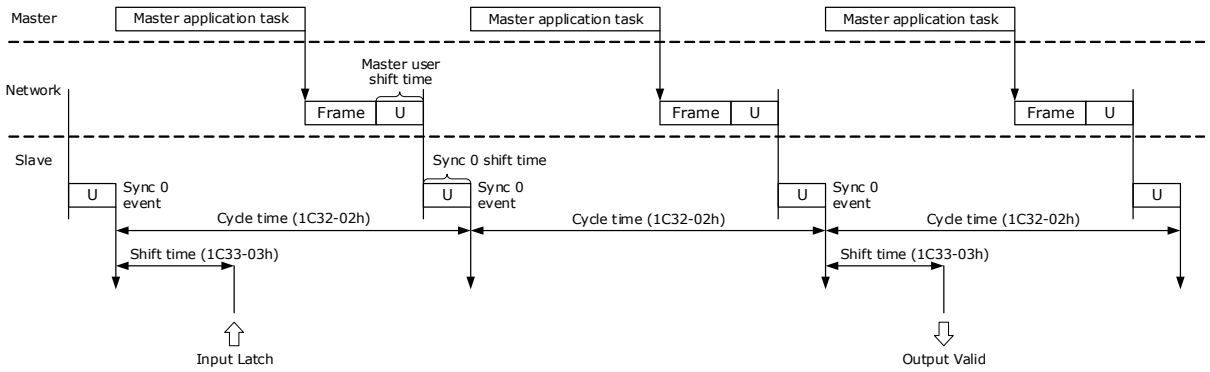
Emergency Message

When an alarm occurs in the Drive, the CoE service can trigger an emergency message to inform the user of the error code. The Motion Coordinator response to the emergency message can be set by the ECAT_MODE system parameter in the controller.

Distributed Clock (DC)

The synchronization of EtherCAT communications is based on a mechanism called a distributed clock. With the distributed clock, all devices are synchronized with each other by sharing the same reference clock. The slave devices synchronize the internal applications to the Sync0 events that are generated according to the reference clock.

The figure below shows a timing chart for DC synchronization.



NOTE: Only the object 1C33-03h can be set.

9.1.6 Relevant Settings

For correct operation using EtherCAT ensure the parameters below are set correctly.

Parameter	Name	Setting	Meaning
Pn006.0	Bus Selection	1	Use EtherCAT. [Default]

The Device Node Number can be used to force the axis number used by the controller. If the Drive has a non-zero device node number (Pn704) and this node number is unique on the network, then the axis number will be the node number -1. Node number 13 would be axis number 12.

Parameter	Name	Range	Unit	Default
Pn704	Device Node Number	0 to 127	—	1

NOTE: Changing the Device Node Number will require the drive to be restarted.

9.1.7 CANopen over EtherCAT Reference Model

The DX4 uses the IEC 61800-7 CiA402 drive profile over EtherCAT which is often referred to as CoE. This defines the behavior of the drive for enable, disable command, error conditions and the set of objects used to configure the operation of the drive and expose status information.

The state of the control word and status word can be seen in the device configuration screen within Motion Perfect. The image below shows an example or a drive in a running state.

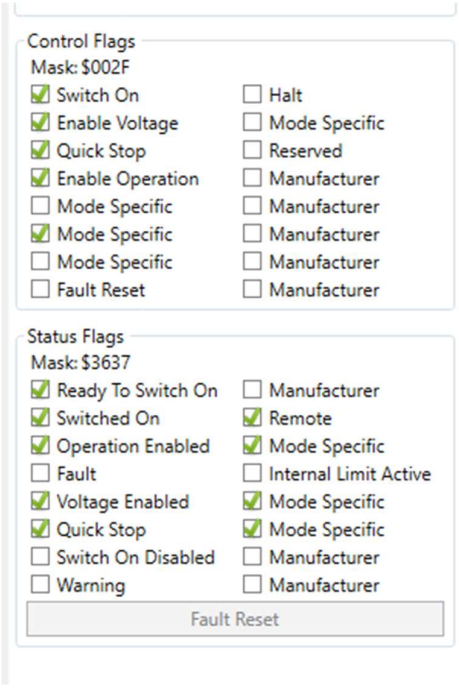


Figure 9-3 Motion Perfect Device Configuration, Motor screen

9.2 Object Dictionary

Group 1000h

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
1003	Pre-defined error field							
	00	Number of entries	UINT8	RO	No	—	—	—
	01	Standard error field 1	UINT32	RO	No	—	—	—
	02	Standard error field 2	UINT32	RO	No	—	—	—
	03	Standard error field 3	UINT32	RO	No	—	—	—
	04	Standard error field 4	UINT32	RO	No	—	—	—
	05	Standard error field 5	UINT32	RO	No	—	—	—
	06	Standard error field 6	UINT32	RO	No	—	—	—
	07	Standard error field 7	UINT32	RO	No	—	—	—
	08	Standard error field 8	UINT32	RO	No	—	—	—
1010	Store parameters							
	00	Highest sub-index supported	UINT8	RO	No	—	—	—
	01	Reserved	UINT32	RO	No	—	—	—
	02	Reserved	UINT32	RO	No	—	—	—
	03	save application parameters	UINT32	RW	No	—	—	—
1018	Identity Object							
	00	Number of entries	UINT8	RO	No	—	—	—
	01	Vender ID	UINT32	RO	No	—	—	—
	02	Product code	UINT32	RO	No	—	—	—
	03	Revision number	UINT32	RO	No	—	—	—
	04	Serial number	UINT32	RO	No	—	—	—
1600	1st Receive PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UwINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1601	2nd Receive PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1602	3rd Receive PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1603	4th Receive PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1A00	1st Receive PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1A01	2nd Transmit PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1A02	3rd Transmit PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
1A03	4thTransmit PDO Mapping							
	00	Number of entries	UINT8	RW	No	—	—	—
	01	Mapping entry 1	UINT32	RW	No	—	—	—
	02	Mapping entry 2	UINT32	RW	No	—	—	—
	03	Mapping entry 3	UINT32	RW	No	—	—	—
	04	Mapping entry 4	UINT32	RW	No	—	—	—
	05	Mapping entry 5	UINT32	RW	No	—	—	—
	06	Mapping entry 6	UINT32	RW	No	—	—	—
	07	Mapping entry 7	UINT32	RW	No	—	—	—
	08	Mapping entry 8	UINT32	RW	No	—	—	—
1C12	Sync Manager PDO assignment 2							
	00	Number of assigned PDOs	UINT8	RW	No	—	—	—
	01	Index of assigned RxPDO 1	UINT16	RW	No	—	—	—
	02	Index of assigned RxPDO 2	UINT16	RW	No	—	—	—
1C13	Sync Manager PDO assignment 3							
	00	Number of assigned PDOs	UINT8	RW	No	—	—	—
	01	Index of assigned TxPDO 1	UINT16	RW	No	—	—	—
	02	Index of assigned TxPDO 2	UINT16	RW	No	—	—	—
1C32	Sync Man 2 Synchronization							
	00	Number of elements	UINT8	RO	No	—	—	—
	01	Synchronization type	UINT16	RW	No	—	—	—
	02	Cycle time/ns	UINT16	RW	No	—	—	—
1C33	Sync Man 3 Synchronization							
	00	Number of elements	UINT8	RO	No	—	—	—
	01	Synchronization type	UINT16	RW	No	—	—	—
	02	Cycle time/ns	UINT16	RW	No	—	—	—

Group 3000h

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
30A5	—	SinglePos	DINT	RO	No	—	—	—
30A6	—	MultiPos	UDINT	RO	No	—	—	—
30A8	—	External Encoder Position	INT32	RO	Yes	1 pulse	-231～(231-1)	—
3164	Pn000	Basic Function Selections 0	INT32	RW	No	—	0000 to 0111	0000
3165	Pn001	Basic Function Selections 1	INT32	RW	No	—	0000 to 0001	0000
3166	Pn002	Application Function Selections 2	INT32	RW	No	—	0000 to 0100	0000
3167	Pn003	Application Function Selections 3	INT32	RW	No	—	0000 to 1032	0000
3168	Pn004	Application Function Selections 4	INT32	RW	No	—	0000 to 0025	0000
3169	Pn005	Application Function Selections 5	INT32	RW	No	—	00d0 to 33d3	00d0
316A	Pn006	Application Function Selections 6	INT32	RW	No	—	0000 to 0001	0001
316B	Pn007	Application Function Selections 7	INT32	RW	No	—	0000 to 1120	0010
316C	Pn008	Initial Display Selection When Power On	INT32	RW	No	—	0 to 9999	0010
316D	Pn009	Application Function Selections 9	INT32	RW	No	—	0000 to 0001	0000
31C8	Pn100	Tuning Function	INT32	RW	No	—	0001 to 1105	0001
31C9	Pn101	Servo Rigidity	INT32	RW	No	Hz	0 to 500	40
31CA	Pn102	Speed Loop Gain	INT32	RW	No	rad/s	1 to 10000	500
31CB	Pn103	Speed Loop Integral Time	INT32	RW	No	0.1ms	1 to 5000	125
31CC	Pn104	Position Loop Gain	INT32	RW	No	1/s	0 to 1000	40
31CD	Pn105	Torque Command Filter Time	INT32	RW	No	0.01ms	0 to 2500	50
31CE	Pn106	Load Inertia Percentage	INT32	RW	No	%	0 to 9999	0
31CF	Pn107	Second Speed Loop Gain	INT32	RW	No	rad/s	1 to 10000	250

