Sumitomo Drive Technologies

smartris

smartris Servo Drive

<Note>

■ This product should be handled by only those who have been trained for the work.
Please read this manual carefully before use.
■ Deliver this manual to the customer who will actually use the product.
■ This instruction manual should be carefully stored.

Introduction: Safety Precautions

- Carefully read this maintenance manual and all accompanying documents before use (installation, operation, maintenance, inspection, etc.). Please use this product after thoroughly understanding the machine, information about safety, and all precautions for correct operation.
 After reading, retain this manual for future reference.
- Pay close attention to the "DANGER" and "CAUTION" warnings regarding safety and proper use.

⚠ **DANGER** Improper handling may result in physical damage, serious personal injury and / or death.

⚠ **CAUTION** Improper handling may result in physical damage and/ or personal injury.

Matters described in ⚠ CAUTION may lead to serious danger depending on the situation.
Be sure to observe important matters described herein.

⚠ DANGER

- Transport, installation, wiring, operation, maintenance, and inspections should be performed by trained technicians; otherwise, electric shock, injury, fire, or damage to the equipment may result.
- When the unit is to be used for the personnel transport vehicle, install a safety protecting device on the elevator side to prevent it from falling; otherwise, personal injury or damage to the equipment due to falling of hoisting equipment.

Introduction: Reading the Maintenance Manual, Table of Contents

This is the maintenance manual for the smartris servo drive unit.
For handling of motor and gear units, see the smartris Gearmotor Maintenance Manual (No. DM1801E).

Contents

Note: [RS-485 Modbus RTU Communication] is written as [Modbus Communication].

1. Overview

1-1 Purpose of This Document

This document describes the safe installation and operation of this product.
Please read it before using, and follow all safety warnings and cautions herein to ensure safe handling of this product.
Keep this document in a location where you can use it at any time.

⚠CAUTION
- This document is a maintenance manual for qualified persons who will use this product.

Only qualified persons should transport, wire, install, and operate this motor.
The contents of this document are subject to change without notice as a result of product improvements, etc.

1-2 Safety Precautions

Follow the safety procedures described in this document to ensure safe operation.
When operating this product and its peripheral devices, It is required to protect its operators and the surrounding area.

⚠CAUTION
- It is necessary to confirm that all system switches are working properly and that there are no warning indicators. - Before startup, check wiring and confirm that there is no damage to the drive unit. - Applying voltages other than those specified or reversed cable connections may cause faults in the drive unit. - Do not connect or disconnect cables while the power is on or during operation. - Operators are responsible for performing safe installations in compliance with any applicable laws and standards.

Note: Thoroughly read this document before performing installation.

This product contains parts that are sensitive to static electricity; improper handling may result in faults.
To prevent electrostatic faults, avoid contact with highly insulating plastic films and synthetic fibers.
Place this product on a conductive material and ground it to discharge static electricity.
Keep covers and control panels closed to avoid worker injury and product faults.

1. Overview

⚠DANGER
- Never connect or disconnect drive unit wiring when the power is ON; otherwise, faults or electro-cution due to arcing discharge may occur. - High voltage is applied to cables even when the motor is stopped. Never remove any cables. - When disconnecting power connections after turning the power off, wait at least one minute before touching the device, because capacitors and contacts will remain charged. We recommend using an instrument to measure voltage before touching the device.

⚠DANGER
- The drive unit surface can become dangerously hot. - Note that the heat sink and cables can also reach high temperatures.

⚠CAUTION
The following are cautions for avoiding personal injury and faults in the product and other devices. - Only apply DC power within the voltage specifications listed in this document. - When connecting power cables to this product, isolate it from dangerous high-voltage lines and use insulation that complies with safety standards. - Before operating this product, ensure it was installed according to the procedures in this manual. - Confirm proper operation before using the Safe Torque Off function. - If the device catches fire, never throw water directly on it to extinguish it.

⚠CAUTION
- This is information for confirmation to ensure normal operation and understanding of the prod-uct.

Safety checks must be performed for workers and devices according to the appropriate standards.

1. Overview

1-3 Warranty

This manual presents information that is guaranteed to prevent accidents due to faults or wiring tasks for this product.

Strictly adhere to the specifications described in this document and catalogs.

- Do not remove the cover from the main unit.
- Do not remove any warning labels.
- Modifications to the drive unit or its parts will void the warranty.

Also, faults due to failure to perform actions described in this Maintenance Manual will void the warranty.

See "11. Warranty" for details regarding the product warranty.

1-4 Power Source Specifications

Table 1-1 Power Source Specifications

Item	Description
Power supply voltage	48 Vdc (30 - 60 Vdc)
STO power supply voltage	24 Vdc (20 - 28 Vdc)

Note: Never connect power supplies with voltages exceeding specifications.
Supplying high voltage to the drive unit may result in faults in its internal parts.