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
31D0	Pn108	Second Speed Loop Integral Time	INT32	RW	No	rad/s	1 to 5000	200
31D1	Pn109	Second Position Loop Gain	INT32	RW	No	1/s	0 to 1000	40
31D2	Pn110	Second Torque Reference Filter Time	INT32	RW	No	0.01ms	0 to 2500	100
31D4	Pn112	Speed Feedforward	INT32	RW	No	%	0 to 100	0
31D5	Pn113	Speed Feedforward Filter Time	INT32	RW	No	0.1ms	0 to 640	0
31D6	Pn114	Torque Feedforward	INT32	RW	No	%	0 to 100	0
31D7	Pn115	Torque Feedforward Filter Time	INT32	RW	No	0.1ms	0 to 640	0
31D8	Pn116	P/PI Switch Mode	INT32	RW	No	—	0 to 4	0
31D9	Pn117	Torque Reference Threshold for P/PI Switch	INT32	RW	No	%	0 to 300	200
31DA	Pn118	Deviation Counter Threshold for P/PI Switch	INT32	RW	No	1 pulse	0 to 10000	0
31DB	Pn119	Acceleration Reference Threshold for P/PI Switch	INT32	RW	No	10 rpm/s	0 to 3000	0
31DC	Pn120	Speed Reference Threshold for P/PI Switch	INT32	RW	No	rpm	0 to 10000	0
31DD	Pn121	Gain Switch Mode	INT32	RW	No	—	0 to 10	0
31DE	Pn122	Delay Time for Gain Switch	INT32	RW	No	0.1 ms	0 to 20000	0
31DF	Pn123	Threshold for Gain Switch	INT32	RW	No	—	0 to 20000	0
31E0	Pn124	Speed Threshold for Gain Switch	INT32	RW	No	rpm	0 to 2000	0
31E1	Pn125	Ramp Time for Position Loop Gain Switch	INT32	RW	No	0.1 ms	0 to 20000	0
31E2	Pn126	Hysteresis for Gain Switch	INT32	RW	No	—	0 to 20000	0
31E3	Pn127	Low Speed Filter	INT32	RW	No	1 cycle	0 to 100	0
31E6	Pn130	Coulomb Friction Compensation	INT32	RW	No	0.1%Tn	0 to 3000	0
31E7	Pn131	Speed Dead Band for Coulomb Friction Compensation	INT32	RW	No	rpm	0 to 100	0

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
31E8	Pn132	Viscous Friction Compensation	INT32	RW	No	0.1%Tn/1000rpm	0 to 1000	0
31EB	Pn135	Encoder Speed Filter Time	INT32	RW	No	0.01ms	0 to 30000	4
31FA	Pn150	Model Following Control Function	INT32	RW	No	—	0000 to 0002	0000
31FB	Pn151	Model Following Control Gain	INT32	RW	No	1/s	10 to 1000	50
31FC	Pn152	Model Following Control Gain Correction	INT32	RW	No	%	20 to 500	100
31FD	Pn153	Model Following Control Speed Feedforward	INT32	RW	No	%	0 to 200	100
31FE	Pn154	Model Following Control Torque Feedforward	INT32	RW	No	%	0 to 200	100
31FF	Pn155	Load Oscillation Frequency	INT32	RW	No	0.1 Hz	50 to 500	100
3200	Pn156	Filter Time for Load Oscillation Suppression	INT32	RW	No	0.1 ms	2 to 500	10
3201	Pn157	Limit for Load Oscillation Suppression	INT32	RW	No	rpm	0 to 1000	100
3204	Pn160	Load Torque Compensation	INT32	RW	No	%	0 to 100	0
3205	Pn161	Load Torque Observer Gain	INT32	RW	No	Hz	0 to 1000	200
3206	Pn162	Feedback Speed Selection	INT32	RW	No	—	0 to 1	0
3208	Pn164	Turns for PJOG0	INT32	RW	No	rotation	-50 to 50	5
3209	Pn165	Max Speed for PJOG0	INT32	RW	No	rpm	100 to 3000	1000
320A	Pn166	Acc./Dec. Time for PJOG0	INT32	RW	No	ms	50 to 2000	500
320B	Pn167	Stop Time for PJOG0	INT32	RW	No	ms	100 to 10000	1000
320C	Pn168	Turns for PJOG1	INT32	RW	No	rotation	-50 to 50	5
320D	Pn169	Max Speed for PJOG1	INT32	RW	No	rpm	100 to 3000	1000
320E	Pn170	Acc./Dec. Time for PJOG1	INT32	RW	No	ms	50 to 2000	500
320F	Pn171	Stop Time for PJOG1	INT32	RW	No	ms	100 to 10000	1000
3210	Pn172	Turns for Inertia Identification	INT32	RW	No	—	0 to 1	0

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
3211	Pn173	Frequency of Vibration Suppression Filter	INT32	RW	No	Hz	100 to 2000	2000
3212	Pn174	Adjust Bandwidth of Vibration Suppression Filter	INT32	RW	No	—	1 to 100	30
3213	Pn175	Vibration Suppression	INT32	RW	No	—	0 to 500	100
3214	Pn176	Lowpass Filter Time for Vibration Suppression	INT32	RW	No	0.1 ms	0 to 50	0
3215	Pn177	Highpass Filter Time for Vibration Suppression	INT32	RW	No	0.1 ms	0 to 1000	1000
3216	Pn178	Damping of Vibration Suppression Filter	INT32	RW	No	—	0 to 500	100
3217	Pn179	Amplitude Threshold for Vibration Detection	INT32	RW	No	—	5 to 500	100
3218	Pn180	Frequency Threshold for Vibration Detection	INT32	RW	No	—	0 to 100	100
3219	Pn181	Frequency of Notch Filter 1	INT32	RW	No	Hz	50 to 5000	5000
321A	Pn182	Depth of Notch Filter 1	INT32	RW	No	—	0 to 23	0
321B	Pn183	Width of Notch Filter 1	INT32	RW	No	—	0 to 15	2
321C	Pn184	Frequency of Notch Filter 2	INT32	RW	No	Hz	50 to 5000	5000
321D	Pn185	Depth of Notch Filter 2	INT32	RW	No	—	0 to 23	0
321E	Pn186	Width of Notch Filter 2	INT32	RW	No	—	0 to 15	2
321F	Pn187	Frequency of Notch Filter 3	INT32	RW	No	Hz	50 to 5000	5000
3220	Pn188	Depth of Notch Filter 3	INT32	RW	No	—	0 to 23	0
3221	Pn189	Width of Notch Filter 3	INT32	RW	No	—	0 to 15	2
322C	Pn200	Pulse Numbers for PG Frequency Division	INT32	RW	No	1 pulse	16 to 16384	16384
3236	Pn210	External Encoder Setting 1	INT32	RW	No	—	0000 to 1111	0000
3237	Pn211	External Encoder Setting 2	INT32	RW	No	—	0000 to 0001	0001

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
3238	Pn212	Resolution of External Encoder	INT32	RW	No	1 pulse	1 to 2^{20}	10000
3239	Pn213	Position Deviation Threshold between Encoder and External Encoder	INT32	RW	No	1 pulse	0 to 2^{27}	1000
323A	Pn214	Position Deviation Clear between Encoder and External Encoder	INT32	RW	No	%	0 to 100	0
3294	Pn304	Inner Speed Reference	INT32	RW	No	rpm	-6000 to 6000	500
3295	Pn305	Jogging Speed	INT32	RW	No	rpm	0 to 6000	500
3296	Pn306	Soft Start Acceleration Time	INT32	RW	No	ms	0 to 10000	0
3297	Pn307	Soft Start Deceleration Time	INT32	RW	No	ms	0 to 10000	0
3298	Pn308	Speed Reference Filter Time	INT32	RW	No	ms	0 to 10000	0
3299	Pn309	S-Curve Rise Time	INT32	RW	No	ms	0 to 10000	0
329A	Pn310	Speed Reference Smooth Mode Selection	INT32	RW	No	—	0 to 3	0
329B	Pn311	S-Curve Selection	INT32	RW	No	—	0 to 3	0
32A7	Pn323	Overspeed Detection Threshold	INT32	RW	No	—	1 to 8000	8000
32AF	Pn331	Touch Probe Signal Allocation	INT32	RW	No	—	0000 to 0022	0010
32B0	Pn332	Touch Probe Digital Input Filtering Time	INT32	RW	No	10ns	0 to 1000	0
32F5	Pn401	Forward Internal Torque Limit	INT32	RW	No	%	0 to 350	350
32F6	Pn402	Reverse Internal Torque Limit	INT32	RW	No	%	0 to 350	350
32F7	Pn403	Forward External Torque Limit	INT32	RW	No	%	0 to 350	100
32F8	Pn404	Reverse External Torque Limit	INT32	RW	No	%	0 to 350	100
32F9	Pn405	Reverse Brake Torque Limit	INT32	RW	No	%	0 to 350	300
32FA	Pn406	Torque Limit at Main Circuit Voltage Drop	INT32	RW	No	%	0 to 100	50

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
32FB	Pn407	Release Time for Torque Limit at Main Circuit Voltage Drop	INT32	RW	No	ms	0 to 1000	100
32FC	Pn408	Speed Limit during Torque Control	INT32	RW	No	rpm	0 to 6000	1500
3358	Pn500	Position Arrival Tolerance	INT32	RW	No	1 pulse	0 to 50000	10
3359	Pn501	Speed Arrival Tolerance	INT32	RW	No	rpm	0 to 100	0
335B	Pn503	Rotation Status Detection Threshold	INT32	RW	No	rpm	0 to 3000	20
335C	Pn504	Position Deviation Counter Overflow Threshold	INT32	RW	No	1 pulse	1 to $10*2^{23}$	—
335D	Pn505	Servo ON Waiting Time	INT32	RW	No	ms	-2000 to 2000	0
335E	Pn506	Servo OFF Waiting Time	INT32	RW	No	10 ms	0 to 500	0
335F	Pn507	Brake Enable Speed Threshold	INT32	RW	No	rpm	10 to 100	100
3360	Pn508	Brake Enable Waiting Time	INT32	RW	No	10 ms	10 to 100	50
3361	Pn509	Digital Input Signal Allocations 1	INT32	RW	No	—	0000 to 7777	3210
3362	Pn510	Digital Input Signal Allocations 2	INT32	RW	No	—	0000 to 0007	0004
3363	Pn511	Digital Output Signal Allocations	INT32	RW	No	—	0000 to 0bbb	0210
3364	Pn512	Digital Input Signals (Low Bits) from Bus Master	INT32	RW	No	—	0000 to 1111	0000
3365	Pn513	Digital Input Signals (High Bits) from Bus Master	INT32	RW	No	—	0000 to 1111	0000
3366	Pn514	Digital Input Signals Filter Time	INT32	RW	No	1 cycle	0 to 1000	1
3367	Pn515	Alarm Output Signal Filter Time	INT32	RW	No	2 cycle	0 to 3	1
3368	Pn516	Digital Input Signal Inverts 1	INT32	RW	No	—	0000 to 1111	0000
3369	Pn517	Digital Input Signal Inverts 2	INT32	RW	No	—	0000 to 0001	0000
336B	Pn519	Serial Encoder Communication Error Tolerance	INT32	RW	No	1 cycle	0 to 10000	3

Index	Parameter	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
336C	Pn520	Position Arrival Status Detection Time Threshold	INT32	RW	No	0.1 ms	0 to 60000	500
336D	Pn521	Alarm Masks	INT32	RW	No	—	0000 to 0011	0011
3371	Pn525	Motor Overload Detection Start Threshold	INT32	RW	No	%	100 to 150	100
3374	Pn528	Digital Output Signal Inverts	INT32	RW	No	—	0000 to 1111	0000
3375	Pn529	Torque Reaches Status Detection Torque Threshold	INT32	RW	No	%	3 to 300	100
3376	Pn530	Torque Reaches Status Detection Time Threshold	INT32	RW	No	ms	1 to 1000	10
337B	Pn535	Discharging Resistor Resistance	INT32	RW	No	Ω	10 to 300	—
337C	Pn536	Discharging Resistor Power	INT32	RW	No	W	0 to 2000	—
337E	Pn538	Momentary Power Interruption Hold Time	INT32	RW	No	1 cycle	0 to 50	1
3424	Pn704	Device Node Number	INT32	RW	No	—	0 to 127	1
3434	Pn720	Homing Method	INT32	RW	No	—	1 to 35	1
3435	Pn721	Speed during Search for Switch	INT32	RW	No	0.1 rpm	1 to 2147483647	5000
3436	Pn722	Speed during Search for Zero	INT32	RW	No	0.1 rpm	1 to 2147483647	100
3437	Pn723	Homing Acceleration	INT32	RW	No	0.1 rpm/s	1 to 2147483647	100
3438	Pn724	Home Offset	INT32	RW	No	1 pulse	-2147483648 to 2147483647	0
3439	Pn725	Electronic Gear Ratio (Numerator)	INT32	RW	No	—	1 to 1073741824	1
343A	Pn726	Electronic Gear Ratio (Numerator)	INT32	RW	No	—	1 to 1073741824	1
35B0	?	Identify drive	INT32	RW	No	-	0 to 1	0

Group 6000h

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
603F	00	Error code	UINT16	RO	Yes	—	0 to 65535	—

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
6040	00	Control word	UINT16	RW	Yes	—	0 to 65535	0
6041	00	Status word	UINT16	RO	Yes	—	0 to 65535	—
605A	00	Quick stop option code	INT16	RW	No	—	0, 1, 2, 5, 6	2
605B	00	Shutdown option code	INT16	RW	No	—	0, 1	0
605C	00	Disable operation option code	INT16	RW	No	—	0, 1	0
605D	00	Halt option code	INT16	RW	No	—	1, 2	1
605E	00	Fault reaction option code	UINT16	RW	No	—	0	0
6060	00	Modes of operation	INT8	RW	Yes	—	0 to 10	0
6061	00	Modes of operation display	INT8	RO	Yes	—	0 to 10	—
6062	00	Position demand value	INT32	RO	Yes	Position units	-2147483648 to 2147483647	—
6063	00	Position actual value	INT32	RO	Yes	Encoder units	-2147483648 to 2147483647	—
6064	00	Position actual value	INT32	RO	Yes	Position units	-2147483648 to 2147483647	—
6065	00	Following error window	UINT32	RW	Yes	Position units	-2147483648 to 2147483647	1048576
6066	00	Following error time out	UINT16	RW	Yes	ms	0 to 65535	5
6067	00	Position window	UINT32	RW	Yes	Position units	0 to 4294967295	734
6068	00	Position window time	UINT16	RW	Yes	ms	0 to 65535	5
6069	00	Velocity sensor actual value	INT32	RO	Yes	Speed units	-2147483648 to 2147483647	—
606B	00	Velocity demand value	INT32	RO	Yes	Speed units	-2147483648 to 2147483647	—

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
606C	00	Velocity actual value	INT32	RO	Yes	Speed units	-2147483648 to 2147483647	—
606D	00	Velocity window	UINT16	RW	Yes	Speed units	0 to 65535	0
606E	00	Velocity window time	UINT16	RW	Yes	ms	0 to 65535	0
606F	00	Velocity threshold	UINT16	RW	Yes	Speed units	0 to 65535	0
6070	00	Velocity threshold time	UINT16	RW	Yes	ms	0 to 65535	0
6071	00	Target Torque	INT16	RW	Yes	0.1 % of rated torque	-32768 to 32768	0
6072	00	Max Torque	UINT16	RW	Yes	0.1% of rated torque	0 to 65535	3500
6077	00	Torque actual value	INT16	RO	Yes	0.1% of rated torque	-5000 to 5000	—
6078	00	Current actual value	INT16	RO	Yes	0.1% of rated current	-32768 to 32768	—
607A	00	Target position	INT32	RW	Yes	Position units	-2147483648 to 2147483647	0
607C	00	Home offset	INT32	RW	Yes	—	—	—
607D	Software Position Limit							
	00	Number of entries	UINT8	RO	No	—	—	2
	01	Min position limit	INT32	RW	No	Position units	-2147483648 to 2147483647	—
	02	Max position limit	INT32	RW	No	Position units	-2147483648 to 2147483647	—
607E	00	Polarity	USINT	RW	No	—	0, 1	0
607F	00	Max profile velocity	UINT32	RW	Yes	Speed units	0 to 200000	Read from motor
6080	00	Max motor speed	UINT32	RW	Yes	RPM	0 to rated speed	Read from motor

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
6081	00	Profile velocity	UINT32	RW	Yes	Speed units	0 to 200000	10000
6082	00	End velocity	UINT32	RW	Yes	Speed units	0 to 4294967295	0
6083	00	Profile acceleration	UINT32	RW	Yes	Acceleration units	0 to 4294967295	200000
6084	00	Profile deceleration	UINT32	RW	Yes	Acceleration units	0 to 4294967295	200000
6085	00	Quick stop deceleration	UINT32	RW	Yes	Acceleration units	0 to 4294967295	200000
6086	00	Motion profile type	INT16	RW	Yes	—	0, 2	0
6087	00	Torque Slope	UINT32	RW	Yes	0.1 %/s	0 to 4294967295	100
6093	Position factor							
	00	Number of entries	UINT8	RO	No	—	—	2
	01	numerator	UINT32	RW	No	—	—	1
	02	divisor	UINT32	RW	No	—	—	1
6094	Velocity encoder factor							
	00	Number of entries	UINT8	RO	No	—	—	2
	01	numerator	UINT32	RW	No	—	—	1
	02	divisor	UINT32	RW	No	—	—	1
6097	Acceleration factor							
	00	Number of entries	UINT8	RO	No	—	—	2
	01	numerator	UINT32	RW	No	—	—	1
	02	divisor	UINT32	RW	No	—	—	1
6098	00	Homing method	INT8	RW	Yes	—	1 to 35	1
6099	Homing speeds							
	00	Number of entries	UINT8	RO	No	—	—	2
	01	Speed during search for switch	UINT32	RW	Yes	Speed units	0 to 4294967295	5000
	02	Speed during search for zero	UINT32	RW	Yes	Speed units	0 to 4294967295	100

Index	Subindex	Name	Data Type	Access	PDO Mapping	Unit	Range	Default
60E0	00	Positive Torque Limit Value	RW	UINT16	Yes	0.1%	0 to 65535	3500
60E1	00	Negative Torque Limit Value	RW	UINT16	Yes	0.1%	0 to 65535	3500
60F4	00	Following Error	RO	INT32	Yes	Position units	-2147483648 to 2147483647	—
60FC	00	Position Demand Internal Value	RO	INT32	Yes	Position units	-2147483648 to 2147483647	—
60FF	00	Target Velocity	RW	INT32	Yes	Speed units	-2147483648 to 2147483647	0
6502	00	Supported Drive Modes	RO	UINT32	No	—	—	1005

9.3 Parameter List

9.3.1 Parameter Table

No.		Name	Range	Default	Unit	Function Description	Restart
Pn000		Basic Function Selection 0	b0000 ~ b0111	0000	—		Yes
	Pn000.0	Reserved	0 ~ 0		—		
	Pn000.1	Forward Drive Prohibit Input	0 ~ 1		—	[0] Enabled. The motor is stopped according to Pn003.1 when an overtravel occurs [1] Disabled. Always allow forward motion	
	Pn000.2	Reverse Drive Prohibit Input	0 ~ 1		—	[0] Enabled. The motor is stopped according to Pn003.1 when the overtravel occurs [1] Disabled. Always allow reverse motion	
	Pn000.3	Reserved	0 ~ 0				
Pn001		Basic Function Selection 1	b0000 ~ b0001	0000	—		Yes
	Pn001.0	Motor Direction	0 ~ 1		—	[0] Use CCW as the forward direction [1] Use CW as the forward direction	
	Pn001.1	Reserved	0 ~ 0				
	Pn001.2	Reserved	0 ~ 0				
	Pn001.3	Reserved	0 ~ 0				
Pn002		Application Function Selection 2	b0000 ~ b0100	0000	—		Yes
	Pn002.0	Reserved	0 ~ 0				
	Pn002.1	Reserved	0 ~ 0				
	Pn002.2	Absolute Encoder Usage	0 ~ 1		—	[0] Use the encoder as an absolute encoder (requires encoder battery) [1] Use the encoder as an incremental encoder	
	Pn002.3	Reserved	0 ~ 0				
Pn003		Application Function Selection 3	h0000 ~ h1032	0000	—		Yes
	Pn003.0	Stopping Method for Gr.1 Alarms, Servo OFF, STO, Servo OFF	0 ~ 2		—	[0] Dynamic brake and coast [1] Dynamic brake then DB state [2] Coast	
	Pn003.1	Motor Stopping Method for Overtravel	0 ~ 3		—	[0] Dynamic brake and coast [1] Coast [2] Reverse brake then Zero clamping state [3] Reverse brake then coast	
	Pn003.2	Reserved	0 ~ 0				
	Pn003.3	Overload Enhancement	0 ~ 1		—	[0] Disabled. [1] Enabled. This function increases the motor overload limit which can be used in the conditions that require frequent start and stop. This setting is not valid for MXL motors.	
Pn004		Application Function Selection 4	h0000 ~ h0025	0000	—		Yes