1-5 Installation and Terminal Connections
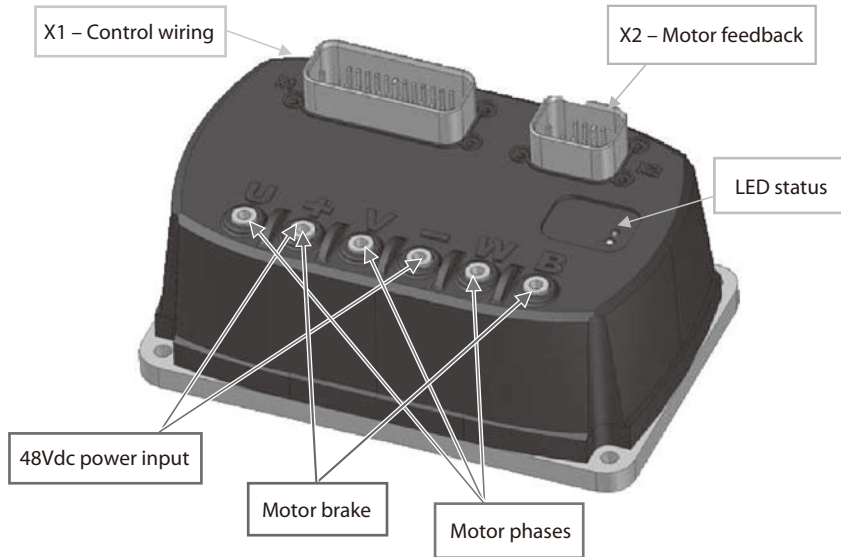
Fig. 1-1 Eternal Appearance of the smartris Servo Drive Unit

Table 1-2 Power Connections

Pin No.	Signal	Description
+	+VBUS	Connection to +VBUS (+48 Vdc)
—	-VBUS	Connection to –VBUS

Table 1-3 Motor Connections

Pin No.	Signal	Description
U	phase U	Motor phase U
V	phase V	Motor phase V
W	phase W	Motor phase W

Note: See "3-1 Power Cables" regarding recommended cables.
      Terminal: M6 screw, 7 N・m tightening torque

Table 1-4 Bake Connections

Pin No.	Signal	Description
+	+VBUS	"Brake+" and +VBUS connection
B	BRAKE	"Brake" and B connection

Note: Cable with 1 mm^2-AWG19 or higher is recommended

1. Overview

■ **X1 Connector Connections (Control Signals)**

Pin 1   Pin 12   Pin 24   Pin 35

Note: See "11. Cables (Optional)" regarding cables.

Table 1-5 X1 Connector Control Signals

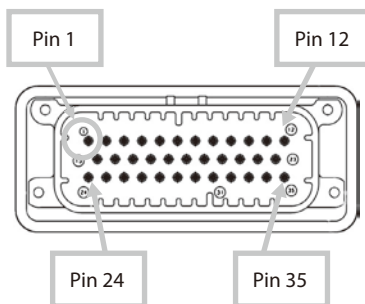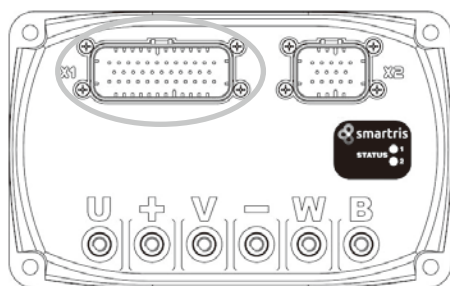| Pin No.	Signal	Description	Electrical Characteristics
1	0V24	GND (control board power)	-
2	COMMON	Digital input common	
3	IN1	Digital input: Reserved	
4	IN2	Digital input: Reserved	DC24V±20%
5	IN3	Digital input: Emergency stop	Input Impedance 3KΩ
6	IN4	Digital input: Reset	
7	TX/485+	TX232 signal/485+signal	
8	RX/485−	RX232 signal/485−signal	
9	485_T	120Ω terminal resistor 485 (connected to 485+)	-
10	GND_COM	GND (RS232 Serial communication)	
11	RET1	Safety relay1(output)	Max. DC30V 0.5A (contact)
12	STO1	Safety relay STO1 (input)	DC20~28V, 29mA (typ.)
13	GND_REF	GND (analog command)	-
14	REF−	Analog input−	Input DC±10V or 0 to 10V
15	REF+	Analog input+	
16	+10V	10Vdc output	Output DC10V±4%
17	OUTDAC	Analog output	Output DC0 to 10V
18	GND_DAC	GND (analog output)	Load Impedance 1kΩ or more
19	GND_CAN/GND_RS485	GND (CAN or Modbus communication) [Note:1]	
20	CAN_T/RS485_T	120Ω terminal resistor(connected to CAN_H or RS485+) [Note:1]	-
21	NC	-	
22	COM_RET	Common (RET1/RET2: output)	
23	STO2	Safety relay STO2 (input)	DC20~28V, 29mA (typ.)
24	24/48V	Control board power (input)	DC20~60V, 6W (typ.)
25	V_OUT	Digital output common	-
26	OUT1	Digital out1: Drive OK	
27	OUT2	Digital out1: Drive warning	DC24V±20%
28	OUT3	Digital out1: Reserved	
29	OUT4	Digital out1: Brake status (release/operation) [Note:2]	
30	CAN_L/RS485−	Connected to CAN_L or RS485− [Note:1]	
31	CAN_H/RS485+	Connected to CAN_H or RS485+ [Note:1]	-
32/33	NC		
34	RET2	Safety relay2 (output)	Max. DC30V 0.5A (contact)
35	STO_COM	Common (STO1/STO2: input)	-

Notes: 1. CANopen or Modbus communication can be used this product.
        Check the drive model that communication can be used. See 10-2 Nameplate and codes.
    2. Valid if the brake is connected.

■ **X2 Connector Connections (for Feedback)**
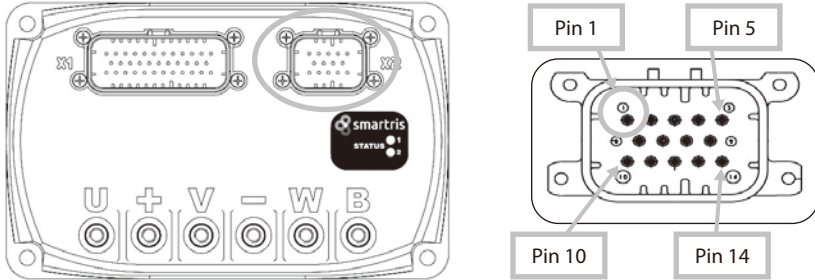
Table 1-6 X2 Connector, Feedback Signals

Pin No.	Resolver	Absolute encoder
1	S2 (SIN+)	SIN
6	S4 (SIN-)	REFSIN
2	S1 (COS+)	COS
7	S3 (COS-)	REFCOS
3	R1 (REF+)	DATA+
8	R2 (REF-)	DATA-
10	-	+8V
11	-	GND
4	-	-
9	-	-
14	-	-
5	SCH	SCH
12	NTC1a	NTC1a
13	NTC1b	NTC1b

Note: See "10. Cables (Optional)" regarding cables.

⚠DANGER

The following are precautions for avoiding injury and risk of death due to improper use.

■ Avoid ground loops in wiring for control devices.

- When connecting the PC, the encoder, switches, actuators, etc., to the control connector, never connect ground (pins 1, 10, 13, 18, 19) and battery negative (–) terminals.
  Never disconnect the battery negative (–) terminal while the battery positive (+) terminal is connected to the drive unit. Excess current flows from the ground pin, so disconnecting a wire or connector can result in damage or faults to controllers and peripherals.
- The controller connector grounds (pins 1, 10, 13, 18, 19) are connected to drive unit by internal negative (–) terminals.
- Be sure to connect battery negative (–) terminals in controller ground wiring.
- Do not use power ground cables for connectors and switches.
- Shield external I/O signals to prevent effects from main power.

1. Overview

■ **Connection Example**
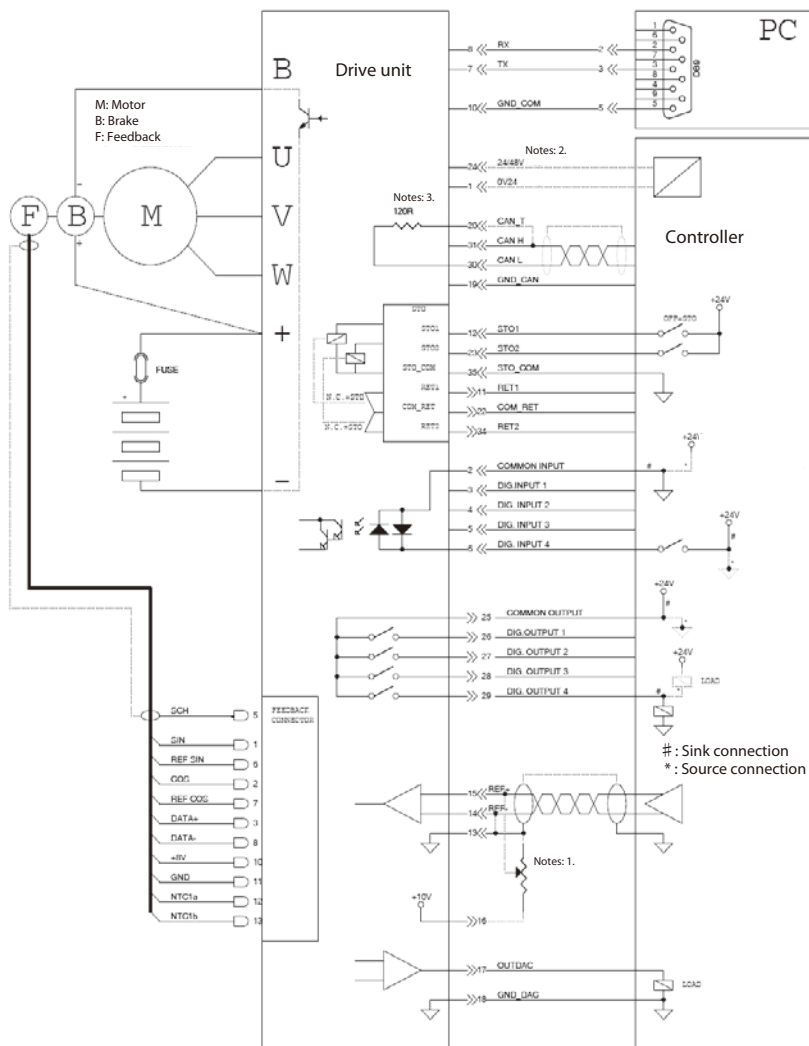
Notes: 1. The potentiometer connections
   2. Backup power supply for logic
   3. CAN terminal connection: Pin 20 and Pin 31 (CAN H signal)

Fig. 1-2 Connection Example for Drive Unit and Controller

1-6 Ambient Conditions

This product must be installed in appropriate ambient conditions to ensure safe operation.

Faults due to modifications or inappropriate storage conditions will void the product warranty.