No.		Name	Range	Default	Unit	Function Description	Restart
	Pn004.0	Motor Stopping Methods for Gr.2 Alarms	0 ~ 5		—	[0] Dynamic brake then coast [1] Dynamic brake then DB state [2] Coast [3] Reverse brake then DB state [4] Reverse brake then coast [5] Treat as warning, no action	
	Pn004.1	Deviation Counter Clear in Local Control Mode	0 ~ 2			[0] Reset to zero when Servo is OFF or STO is valid [1] Reserved setting (Do not use) [2] Reset to zero when Servo is OFF, or STO is valid, or Overtravel occurs	
	Pn004.2	Reserved	0 ~ 0				
	Pn004.3	Reserved	0 ~ 0				
Pn005		Application Function Selection 5	h00d0 ~ h33d3	00d0	—		Yes
	Pn005.0	Internal Torque Feedforward Method	0 ~ 3			[0] Use the general internal torque feedforward [1] Reserved setting (Do not use) [2] Use the high-speed internal torque feedforward [3] Reserved setting (Do not use)	
	Pn005.1	Local Control Method	d ~ d			Use speed control (internal speed reference) The speed is determined by Pn304.	
	Pn005.2	Torque Feedforward Method	0 ~ 3			[0] Use internal torque feedforward [1] Use Model Following Control torque feedforward [2] Use external torque feedforward (object 60B2) [3] Use torque feedforward generated by cubic interpolation algorithm	
	Pn005.3	Speed Feedforward Method	0 ~ 3			[0] Use internal speed feedforward [1] Use Model Following Control speed feedforward [2] Use external speed feedforward (object 60B1) [3] Use speed feedforward generated by cubic interpolation algorithm	
Pn006		Application Function Selection 6	h0000 ~ h0001	0001	—		Yes
	Pn006.0	Bus Selection	0 ~ 1		—	[0] Do not use the Bus. Select the control method by the setting of Pn005.1 [1] Use EtherCAT	
	Pn006.1	Reserved	0 ~ 0				
	Pn006.2	Reserved	0 ~ 0				
	Pn006.3	Reserved	0 ~ 0				
Pn007		Application Function Selection 7	h0000 ~ h1120	0010	—		Yes
	Pn007.0	Reserved					
	Pn007.1	Power Supply Selection	0 ~ 2		—	[0] Single-phase AC (for 1.5kW, 2.0kW and 3.0kW the drive will apply an 80% de-rate) [1] Three-phase AC [2] DC	

No.		Name	Range	Default	Unit	Function Description	Restart
	Pn007.2	Torque Limit Action When Undervoltage Occurs	0 ~ 1		—	[0] Disabled [1] Enabled	
	Pn007.3	AC Supply Frequency	0 ~ 1		—	[0] 50Hz [1] 60Hz	
Pn008		Reserved	0 ~ 9999	9999	—		
Pn009		Application Function Selection 9	h0000 ~ h0001	0000	—		Yes
	Pn009.0	Common DC Bus Function	0~1	0		[0] Disabled [1] Enabled	
	Pn009.1	Reserved	0~0	0			
	Pn009.2	Reserved	0~0	0			
	Pn009.3	Reserved	0~0	0			
Pn100		Tuning Function	h0001 ~ h1105	0001	—		Yes
	Pn100.0	Tuning Mode	1 ~ 5		—	[1] Tuning-less [2] Reserved setting (Do not use) [3] One-parameter auto-tuning [4] Reserved setting (Do not use) [5] Manual tuning Note: it is necessary to set a proper Load Inertia Percentage (Pn106) when this parameter is set to [3] or [5].	
	Pn100.1	Reserved	0 ~ 0		—		
	Pn100.2	Automatic Vibration Suppression Selection	0 ~ 1		—	[0] Disabled [1] Enabled	
	Pn100.3	Damping Selection	0 ~ 1		—	[0] Standard: Short positioning time, may increase overshoot [1] Stable: Stable positioning, may slow response time This parameter is valid when the 'One-parameter auto-tuning' mode is selected (Pn100.0=3).	
Pn101		Servo Rigidity	0 ~ 500	40	Hz	This parameter determines the response performance of the servo system. The performance can be improved by increasing this value and decreased if vibration occurs.	
Pn102		Speed Loop Gain	1 ~ 10000	500	rad/s	This parameter determines the bandwidth of the speed loop.	
Pn103		Speed Loop Integral Time	1 ~ 5000	125	0.1ms	Reducing this value can shorten positioning time and speed response time.	
Pn104		Position Loop Gain	0 ~ 1000	40	1/s	This parameter determines the bandwidth of position loop. Increase this value can improve the stiffness of positioning, decrease if the system vibrates.	
Pn105		Torque Reference Filter Time	0 ~ 2500	50	0.01ms	This parameter determines the bandwidth of torque reference filter. This is used to filter out noise in the torque reference.	
Pn106		Load Inertia Percentage	0 ~ 9999	0	%	This value should be set to the percentage of load	

No.		Name	Range	Default	Unit	Function Description	Restart
						inertia and motor inertia (Pn106 = (load inertia / motor rotor inertia) * 100%).	
Pn107		Second Speed Loop Gain	1 ~ 10000	500	rad/s		
Pn108		Second Speed Loop Integral Time	1 ~ 5000	125	0.1ms		
Pn109		Second Position Loop Gain	0 ~ 1000	40	1/s		
Pn110		Second Torque Reference Filter Time	0 ~ 2500	50	0.01ms		
Pn112		Speed Feedforward	0 ~ 100	0	%	This value is a percentage of the internal speed feedforward. Used when the internal speed feedforward is selected (Pn005.3=0).	
Pn113		Speed Feedforward Filter Time	0 ~ 640	0	0.1ms	This parameter determines the bandwidth of internal speed feedforward filter. This is used to filter out noise in the internal speed feedforward.	
Pn114		Torque Feedforward	0 ~ 100	0	%	This value is a percentage of the internal torque feedforward. Used when the internal torque feedforward is selected (Pn005.2=0).	
Pn115		Torque Feedforward Filter Time	0 ~ 640	0	0.1ms	This parameter determines the bandwidth of internal torque feedforward filter. This is used to filter out noise in the internal torque feedforward.	
Pn116		P/PI Switch Mode	0 ~ 4	0	—	[0] Use torque reference as the condition (threshold setting: Pn117) [1] Use position deviation counter as the condition (threshold setting: Pn118) [2] Use acceleration reference as the condition (threshold setting: Pn119) [3] Use the speed reference as the condition (threshold setting: Pn120) [4] Fixed to PI Control	Yes
Pn117		Torque Reference Threshold for P/PI Switch	0 ~ 300	200	%	The threshold used to switch speed regulator from PI to P. This value is a percentage of torque reference.	
Pn118		Deviation Counter Threshold for P/PI Switch	0 ~ 10000	0	pulse	The threshold used to switch speed regulator from PI to P. This value is a pulse number.	
Pn119		Acceleration Reference Threshold for P/PI Switch	0 ~ 3000	0	10rpm/s	The threshold used to switch speed regulator from PI to P. This value is a acceleration reference.	
Pn120		Speed Reference Threshold for P/PI Switch	0 ~ 10000	0	rpm	The threshold used to switch speed regulator from PI to P. This value is a speed reference.	

No.		Name	Range	Default	Unit	Function Description	Restart
Pn121		Gain Switch Mode	0 ~ 10	0	—	[0] Fixed to first gain set [1] Use digital input (G-SEL) [2] Use torque reference (see Pn117) [3] Use position deviation counter (see Pn118) [4] Use acceleration (see Pn119) [5] Use speed reference (see Pn120) [6] Use position reference (see Pn123) [7] Use actual speed (see Pn124) [8] Use position reference (see Pn123) and actual speed (see Pn124) [9] Fixed to second gain set [10] Use positioning completed flag	Yes
Pn122		Delay Time for Gain Switch	0 ~ 20000	0	0.1ms	The delay time for gain switching after the condition has been satisfied.	
Pn123		Threshold for Gain Switch	0 ~ 20000	0	—	The threshold of speed reference for gain switching.	
Pn124		Speed Threshold for Gain Switch	0 ~ 2000	0	rpm	Valid only when using position reference and actual speed as the condition (Pn121=8).	
Pn125		Ramp Time for Position Loop Gain Switch	0 ~ 20000	0	0.1ms	Ramp time for gain switching, only valid to position loop gain.	
Pn126		Hysteresis for Gain Switch	0 ~ 20000	0	—	Hysteresis of gain switching conditions, used to prevent gain switching frequently.	
Pn127		Low Speed Filter	0 ~ 100	0	1cycle	Determines the performance of the filter used for low speed measurement. Note: This filter can introduce significant delay into the measured speed if this value is large.	
Pn130		Coulomb Friction Compensation	0 ~ 3000	0	0.1%Tn	This parameter is used to compensate coulomb friction. Value entered is the % torque which is required to overcome coulomb friction.	
Pn131		Speed Dead Band for Coulomb Friction Compensation	0 ~ 100	0	rpm	Sets a dead band to disable coulomb friction compensation. Used to prevent vibration at zero speed.	
Pn132		Viscous Friction Compensation	0 ~ 1000	0	0.1%Tn/1000rpm		
Pn135		Encoder Speed Filter Time	0 ~ 30000	4	0.01ms	Sets a time constant for smoothing the changes in the feedback speed to reduce vibration. Use when the instantaneous speed is not used as the speed feedback (Pn162=0).	
Pn150		Model Following Control Function	h0000 ~ h0002	0000	—		Yes
	Pn150.0	Model Following Control Selection	0 ~ 2	0	—	[0] Disabled. [1] Use the model following control. [2] Use the model following control and load oscillation suppression.	
	Pn150.1	Reserved	0 ~ 0	0	—		
	Pn150.2	Reserved	0 ~ 0	0	—		
	Pn150.3	Reserved	0 ~ 0	0	—		