Keep the device covered for protection from dust, metal filings, water, oil, etc.

Item	Details
Ambient temperature IEC60068-2-2	-10 °C - 40 °C
Ambient humidity	≤85% RH, no condensation
Altitude	Altitude: 1000 m max.
Protection class	IP54
Contamination level	2(EN 2, 61800, EN61800-5-1)

Storage	Details
Storage temperature	-10 °C - 70 °C
Storage humidity	≤90% RH, no condensation

1-7 Certification

(1) CE Compliance

This product is certified for the conformance with the following EC Directives by Certification Bodies.

- EMC Directive (2014/30/EU)

- RoHS Directive (2011/65/EU)

- WEEE Directive (2012/19/UE)

(2) Safety

This product is compliant with the following EN safety standards:

- **EN 61800-5-1**: Adjustable speed electrical power drive systems - Part 5-1: Safety requirements – Electrical, thermal and energy.

(3) EMC Requirements

This product satisfies category requirements for emission and immunity conditions for "type-2 environments" (industrial environments).

- **EN 61800-3**: Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods.

1. Overview

(4) Safety Conformity (STO)

This product is equipped with two-channel Safe Torque Off (STO) input compliant with safety functions. (Optional)

This function halts PWM output and safely stops torque of the drive unit.

The circuit designs have been tested and certified by TÜV SÜD.

The STO safety function for circuit designs in this product are compliant with the following EN standards:

- **EN61508**: Functional safety of electrical/electronic/programmable electronic safety-related systems
- **EN61800-5-2** and category: Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional
- **EN ISO 13849-1:2015**: Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design.

Subsystems include safety conditions with the following characteristics:

EN 13849-1	EN 61508	PFHD [1/h]
PLe	SIL3	-

(5) Ambient Conditions for Vibration and Shock

The drive unit satisfies the following specifications:
- Vibration: DIN EN 60068-2-6:2008
- Vibration frequency range: 10–150 Hz
- Acceleration: 5G

1-8 Motor and Circuit Protection

There is no need for connecting a thermal relay for motor protection. Overload protection is possible with the I²t function (electronic thermal).

Protection function parameters are as follows:
- Nominal current
- Peak current
- Overload

Nominal current and peak current are motor characteristics. The overload time is the initial value due to the load and motor, but can be set programmatically.

Drive behavior after the overload time has elapsed can be set as follows:
- Occurrence of overload alarms
- Operation under peak nominal current

The motor's temperature sensor has a function for protecting the motor from overheating.

In that case, drive operation can be set as follows:
- Even with the sensor detecting temperatures above the threshold, continue operation until the motor overheat alarm.
- It is possible to read sensor temperature values and reduce the load or speed to lower the motor temperature.

Drive Output Current

Model No.	Nominal Current	Peak Current (2sec)
AG110D4-A60##	11.5A	41.7A
AG110D4-1A5##	25.8A	96.3A
AG110D4-2A0##	35.8A	136.2A

1-9 Startup

EMC directives forbid startup before confirmation that this product was installed in compliance with EC Directive standards.

Also, standards for machinery directives (2006/42/EC) and EMC directives (2014/30/EU) prohibit application and operation of this product with incompatible mechanical systems.

Machine and system manufacturers must ensure EMC thresholds satisfying the requirements of EMC standards.

(1) Proper Usage

This product can be applied to drive synchronous servo motors using permanent magnets
(servo motors compatible with machine and system feedback systems).

This product is certified for use in industrial applications. Note that its use in residential areas requires additional EMC countermeasures.

The customer will need to prepare a risk analysis for the final product.

⚠CAUTION

- Customers planning use for nonindustrial applications must first obtain our approval.

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(2) Inappropriate Uses

This product is incompatible with motors other than synchronous servo motors. It also cannot be used in motors incompatible with feedback systems.

Note that installation in areas presenting the danger of flammable materials, flammable gases, dust, etc., can result in fire or explosion.

Do not install the drive unit or gearmotor of this product in such environments.

1-10 Location of Installation

Install this Protection Standard IP54 product in a place where it can operate reliably.

It must be installed in a location conforming to IP54 class or higher protective structures.

1-11 Maintenance

Perform periodic maintenance and inspections to ensure that the drive unit is free of abnormal appearances, dust adhesion, and loose connectors or terminals.

Disassembling this product will void its warranty. When disassembling, safety functions corresponding to standards are not guaranteed.

2. Dimensions

2-1 Dimensions

84.25

9
60

4-Ø6.4

116

168.3

98.3

34.65

116.7

(34.65)

186

186

72

U
+
V
−
W
B

X1

X2

smartris

116

69

69

69

84.25 (with plug)

Unit: mm Mass: 1.6kg

14
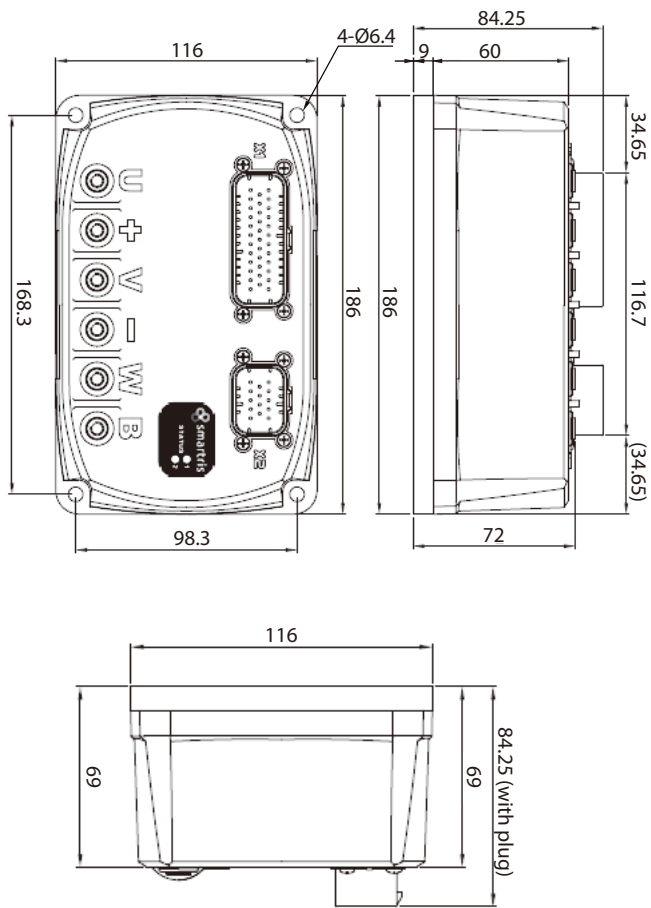
2-2 Installation

Safety Precautions
- Install the drive unit inside a control panel to prevent humidity, water droplets, and metal dust.
- Before installation, confirm that the drive unit is not damaged.
- Ensure sufficient ventilation within the control panel.
- Do not operate the drive unit if condensation generates.

2-3 Wiring Precautions

Safety Precautions

> ⚠ **CAUTION**
>
> - Ensure that the system is displaying no alarms to confirm safety.
> - Before operation, check that the wiring with the drive unit is correct and theses cables have no damage.
>   Before operation, confirm there are no problems with the drive unit and wiring.
> - Non-specification voltages, reversed polarity of connections, improper wiring, etc., can result in drive unit faults or damage.
> - Improper protection against excess power can result in damage to the drive unit or wiring.
> - See "5. STO Safety Function (Optional)."

2-4 Power Adapters and Supplied Voltage

24V for STO logic and 48Vdc power supply must supply constant voltage.

> ⚠ **CAUTION**
>
> - Using power adapters that do not conform to SELV/PELV designs can produce dangerously high voltages that may result in injury or death.

48 Vdc power adapters must allow regeneration up to 60 Vdc during motor regeneration operation. Power adapters must be designed to accommodate the above regeneration operation.

3. Technical Data

3-1 Power Cables

The table below shows an example of cable size selection for wiring to the servo motor and power supply.

Table 3-1 Example of Power Cable Selection

AGV load (kg)	Motor output (W)	Power source cable (mm^2) - AWG	Protective fuse (A)
600	430	2.5 - AWG14	25
1000	600	4 - AWG12	50
1500	1000		
1500	1000	6 - AWG10	100
2500	1500		

Note: Power supply voltage is 48 Vdc (max. 60 Vdc)

Cables in the table are reference examples. Applicable to Lafert or similar servo motors.

■ This document is applicable to the following feedback.
・Resolver
・Absolute encoder

4. Operation Mode Functions

4-1 Communication Mode

The open network CANopen or Modbus communication can be used this product.

Check the drive model that communication can be used. (See 10-2 Nameplate and codes)

See CANopen Communication Manual (No.DM1803E) or Modbus Communication Manual (No. DM1804E).

The following chapter is written using CANopen communication as an example.

4-2 Motor Brake

Motor brake operates by being supplied power of the drive.

The DIG-OUT4 (digital output 4) signal operates the brake relay.

(The relay requires external power.)

The brake can be set to automatic or manual.

- Automatic mode: Inputting the RUN/Enable operation command allows automatic brake release.
  Brake power (+24 V)
- Manual mode: The brake release command can be issued by CANopen communication or a parameter.
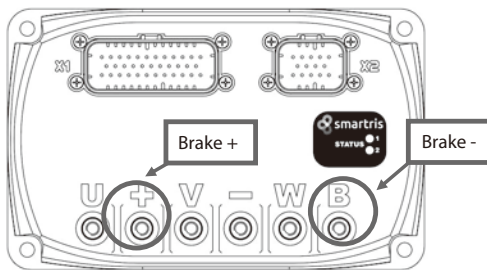
■ Automatic Mode
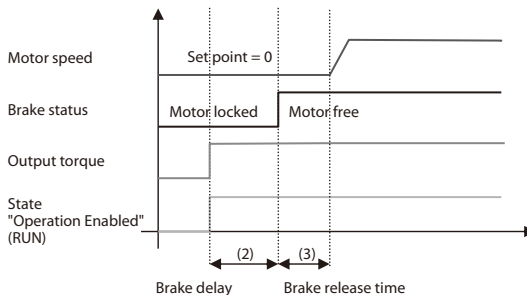
Fig. 4-1 Automatic Brake Operation

4. Operation Mode Functions

■ **Manual Mode**

In CANopen mode, set bit 1 of 60FEh (subindex 1).
• Set brake [60FEh (subindex 1), bit 0] = 1 for brake release.

(1) Standby to Operation Phase (STBY → RUN)

In STBY, the brake is released and the motor is locked.

During the time set by Delay 1, the motor is in the stop status even if the RUN signal is input.