No.		Name	Range	Default	Unit	Function Description	Restart
Pn151		Model Following Control Gain	10 ~ 1000	50	1/s	Determines the response characteristic of the servo system. Increasing this will improve the response characteristic and reduce the positioning time.	
Pn152		Model Following Control Gain Correction	20 ~ 500	100	%	Used for correcting the setting of the model following control gain.	
Pn153		Model Following Control Speed Feedforward	0 ~ 200	100	%	Used for fine tuning the speed feedforward value output by the model following control gain. Increasing this value can reduce bias but may result in overshoot.	
Pn154		Model Following Control Torque Feedforward	0 ~ 200	100	%	Used for fine-tuning the torque feedforward value output by the model following control gain. Increase this value can improve the response but may to result in overshoot.	
Pn155		Load Oscillation Frequency	50 ~ 500	100	0.1Hz	Typically, this setting is the anti-resonance frequency of the two-mass servo system.	
Pn156		Filter Time for Load Oscillation Suppression	2 ~ 500	10	0.1ms	Increasing this value will slow down the vibration suppression creating a 'softer' response. If this value is too large the vibration suppression may become ineffective.	
Pn157		Limit for Load Oscillation Suppression	0 ~ 1000	100	r/min	Limit the effect of vibration suppression. Decreasing this value will 'soften' the response. If this value is too small the vibration suppression may become ineffective.	
Pn160		Load Torque Compensation	0 ~ 100	0	%	Coefficient (percentage) to compensate load torque. Increasing this value can improve the load disturbance rejection performance but may cause vibration.	
Pn161		Load Torque Observer Gain	0 ~ 1000	200	Hz	Response characteristic of the load observer.	
Pn162		Feedback Speed Selection	0 ~ 1	0	—	[0] Use encoder speed as the feedback speed. [1] Use observed speed as the feedback speed.	Yes
Pn164		Move Distance for first move	-50 ~ 50	5	rev		
Pn165		Max Speed for first move	100 ~ 3000	1000	rpm		
Pn166		Accel/Decel Time for first move	50 ~ 2000	500	ms		
Pn167		Dwell Time for first move	100 ~ 10000	1000	ms		
Pn168		Move Distance for second move	-50 ~ 50	-5	rev		
Pn169		Max Speed for second move	100 ~ 3000	1000	rpm		
Pn170		Accel/Decel Time for second move	50 ~ 2000	500	ms		
Pn171		Dwell Time for second move	100 ~ 10000	1000	ms		
Pn172		Turns for Inertia Identification	0 ~ 1	0		Number of revolutions used in inertia identification operation. [0] 8 revolutions [1] 4 revolutions	

No.		Name	Range	Default	Unit	Function Description	Restart
Pn173		Frequency of Vibration Suppression Filter	100 ~ 2000	2000	Hz		
Pn174		Adjust Bandwidth of Vibration Suppression Filter	1 ~ 100	30	—		
Pn175		Vibration Suppression	0 ~ 500	100	—		
Pn176		Low pass Filter Time for Vibration Suppression	0 ~ 50	0	0.1ms		
Pn177		High pass Filter Time for Vibration Suppression	0 ~ 1000	1000	0.1ms		
Pn178		Damping of Vibration Suppression Filter	0 ~ 500	100	—		
Pn179		Amplitude Threshold for Vibration Detection	5 ~ 500	100	—	Used for automatic vibration suppression.	
Pn180		Frequency Threshold for Vibration Detection	0 ~ 100	100	Hz	Used for automatic vibration suppression.	
Pn181		Frequency of Notch Filter 1	50 ~ 5000	5000	Hz		
Pn182		Depth of Notch Filter 1	0 ~ 23	0	—		
Pn183		Width of Notch Filter 1	0 ~ 15	2	—		
Pn184		Frequency of Notch Filter 2	50 ~ 5000	5000	Hz		
Pn185		Depth of Notch Filter 2	0 ~ 23	0	—		
Pn186		Width of Notch Filter 2	0 ~ 15	2	—		
Pn187		Frequency of Notch Filter 3	50 ~ 5000	5000	Hz		
Pn188		Depth of Notch Filter 3	0 ~ 23	0	—		
Pn189		Width of Notch Filter 3	0 ~ 15	2	—		
Pn200		Reserved	0 ~ 16384	16384			
Pn210		External Encoder Setting 1	b0000 ~ b1111	0000	—		Yes
	Pn210.0	External Encoder Selection	0 ~ 2	0	—	[0] Do not use an external encoder [1] Use the external encoder for fully-closed loop control [2] Use the external encoder as a general purpose peripheral	
	Pn210.1	Reserved	0 ~ 0	0	—		
	Pn210.2	Reserved	0 ~ 0	0	—		
	Pn210.3	Direction of External Encoder	0 ~ 1	0	—	[0] Normal [1] Inverted	
Pn211		External Encoder Setting 2	b0000 ~ b0001	0001			Yes
	Pn211.0	C-pulse of External Encoder	0 ~ 1	1		[0] Do not use C-pulse of the external encoder [1] Use C-pulse of the external encoder	
	Pn211.1	Reserved	0 ~ 0	0			
	Pn211.2	Reserved	0 ~ 0	0			
	Pn211.3	Reserved	0 ~ 0	0			
Pn212		Resolution of External Encoder	1 ~ 1048576	10000	pulse		Yes
Pn213		Position Deviation Threshold between	0 ~ 134217728	1000	pulse		

No.		Name	Range	Default	Unit	Function Description	Restart
		Encoder and External Encoder					
Pn214		Position Deviation Clear between Encoder and External Encoder	0 ~ 100	0	%		
Pn225		Delay Compensation Method for Biss Encoder	0 ~ 1	0	—	[0] Automatic compensation [1] Manual compensation	
Pn226		Manual Delay Compensation Value for Biss Encoder	0~0xFF	0	10ns		
Pn304		Reserved	0 ~ 500	500			
Pn305		Jogging Speed	0 ~ 6000	500	rpm	Speed used by JOG operation	
Pn306		Acceleration Time	0 ~ 10000	0	ms	Time to accelerate from rest to 1000 RPM.	
Pn307		Deceleration Time	0 ~ 10000	0	ms	Time to decelerate from 1000 RPM to rest.	
Pn308		Speed reference filter time	0 ~ 10000	0	ms	Speed reference filter time.	
Pn309		S-Curve Rise Time	0 ~ 10000	0	ms	Rise time for transiting from one speed point to another speed point. Used in S-curve speed reference mode (Pn310 = 1)	
Pn310		Speed Reference Smooth mode Selection	0 ~ 3	0	—	[0] Ramp [1] S-Curve [2] Primary filtering [3] Secondary filtering	Yes
Pn311		S-Curve Selection	0 ~ 3	0		Transition form of the S-curve.	Yes
Pn323		Overspeed Detection Threshold	1 ~ 8000	8000	rpm	Threshold for overspeed trip (A03 alarm). Alarm will be generated if the motor speed exceeds this threshold.	
Pn331		Touch Probe Signal Allocation	h0000 ~ h0022	0010			Yes
	Pn331.0	Touch Probe 1 Signal Allocated Pin Number	0 ~ 2	0		[0] Allocate the signal to X7-1 [1] Allocate the signal to X7-3 [2] Use the C-Pulse instead of the allocation	
	Pn331.1	Touch probe 2 Signal Allocated Pin Number	0 ~ 2	1		[0] Allocate the signal to X7-1 [1] Allocate the signal to X7-3 [2] Use the C-Pulse instead of the allocation	
	Pn331.2	Reserved	0 ~ 0	0			
	Pn331.3	Reserved	0 ~ 0	0			
Pn332		Touch Probe Digital Input Filtering Time	0~1000	0	10ns		
Pn333		Touch probe Signal Inverts	0000~0011	0000			
	Pn333.0	Touch Probe Input 1 Inverse selection				[0] Normal [1] Inverted	
	Pn333.1	Touch Probe Input 2 Inverse selection				[0] Normal [1] Inverted	
	Pn333.2	Reserved					
	Pn333.3	Reserved					
Pn401		Forward Internal Torque Limit	0 ~ 400	350	%		

No.		Name	Range	Default	Unit	Function Description	Restart
Pn402		Reverse Internal Torque Limit	0 ~ 400	350	%		
Pn403		Forward External Torque Limit	0 ~ 400	100	%		
Pn404		Reverse External Torque Limit	0 ~ 400	100	%		
Pn405		Reverse Brake Torque Limit	0 ~ 400	300	%		
Pn406		Torque Limit at Main Circuit Voltage Drop	0 ~ 100	50	%		
Pn407		Release Time for Torque Limit at Main Circuit Voltage Drop	0 ~ 1000	100	ms		
Pn408		Speed Limit during Torque Control	0 ~ 6000	1500	rpm		
Pn409		Reserved					
Pn410		Reserved					
Pn500		Position Arrival Tolerance	0 ~ 50000	10	pulse	The /COIN (Positioning Completion Output) signal will turn ON when the deviation counter is less than this setting.	
Pn501		Speed Arrival Tolerance	0 ~ 100	10	rpm	The /VCMP (Speed Coincidence Detection Output) signal will turn ON when the deviation between the speed reference and speed feedback is less than this setting.	
Pn503		Rotation Status Detection Threshold	0 ~ 3000	20	rpm	The /TGON (Rotation Detection Output) signal will turn ON when the motor speed exceeds this setting.	
Pn504		Position Deviation Counter Overflow Threshold	1 ~ 83886080	—	1pulse	Threshold for position deviation. The A06 alarm will be generated if the deviation counter exceeds this setting. Note: the default setting depends on the encoder resolution.	
Pn505		Brake Disengage Delay Time	-2000 ~ 2000	0	ms	If this value is positive, when the drive enable command is received the brake signal will turn ON and wait for the specified time before enabling the motor control. If this value is negative, when the drive enable command is received the motor control will be enabled and wait for the specified time before turning ON the brake signal.	
Pn506		Brake Engage Delay Time	0 ~ 500	0	10ms	When the drive disable command is received the brake signal will turn OFF and wait for the specified time before disabling the motor control.	
Pn507		Brake Engage Speed Threshold	10 ~ 100	100	rpm	If the drive disable command is received during motion then the brake signal will turn ON when the motor speed is lower than the specified value after receiving the command. Note: the brake signal will remain ON as long as one of	