Even after the Delay 1 time elapses and the brake is released, the motor remains stopped for the time set by Delay 2.

After the Delay 2 time, RUN mode starts and the motor reaches the set speed.

Even when the motor is stopped, stall torque (retention torque) is generated.

Note: Brake delay time is the time from issuance of the brake release command to motor lock release.
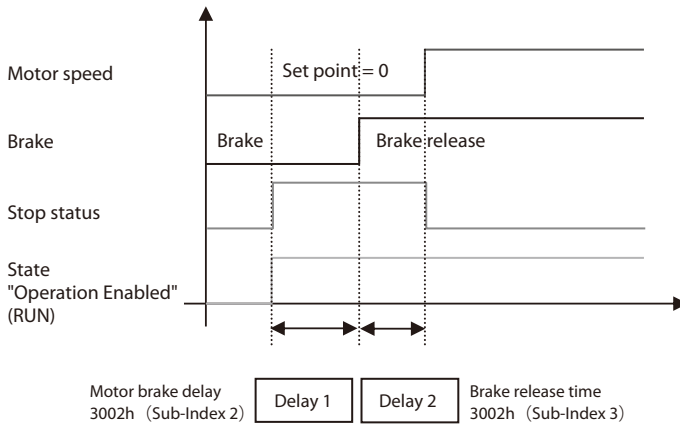
Fig. 4-2 Automatic Brake Delay Time

(2) Phases from Operation to Standby (RUN → STBY)

In the RUN state, the brake is released. When halting, stop operation differs according to whether dynamic brake is enabled, as shown in the figure below.
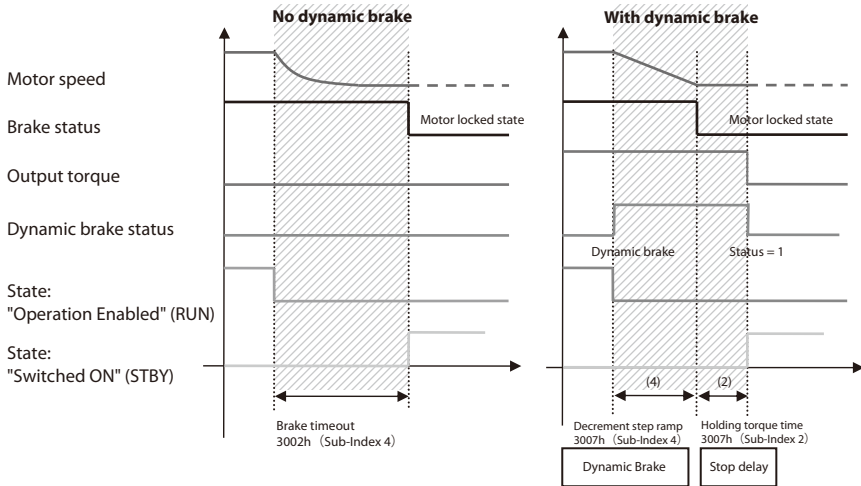
Fig. 4-3 Dynamic Brake

The motor decelerates at the free run speed without dynamic brake.

The brake locks the motor when the speed reaches zero, or when the deceleration time exceeds the set brake timeout time.

If there is the function of dynamic brake, deceleration occurs in the time set in the dynamic brake parameters.

After ramp deceleration completes, the brake's locking the motor, and the motor's stopping with the delay time set in the dynamic brake parameters, the drive unit turns to be STBY mode.

4. Operation Mode Functions

4-3 Digital I/O

The following digital I/O are available.
・Digital input 4: **DIG-INx**
・Digital input 4: **DIG-OUTx**
・Safety digital input 2: **DIG- STO**

(1) Digital Input

This is an analog mode for operating the motor by using two digital inputs.
・**DIG-IN1** : reserved
・**DIG-IN2** : reserved

DIG-IN3 can be programmed as "**Enable Input Emergency**."
In this case, DIG-IN3 is used for transition from RUN to STANDBY in an emergency with dynamic brake.

This function is enabled through the following settings:
• CANopen: Set object 0x3008h (Emergency Input Enable) subindex 1.

Logic for dynamic brake input (DIG-IN3) can be selected.
• CANopen: Set object 0x3008h (Emergency Input Enable) subindex 2.

DIG-IN4 resets the drive unit hardware.

(2) Digital Input, Safety STO

DIG-STO : STO input is shown in the following circuits.
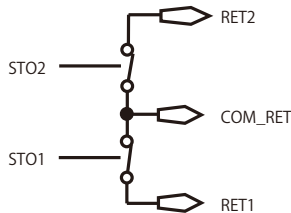
Fig. 4-4 STO Output Feedback Relay

If the application requires deceleration and stop (controlled deceleration and stop) before use of the STO function, first perform deceleration and stop operation, then activate the STO function after stop.
1. Drive deceleration and stop operation
2. In the case of stop state, disable the drive unit.
3. If there is a suspended load, mechanically lock the drive as well.
4. Activate the STO function.

> **⚠ CAUTION**
>
> The drive unit cannot generate torque when the STO function operates, so load cannot be maintained.
> - When the STO function is operated during driving, the drive unit stops without control.
> - If the drive unit has an STO function, it is necessary to confirm that all circuits for the drive unit are correct in addition to function settings for it.

■ STO 2 Input Feedback

Feedback signals for each STO input can be monitored by two-channel relay output (RET1, RET2).
The status of STO commands can be monitored by output from each relay. (Safety functions can be completely monitored.)
The state of digital input can be read with CANopen DSP402 (60FDh: Sub-Index 0)

(3) Digital Output

DIG-OUT1: Indicates the drive state.
• 1 = Drive OK
• 0 = Drive fault
DIG-OUT2 : Indicates the drive warning.
• 1 = There is a warning activate.
• 0 = No waring.
DIG-OUT3 : Reserved.
DIG-OUT4 : Indicates the brake status.
• 1 = Brake release, motor shaft free.
• 0 = Brake operation, motor lock

CANopen DSP402: 0x60FE can can be read with the status of digital output.

4. Operation Mode Functions

4-4 Torque Limit (Add from FW Ver.2.0.1) ^{NOTE}

It is possible to set a torque limit to set the configured maximum torque in the motor. The value shall be given percent of rated current.

Setting value for peak current (0x3003:2) is depend on the drive model.

Model No.	Peak Current
AG110D4-A60##	41.7A
AG110D4-1A5##	96.3A
AG110D4-2A0##	136.2A

while in CANopen there are different values of maximum torque:

· Positive takes effect in the case of motive operation is positive velocity or regenerative operation is negative velocity.

· Negative torque takes effect in the case of motive operation is negative velocity or regenerative operation is positive velocity

The default value of torque limit is 100% and modifies can't be saved in EEPROM memory but it can be saved in RAM.

⚠WARNING

· This object is controlled by some limits of drive. If the value is not correct the drive sends an Abort Code. If the value is not correct during initialization the drive sends an error messages with Emergency Protocol. See Error Code 0x8B23. The range is [1 to 100] %.

· The setting value of torque limit returns to 100% (default value) when the power is turned off. It is not saved in EEPROM.

4-5 Overload Management (I²T) (Add from FW Ver.2.0.1) ^{NOTE}

The smartris drive uses the I²t protection method to prevent motor winding and insulation damage caused by high motor temperature due to motor excessive work.

The I²t algorithm evaluates the motor dissipating heat without any sensor. When the evaluated temperature exceeds the maximum, I²t algorithm protects the motor placing the drive in Fault Overload

The I²t principal algorithm calculation is as follows:

$$I^2T = (I_p^2 - I_n^2) * T_p$$

I_p: Motor peak current (rms)

I_n: Motor nominal current (rms)

T_p: Motor peak current time in seconds
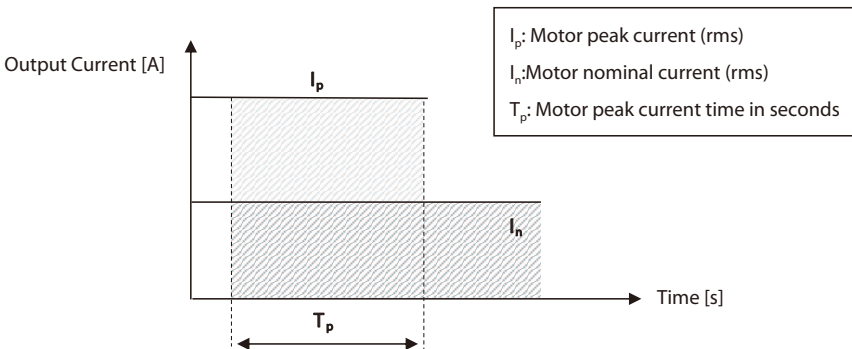
Fig.4-5 Overload Management I2T

Note: FW ver. is listed in the nameplate. See 10-2 Nameplate and codes.

The smartris drive manage also 2 kind of Overload:
· Overload at low speed (default 30 rpm - settable only by manufacturer)
· Protection to Overload close events

4.5.1 Overload at low speed
In smartris drive there is a function to modify the Overload function depending by speed.
Under a specific value the Energy is reduced. This means that at low speed the I^2t time is reducing to half and the Rated Current is around 70% of the standard.
At normal speed there is no effect.
It is possible with CANopen DSP402 read the status with the bit 11 of statusword (0x6041 object).
During the limitation there is emergency message that describes when the drive is in Warning Limitation i^2t for Overload (error code 0x2351) and in alarm (error code 0x2350).

4.5.2 Overload with closer events
There is a function that prevent the drive goes to Run if numerous close I^2t events have occurred.
After 2 consecutive Fault Overload Events it is necessary to wait one minute before enabling the drive, otherwise the drive will go into Fault I^2t Overload Protection (LED status code 5,2).
When re-enabling the drive, reset after unlocking the interlock.
It is possible with CANopen DSP402 read the alarm (error code 0x2352).

5. STO Safety Function (Optional)

Safety circuits include safety functions based on IEC 61800-5-2.

The STO module conforms to uncontrolled stop in "Stop category 0: IEC 60204-1," shutting off torque output.

5-1 STO (Safe Torque Off)

In the STO state, power for the motor to generate torque is not supplied.
The motor therefore cannot rotate.

Notes: 1. This safety function is compatible with uncontrolled stop.
2. Use this function when required to shut off output to prevent unexpected start-up.
3. In the presence of external influences (falling due to suspended load, etc.), it is necessary to use an additional measures (a mechanical brake, etc.) to prevent danger.