No.		Name	Range	Default	Unit	Function Description	Restart
						the conditions (Pn507, Pn508) is satisfied.	
Pn508		Brake Engage Timeout	10 ~ 100	50	10ms	If the drive disable command is received during motion, then the brake signal will turn ON when the delay exceeds the specified value after receiving the command. Note: the brake signal will remain ON as long as one of the conditions (Pn507, Pn508) is satisfied.	
Pn509		Digital Input Signal Allocations 1	h0000 ~ h7777	7777	—	Select the function assigned to each digital input [0] S-ON [1] P-OT [2] N-OT [3] P-CL [4] N-CL [5] G-SEL [6] HmRef [7] Remote Where: Pn509.0 maps to X7-14 Pn509.1 maps to X7-15 Pn509.2 maps to X7-16 Pn509.3 maps to X7-17 If a function is repeatedly allocated, it will only be allocated to the lowest input channel.	Yes
Pn510		Digital Input Signal Allocations 2	h0000 ~ h0007	0007		Select the function assigned to each digital input [0] S-ON [1] P-OT [2] N-OT [3] P-CL [4] N-CL [5] G-SEL [6] HmRef [7] Remote Where: Pn510.0 maps to X7-18 Pn510.1 is reserved. Pn510.2 is reserved. Pn510.3 is reserved. If a function is repeatedly allocated, it will only be allocated to the lowest input channel.	Yes
Pn511		Digital Output Signal Allocations	h0000 ~ h0bbb	0ba9	—		Yes

No.		Name	Range	Default	Unit	Function Description	Restart
	Pn511.0	X7-6,7 Signal Allocation	h0 ~ hb	9	—	Select function assigned to digital output: [0] COIN/VCMP [1] TGON [2] S-RDY [3] CLT [4] BK [5] PGC [6] OT [7] RD [8] TCR [9] Remote0 [a] Remote1 [b] Remote2	
	Pn511.1	X7-10,11 Signal Allocation	h0 ~ hb	a	—	Select function assigned to digital output: [0] COIN/VCMP [1] TGON [2] S-RDY [3] CLT [4] BK [5] PGC [6] OT [7] RD [8] TCR [9] Remote0 [a] Remote1 [b] Remote2	
	Pn511.2	X7-12,13 Signal Allocation	h0 ~ hb	b	—	Select function assigned to digital output: [0] COIN/VCMP [1] TGON [2] S-RDY [3] CLT [4] BK [5] PGC [6] OT [7] RD [8] TCR [9] Remote0 [a] Remote1 [b] Remote2	
	Pn511.3	Reserved	—	—	—		
Pn512		Digital Input Signals (Low Bits) from Bus Master	b0000 ~ b1111	0000		Use the bit16 to bit23 in the sub-index 01 of the object 60FE in CiA402 as the inputs, corresponding from CN1-14 to CN1-17.	Yes
Pn513		Digital Input Signals (High Bits) from Bus Master	b0000 ~ b0001	0000		Use the bit24 in the sub-index 01 of the object 60FE in CiA402 as the input, corresponding to CN1-18.	Yes
Pn514		Digital Input Signals Filter Time	0 ~ 1000	1	1cycle	Sets a filtering time for the input signals. Increasing this value will result in a delay in signal changes.	
Pn515		Alarm Output Signal Filter Time	0 ~ 3	1	2cycle	Sets a filtering time for the alarm signals. Increasing	

No.		Name	Range	Default	Unit	Function Description	Restart
						this value will result in a delay in the alarm output.	
Pn516		Digital Input Signal Inversion 1	b0000 ~ b1111	0000	—		
	Pn516.0	X7-14 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn516.1	X7-15 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn516.2	X7-16 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn516.3	X7-17 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
Pn517		Digital Input Signal Inversion 2	b0000 ~ b0001	0000	—		
	Pn517.0	X7-18 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn517.1	Reserved	0 ~ 0	0			
	Pn517.2	Reserved	0 ~ 0	0			
	Pn517.3	Reserved	0 ~ 0	0			
Pn519		Serial Encoder Communication Error Tolerance	0 ~ 10000	3	1cycle	The number of consecutive read errors that will cause a encoder communication fault.	
Pn520		Position Arrival Status Detection Time Threshold	0 ~ 60000	500	0.1ms	Sets a required time for completing the positioning.	
Pn521		Alarm Masks 1	b0000 ~ b0111	0011	—		Yes
	Pn521.0	A15 Mask	0 ~ 1	1	—	[0] Do not mask [1] Ignore the alarm Note: for DX4-1A5A to DX4-104A, this can also be regarded as A16 Mask.	
	Pn521.1	A06 Mask	0~1	1	—	[0] Do not mask [1] Ignore the alarm	
	Pn521.2	A83 Mask	0~1	0	—	[0] Do not mask [1] Ignore the alarm	
	Pn521.3	Reserved	0	0	—		
Pn525		Motor Overload Detection Start Threshold	100 ~ 150	100	%	Threshold at which motor overload starts. The A04 alarms occurs if the load percentage exceeds this value for longer than a certain time. The recommended setting is 120 or less, otherwise the servo drive and motor may be damaged. Note: This setting should always be 115 for the MXL motors.	
Pn528		Output Signal Inversion	b0000 ~ b1111	0000	—		
	Pn528.0	X7-6, 7 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn528.1	X7-8, 9 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn528.2	X7-10, 11 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	
	Pn528.3	X7-12, 13 inverse selection	0 ~ 1	0	—	[0] Normal [1] Inverted	

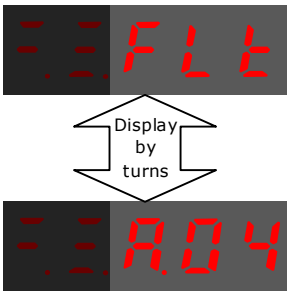
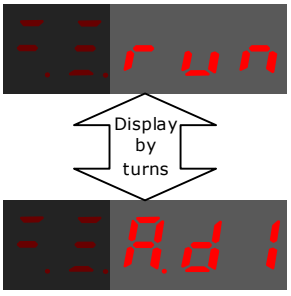
No.		Name	Range	Default	Unit	Function Description	Restart
Pn529		Torque Reaches Status Detection Torque Threshold	3 ~ 300	100	%	When the torque output exceeds the setting of Pn529 and the time is greater than the setting of Pn530, the /TCR (Torque Limit Detection Output) signal turns ON.	
Pn530		Torque Reaches Status Detection Time Threshold	1 ~ 1000	10	ms	When the torque output exceeds the setting of Pn529 and the time is greater than the setting of Pn530, the /TCR (Torque Limit Detection Output) signal turns ON.	
Pn535		Discharging Resistor Resistance	10 ~ 300	50	Ω	Sets the resistance value for the braking. This setting is not reset when the factory setting is restored. The default settings are as following: DX4-1A5A to DX4-110A: 50Ω DX4-115A: 40Ω DX4-120A and DX4-130A: 20Ω	Yes
Pn536		Discharging Resistor Power	0 ~ 2000	60	W	Sets the power value for the braking resistor. This setting is not reset when the factory setting is restored. The default settings are as following: DX4-1A5A to DX4-104A: 40W DX4-108A and DX4-110A: 60W DX4-115A: 80W DX4-120A and DX4-130A: 150W	Yes
Pn537		Reserved					
Pn538		Momentary Power Interruption Hold Time	0 ~ 50	1	period	If the main power supply to the drive is interrupted momentarily, power supply to the motor (servo ON status) will be maintained for the time set by this parameter. The setting is a number of periods, and the time of one period depends on the setting of Pn007.3: Pn007.3=0, the time of one period is 1/50s. Pn007.3=1, the time of one period is 1/60s.	
Pn541		Current Threshold for Detecting Abnormal Operation	0 ~ 400	200	% In	Set a percentage threshold for the current to detect that the motor has been operating abnormally	
Pn542		Acceleration Threshold for Detecting Abnormal Operation	0 ~ 1000	50	krpm/s	Set a threshold for the acceleration to detect that the motor has been operating abnormally	
Pn704		Device node number	0~127	0	—	Device node number or station alias	Yes
Pn720		Homing Method	1 ~ 35	1	—	Mapping to the object 6098 in CiA402.	
Pn721		Speed during Search for Switch	1~0x7FFFFFFF	5000	0.1rpm	Mapping to the object 6099-01 in CiA402.	
Pn722		Speed during Search for Zero	1~0x7FFFFFFF	100	0.1rpm	Mapping to the object 6099-02 in CiA402.	
Pn723		Homing Acceleration	1~0x7FFFFFFF	1000000	0.1r/m/s	Mapping to the object 609A in CiA402.	
Pn724		Home Offset	-2147483648 ~ 2147483647	0	pulse	Mapping to the object 607C in CiA402.	

No.		Name	Range	Default	Unit	Function Description	Restart
Pn725		Electronic Gear Ratio (Numerator)	1 ~ 0x40000000	1	—	Mapping to the object 0x6093-01 in CiA402.	
Pn726		Electronic Gear Ratio (Denominator)	1 ~ 0x40000000	1	—	Mapping to the object 0x6093-02 in CiA402.	Yes

9.4 Alarms Displays

9.4.1 Alarm Classifications

There are three classifications of alarms for the Drive: Gr.1, Gr.2, and Warning. They will affect the display and operation for the Servo System.

Classification	Stopping Method	Panel Display
Gr.1	Stops the Motor according to the setting of Pn003.0	The Panel Operator displays between Alarm No and Servo state **FLT** by turns. 
Gr.2	Stops the Motor according to the setting of Pn004.0	
Warning	Do not stop the Motor, and keep the current operation	The Panel Operator displays between Alarm No and Servo state **run** by turns. 

9.4.2 Alarm Table

Alarm Category	Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
Hardware Self-test and Function Error	A01	Gr.1	Parameter Checksum Error	Error in the stored parameter data	Reset the parameters to the factory settings using 'Restore Factory Settings' from the Parameter page. If the problem persists, contact TRIO or the Authorized Distributor
	A02	Gr.1	Reserved	Reserved	No information
	A03	Gr.1	Overspeed	The motor speed has exceeded the limit	The overspeed threshold is the lower of either Pn323 or maximum motor speed + 1000RPM. Check Pn323 is set to an appropriate value for the application
	A04	Gr.1	Motor Overload	Drive has exceeded the overload capability	Reduce the overload requirement by reducing the load or relaxing the motion parameters. Or re-size the servo drive and servo motor to match the required load conditions
	A05	Gr.1	Following Error Overflow	The following error has exceeded the internal maximum value	Check the target value from the master. Check the tuning of the drive
	A06	Gr.1	Following Error Overflow	The following error has exceeded the limit	Check the value of the following error limit is appropriate (see Pn504). This alarm can be disabled using Pn521.1
	A07	Gr.1	Electronic Gear Error	The electronic gear ratio is outside of the allowed range	Change the electronic gear ratio to a supported value The supported range depends on the encoder resolution: 20bit range is 0.001 to 4000 23bit range is 0.001 to 32000
	A08	Gr.1	U Phase Measurement Error	The measured value of U phase motor current is invalid	Contact TRIO or the Authorized Distributor
	A09	Gr.1	V Phase Measurement Error	The measured value of V phase motor current is invalid	Contact TRIO or the Authorized Distributor
	A0A	Gr.1	Handshake Error	The handshake between DSP and FPGA failed	Contact TRIO or the Authorized Distributor
	A0B		Unused	Unused	No information

Alarm Category		Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
		A0C		Unused	Unused	No information
		A0D		Unused	Unused	No information
		A0E		Unused	Unused	No information
		A0F		Unused	Unused	No information
		A10		Unused	Unused	No information
Power Board Error		A11	Gr.1	IPM Junction Overtemperature	The junction temperature of the IPM has exceeded the limit	Reduce the load
		A12	Gr.1	Overcurrent	The current limit of the IPM was exceeded	Check if the motor shaft is locked
		A13	Gr.1	Overvoltage	The bus voltage is greater than 420V	Check supply voltage. Relax the deceleration.
		A14	Gr.1	Undervoltage	The bus voltage is lower than 165V	Check supply voltage. Check wiring of re-gen resistor and/or external inductor. Check the pre-charge relay
		A15	Gr.2	Discharge Resistor Damaged	The discharge resistor is damaged or unconnected	Check whether the regenerative resistor is connected
		A16	Gr.1	Discharging Error	The discharging operation is abnormal	Check the sizing of regenerative resistor
		A17	/	Reserved	Reserved	No information
		A18	Gr.1	IPM Overtemperature	The temperature of the IPM has exceeded the limit	Check the ambient temperature and/or reduce the load
		A19	/	Reserved	Reserved	No information
		A1A	Gr.2	Charging Resistor Overload	Frequency of main circuit power cycling is too high	Delay the interval between the power cycles. Increase the delay between power-off and power-on
		A1B	Gr.2	DB Circuit Damaged	The circuit of the dynamic brake is damaged	Contact TRIO or the Authorized Distributor
		A1C	Gr.2	Internal Fan Error	The internal fan has failed for 30 seconds	Contact TRIO or the Authorized Distributor
		A1D	Gr.1	Drive Board Temperature Sensor Error	The temperature of the heatsink has exceeded the limit	Contact TRIO or the Authorized Distributor
		A1E	Gr.1	Main Circuit Charging Error	The charging resistor on the main circuit was damaged or the P1 terminal and the P2 terminal are not shorted.	Check the wiring of the P1 and P2 terminals
		A1F	Gr.1	Main Circuit Grounding Error	Short circuit between a motor phase and ground	Check for a short circuit between any of the 3 motor power output phases (U, V, W) and ground
Control Board Error		A20	Gr.2	Phase Loss	Low voltage detected on L1 or L2 or L3 for more than one second while the main power supply was on	Check if the three-phase power supply is connected to the drive properly. Check drive is configured to use the correct supply type (Check Pn007.1)
		A21	/	Reserved	Reserved	No information
		A22	/	Reserved	Reserved	No information
		A23	/	Reserved	Reserved	No information
		A24	Gr.1	Main Circuit Power Supply Wiring Error	The main circuit power supply wiring is incorrect	Check if the power supply (AC / DC) for the main circuit is consistent with the setup of the drive. Check Pn007.1

Alarm Category	Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
	A25	/	Reserved	Reserved	No information
	A26	/	Reserved	Reserved	No information
	A27	/	Reserved	Reserved	No information
	A28	/	Reserved	Reserved	No information
	A29		Unused	Unused	No information
	A2A		Unused	Unused	No information
	A2B		Unused	Unused	No information
	A2C		Unused	Unused	No information
	A2D		Unused	Unused	No information
	A2E		Unused	Unused	No information
	A2F		Unused	Unused	No information
	A30	Gr.2	STO Fault Detected	STO1 and STO2 in different states for more than 10 seconds	Check if the terminal wiring of STO is correct
	A31	Gr.1	STO Circuit Failure	A failure occurred in the STO circuit.	Contact TRIO or the Authorized Distributor
	A32		Reserved	Reserved	No information
	A33		Reserved	Reserved	No information
	A34		Reserved	Reserved	No information
	A35	Gr.2	Control Board Temperature Sensor Error	The temperature sensor on the control board is disconnected	Contact TRIO or the Authorized Distributor
	A36	Gr.2	Reserved	Reserved	No information
	A37	Gr.1	Display Panel Comms Error	Communication to the display panel has failed	Power cycle the drive. If the problem persists contact TRIO or the Authorized Distributor.
	A38		Unused	Unused	No information
	A39		Unused	Unused	No information
	A3A		Unused	Unused	No information
	A3B		Unused	Unused	No information
	A3C		Unused	Unused	No information
	A3D		Unused	Unused	No information
	A3E		Unused	Unused	No information
	A3F		Unused	Unused	No information
1st Encoder Error	A40		Reserved	Reserved	No information
	A41		Reserved	Reserved	No information
	A42	Gr.1	Power Mismatch	The selection or drive and motor is mismatched	Re-select the motor to match the drive
	A43	Gr.1	Encoder Type Error	The data stored in the encoder E2ROM is different from the data read from the internal of the encoder	Contact TRIO or the Authorized Distributor
	A44		Reserved	Reserved	No information
	A45	Gr.1	Multi-turn Data Error	There is a multi-turn data error in the encoder	Check encoder cable routing to reduce EMC effects. Check if the encoder battery is available. Try to reset the alarm using Motion Perfect, then power-cycle the drive

Alarm Category	Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
	A46	Gr.1	Multi-turn Data Overflow	The multi-turn data exceeded the limit value.	Check if the encoder battery is available. Try to reset the alarm using Motion Perfect, then power-cycle the drive
	A47	Gr.1	Encoder Battery V. Low	The battery power of the absolute encoder is lower than 2.45V	For new installations this alarm will need to be cleared after the first power up. If this occurs during normal operation the encoder may not operate correctly. Replace the battery
	A48	Gr.1	Encoder Battery Low	The battery power of the absolute encoder is lower than 3.1V.	For new installations this alarm will need to be cleared after the first power up. If this occurs during normal operation the encoder may not operate correctly. Replace the battery
	A49	Gr.1	Encoder Data Abnormal	There is an internal data error in the encoder.	Check if the encoder battery is fitted correctly. Try to reset the alarm using Motion Perfect, then power-cycle the drive
	A4A	Gr.2	Encoder Overtemperature	The internal temperature of the encoder has exceeded the limit	Reduce the motor load and/or improve the cooling environment
	A4B		Unused	Unused	No information
	A4C		Unused	Unused	No information
	A4D		Unused	Unused	No information
	A4E		Unused	Unused	No information
	A4F		Unused	Unused	No information
	A50	Gr.1	Encoder Disconnected	Connection to the encoder has been lost	Check encoder cable routing to reduce EMC effects. Check if the encoder cable is connected properly
	A51	Gr.1	Overspeed Detected	The encoder detected the motor has exceeded the maximum speed	Check if the encoder battery is fitted correctly. Reduce the motor speed.
	A52	Gr.1	Encoder Internal Error	Internal encoder error, either; code wheel contamination, damage, low encoder supply voltage or encoder aging	Power-cycle the drive and encoder
	A53	Gr.1	Single-turn Data Error	Internal encoder error	Power-cycle the drive and encoder
	A54	Gr.1	Encoder Comms Error	Communication to the encoder detected an in-correct CRC.	Power-cycle the drive and encoder
	A55		Reserved	Reserved	No information
	A56		Reserved	Reserved	No information
	A57		Reserved	Reserved	No information
	A58	Gr.1	Zone 1 Data Error	Incorrect or missing data for the phase of encoder zone 1	Replace the Motor.

Alarm Category	Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
	A59	Gr.1	Zone 2 Data Error	Incorrect or missing data for motor version and/or the phase of encoder zone 2	Replace the Motor.
	A5A		Unused	Unused	No information
	A5B		Unused	Unused	No information
	A5C		Unused	Unused	No information
	A5D		Unused	Unused	No information
	A5E		Unused	Unused	No information
	A5F		Unused	Unused	No information
	A60		Unused	Unused	No information
	A61		Unused	Unused	No information
	A62		Unused	Unused	No information
	A63		Unused	Unused	No information
	A64		Unused	Unused	No information
CAN Error	A65	Gr.1	Delta Target Position Overflow	The difference between two sequential target position exceeds the maximum value	Check position trajectory generation of the master
	A66	Gr.2	Reserved	Reserved	No information
	A67	Gr.2	Reserved	Reserved	No information
	A68	Gr.2	Reserved	Reserved	No information
	A69	Gr.2	Reserved	Reserved	No information
	A6A		Unused	Unused	No information
	A6B		Unused	Unused	No information
	A6C		Unused	Unused	No information
	A6D		Unused	Unused	No information
	A6E		Unused	Unused	No information
	A6F		Unused	Unused	No information
EtherCAT Error	A70	Gr.1	DC Sync Error	The period value set in EtherCAT master station is incorrect or SYNC0 is not synchronized with the drive	Check the distributed clock setting of the master station is compatible with the drive
	A71	Gr.1	SM Event Early	The synchronization operation of the Sync Manager (SM) Event was early	Check the setting of the master
	A72	Gr.1	SM Event Late	The synchronization operation of Sync Manager (SM) Event was late	Check the setting of the master
	A73	Gr.1	Reserved	Reserved	No information
	A74	Gr.1	Cubic Interpolation Error	An error has been detected by the cubic interpolation algorithm, which is equal to the DC synchronization period	Check if the setting of DC synchronization period is valid and non-zero
	A75	Gr.1	Sync Cycle Time Error	The DC synchronization period or the setting value of the interpolation object (60C2) is invalid	Check the setting of DC synchronization period is valid. Check the setting of interpolation object (0x60C2) is an integer multiple of 125us Check the setting of interpolation

Alarm Category	Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
					object (0x60C2) is an not is less than 125us
	A76	Gr.1	Invalid Acceleration For PP/PV Mode	Acceleration is zero in PP / PV mode	Modify the value of acceleration to a non-zero value See obejcts 0x6083, 0x6084, 0x6085
	A77	Gr.1	Sync Signal Lost	The network synchronization was lost	Check if network cable has been disconnected
	A78		Unused	Unused	No information
	A79		Unused	Unused	No information
	A7A		Unused	Unused	No information
	A7B		Unused	Unused	No information
	A7C		Unused	Unused	No information
	A7D		Unused	Unused	No information
	A7E		Unused	Unused	No information
	A7F		Unused	Unused	No information
Motor Protection Error	A80	/	Reserved	Reserved	No information
	A81	Gr.1	Motor Power (U, V, W) Wiring Error	The wiring of the motor power phases (U, V, W) is incorrect	Check if the motor power lines (U, V, and W phases) are connected properly
	A82	Gr.1	Motor Mismatched	The parameter data and encoder data describing the motor are inconsistent	This alarm is generated when the encoder data is used for zone 1 and the parameter data is used for zone 2 and the motor power set by parameter is not the same as the motor power in the encoder data. Check Pn895.0, Pn895.1, Pn807. If the encoder data is incorrect it may be necessary to replace the motor
	A83	Gr.1	Motor Running Error	Possible motor power wiring fault. The motor was driven in reverse	Check and correct the order of phases U, V, and W in the motor wiring. Check and determine the motor is not driven in the reverse direction. Set Pn521.2 to 1 to mask this alarm
	A84		Unused	Unused	No information
	A85		Unused	Unused	No information
	A86		Unused	Unused	No information
	A87		Unused	Unused	No information
	A88		Unused	Unused	No information
	A89		Unused	Unused	No information
	A8A		Unused	Unused	No information
	A8B		Unused	Unused	No information
	A8C		Unused	Unused	No information
	A8D		Unused	Unused	No information
	A8E		Unused	Unused	No information
	A8F		Unused	Unused	No information
2nd Encoder Error	A90	Gr.1	A Channel Disconnected	A channel of the 2nd encoder is disconnected	Check the wiring of the 2nd encoder. Check the setting of Pn210.

Alarm Category		Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
		A91	Gr.1	B Channel Disconnected	B channel of the 2nd encoder is disconnected	Check the wiring of the 2nd encoder. Check the setting of Pn210.
		A92	Gr.1	C Channel Disconnected	C channel of the 2nd encoder is disconnected	Check the wiring of the 2nd encoder. Check the setting of Pn210.
		A93	Gr.1	Encoder Communications Error	Communications between the 2nd encoder and the servo drive is not possible	Contact TRIO or the Authorized Distributor
		A94	Gr.1	Following Error Overflow	The following error limit set by Pn212 has been exceeded	Check the wiring of 2nd encoder. Check if the mechanical connection structure is loose, slippery or has a large gap. Check the settings of Pn210, Pn212, Pn213 and Pn214.
		A95		Unused	Unused	No information
		A96		Unused	Unused	No information
		A97		Unused	Unused	No information
		A98		Unused	Unused	No information
		A99		Unused	Unused	No information
		A9A		Unused	Unused	No information
		A9B		Unused	Unused	No information
		A9C		Unused	Unused	No information
		A9D		Unused	Unused	No information
		A9E		Unused	Unused	No information
		A9F		Unused	Unused	No information
		AA0		Unused	Unused	No information
		AA1		Unused	Unused	No information
		AA2		Unused	Unused	No information
		AA3		Unused	Unused	No information
		AA4		Unused	Unused	No information
		AA5		Unused	Unused	No information
		AA6		Unused	Unused	No information
		AA7		Unused	Unused	No information
		AA8		Unused	Unused	No information
		AA9		Unused	Unused	No information
		AAA		Unused	Unused	No information
		AAB		Unused	Unused	No information
		AAC		Unused	Unused	No information
		AAD		Unused	Unused	No information
		AAE		Unused	Unused	No information
		AAF		Unused	Unused	No information
		AB0		Unused	Unused	No information
		AB1		Unused	Unused	No information
		AB2		Unused	Unused	No information
		AB3		Unused	Unused	No information
		AB4		Unused	Unused	No information
		AB5		Unused	Unused	No information

Alarm Category		Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
		AB6		Unused	Unused	No information
		AB7		Unused	Unused	No information
		AB8		Unused	Unused	No information
		AB9		Unused	Unused	No information
		ABA		Unused	Unused	No information
		ABB		Unused	Unused	No information
		ABC		Unused	Unused	No information
		ABD		Unused	Unused	No information
		ABE		Unused	Unused	No information
		ABF		Unused	Unused	No information
		AC0		Unused	Unused	No information
		AC1		Unused	Unused	No information
		AC2		Unused	Unused	No information
		AC3		Unused	Unused	No information
		AC4		Unused	Unused	No information
		AC5		Unused	Unused	No information
		AC6		Unused	Unused	No information
		AC7		Unused	Unused	No information
		AC8		Unused	Unused	No information
		AC9		Unused	Unused	No information
		ACA		Unused	Unused	No information
		ACB		Unused	Unused	No information
		ACC		Unused	Unused	No information
		ACD		Unused	Unused	No information
		ACE		Unused	Unused	No information
		ACF		Unused	Unused	No information
Warning		AD0	Warning	Reserved	Reserved	No information
		AD1	Warning	Undervoltage Warning	The main circuit DC voltage is too low	Check if the main power input voltage is normal. Check if the power cable wiring of the Drive is correct
		AD2	Warning	Reserved	Reserved	No information
		AD3	Warning	Reserved	Reserved	No information
		AD4	Warning	Reserved	Reserved	No information
		AD5	Warning	Internal Fan Warning	The fan on the control board has not worked for 30 seconds.	Check the fan is not blocked. Contact TRIO or the Authorized Distributor.
		AD6	Warning	Reserved	Reserved	No information
		AD7		Unused	Unused	No information
		AD8		Unused	Unused	No information
		AD9		Unused	Unused	No information
		ADA		Unused	Unused	No information
		ADB		Unused	Unused	No information
		ADC		Unused	Unused	No information

Alarm Category		Alarm No. (hex)	Alarm Classifications	Name	Description	Trouble shooting tips
		ADD		Unused	Unused	No information
		ADE		Unused	Unused	No information
		ADF		Unused	Unused	No information
		AE0		Unused	Unused	No information
		AE1		Unused	Unused	No information
		AE2		Unused	Unused	No information
		AE3		Unused	Unused	No information
		AE4		Unused	Unused	No information
		AE5		Unused	Unused	No information
		AE6		Unused	Unused	No information
		AE7		Unused	Unused	No information
		AE8		Unused	Unused	No information
		AE9		Unused	Unused	No information
		AEA		Unused	Unused	No information
		AEB		Unused	Unused	No information
		AEC		Unused	Unused	No information
		AED		Unused	Unused	No information
		AEE		Unused	Unused	No information
		AEF		Unused	Unused	No information
Internal Error		AF0		Reserved	Reserved	No information
		AF1		Reserved	Reserved	No information
		AF2		Reserved	Reserved	No information
		AF3		Reserved	Reserved	No information
		AF4		Reserved	Reserved	No information
		AF5		Reserved	Reserved	No information
		AF6		Reserved	Reserved	No information
		AF7		Unused	Unused	No information
		AF8		Unused	Unused	No information
		AF9		Unused	Unused	No information
		AFA	Gr.2	Interrupt Overload	The time required to interrupt the operation exceeds the interruption period by 85%	Contact TRIO or the Authorized Distributor.
		AFB	Gr.2	CLA Overload	CLA runs for more than 85% of the interrupt period	Contact TRIO or the Authorized Distributor.
		AFC		Unused	Unused	No information
		AFD		Unused	Unused	No information
		AFE		Unused	Unused	No information
		AFF		Unused	Unused	No information

9.5 Power Dissipation Data

9.5.1 DX4-104AJA

CDM Absolute losses													
Type	**Nominal current** (A)	**Apparent power** (kVA)	**Absolute losses** (W)	**Operating points CDM (8)**								IE Class	Comparison %
				% of the rated speed of the motor			**% of the rated motor speed**			**90% of the rated speed of the motor**			
				25% Current Rating (0/25)	50% Rated Current (0/50)	100% rated current (0/100)	25% Current Rating (50/25)	50% Rated Current (50/50)	100% rated current (50/100)	50% current rating (90/50)	100% rated current (90/100)		
				Absolute losses (W)									
DX4-104AJA	2.9	0.9	8	10	14	22	10	13	24	15	29		

CDM Relative losses													
Type	**Nominal current** (A)	**Apparent power** (kVA)	**Absolute losses** (W)	**Operating points CDM (8)**								IE Class	Comparison %
				0% of the rated speed of the motor			**50% of the rated motor speed**			**90% of the rated speed of the motor**			
				25% Current Rating (0/25)	50% Rated Current (0/50)	100% rated current (0/100)	25% Current Rating (50/25)	50% Rated Current (50/50)	100% rated current (50/100)	50% current rating (90/50)	100% rated current (90/100)		
				Relative losses %									
DX4-104AJA	2.9	0.9	8	1.11%	1.56%	2.44%	1.11%	1.44%	2.67%	1.67%	3.22%		

Remarks:

1.The loss data applies to drive controllers without any accessories.

2.The power loss specifications refer to switching frequency at the default factory setting

Chapter 10 Revision History

Date	Version	Revised Contents
Mar, 2020	V0.01	First Draft.
Jun, 2020	V1.00	Added Motion Perfect and commissioning details
Jul, 2020	V1.01	Updated with comments from ETG
Jul, 2020	V1.02	Updated Object Dictionary table
Sep, 2020	V1.03	Update with single phase filter recommendation
Jan, 2021	V1.04	Added Pn details for re-gen resistor Added current for second encoder supply Corrected DOUT pin numbers in 3.2 Added TP wiring example
Jan, 2022	v1.05	Added current rating for digital outputs Corrected default for object 0x6072 (valid for firmware version 101.3+) Corrected TP polarity in table Added motor overload table Improved holding brake details
Jan, 2022	V1.06	Corrected TP polarity in connector details
Jul, 2022	V1.07	Added details on overload duty cycle (AB) Added example of brake relay circuit (AB) Added current table for brake (page 6-10, 6-11) (AB)
Oct, 2022	V1.08	Added Power Dissipation data (section 9.5) (RT)

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