(1) STO Connections
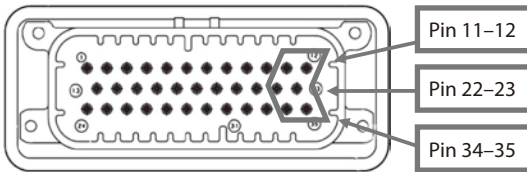
Table 5-1 I/O signals (AGV)

Pin No.	Signal	Description
11	RET1	Safety relay 1 (output)
12	STO1	Safety relay STO1 (input)
22	COM_RET	Common (RET1/RET2: output)
23	STO2	Safety relay STO2 (input)
34	RET2	Safety relay 2 (output)
35	STO_COM	Common (STO1/STO2: input)

5-2 Hardware Specifications

• STO input: STO1, STO2 (common: STO_COM)
• Relay output: RET1, RET2 (common: COM_RET)

Table 5-2 STO Input Specifications

STO Input	Data
STO Inactive status (normal operation) input voltage	20 - 28 Vdc
STO Active (SAFETY) input voltage	< 2.4 Vdc
Input current	29 mA
Active response time (time from normal to STO operation)	10 ms
RET1, RET2 connection specifications (Max. voltage/current for contact)	30 V/0.5 A

5. STO Safety Function (Optional)

Table 5-3 I/O Relay Operation

Input 1	Input 2	Output 1	Output 2	Output Status
STO1	STO2	RET1	RET2	Status
0 V	0 V	Closed	Closed	Safety
24V		Open		
0V	24V	Closed	Open	
24V		Open		Normal mode

■ If either STO1 or STO2 is 0 V, safety mode (zero torque) operates.
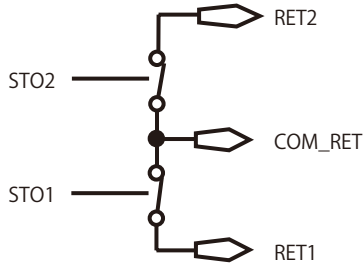
Fig. 5-1 STO Output Feedback Relay

5-3 Software Specifications

Safety procedure: RUN → STANDBY → SAFETY

Recovering from SAFETY to STANDBY mode requires setting STO and RUN to reactive.

The recovery procedure is as follows.

• In CANopen mode: SAFETY → SWITCH ON DISABLED

           → READY TO SWITCH ON → SWITCH ON

           → OPERATION ENABLED
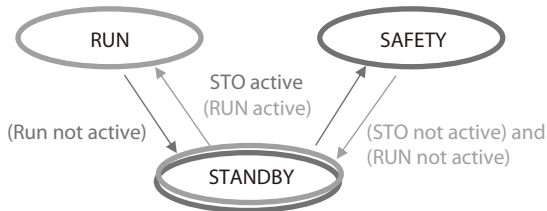
Fig. 5-2 STO State Machine

5. STO Safety Function (Optional)

5-4 Safe Operation Sequence Procedure

If deceleration and stop (controlled deceleration and stopping) is required before using the STO function, first perform deceleration and stop operation, then operate the STO function.

1. Drive deceleration and stop operation.

2. In the case of stop state, disable the drive unit.

3. If there is a suspended load, mechanically lock the drive as well.

4. Activate the STO function.

⚠CAUTION

The drive unit cannot generate torque when the STO function operates, so load cannot be maintained.

- When the STO function is operated during driving, the drive unit stops without control.

5-5 Example of Schematic Application
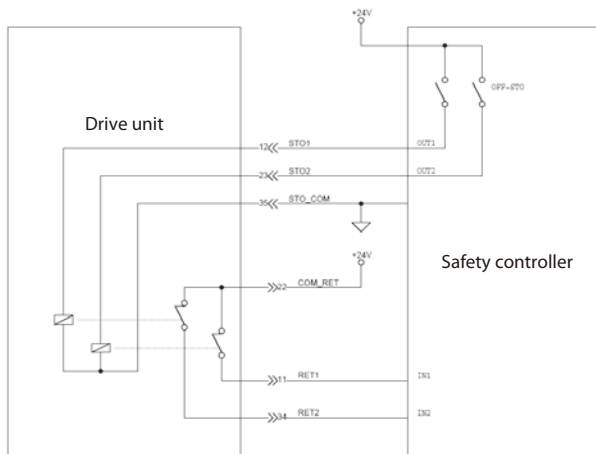
Fig. 5-3 STO Application Example

■ STO 2 Input Feedback

Feedback signals for each STO input can be monitored by two-channel relay output (RET1, RET2).

The status of STO commands can be monitored by output from each relay. (Safety functions can be completely monitored.)

The state of digital input can be read with CANopen DSP402 (60FDh: Sub-Index 0)

5-6 Function Check

The STO function should be confirmed on first startup after system wiring or parts replacement.

Please confirm that STO circuits are functioning correctly every six months.

6. CANopen Communication

6-1 CANopen Network Topology
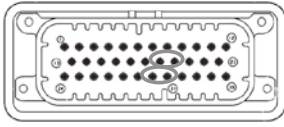
Table 6-1 CANopen Signals

Pin No.	Signal	Description
19	GND_CAN/GND_RS485	GND (CANopen or RS485 Modbus)
20	CAN_T/RS485_T	Termination resistor 120Ω (Connection for CAN_H/RS485+)
30	CAN_L/RS485-	Connection for CAN_L or RS485-
31	CAN_H/RS485+	Connection for CAN_H or RS485+
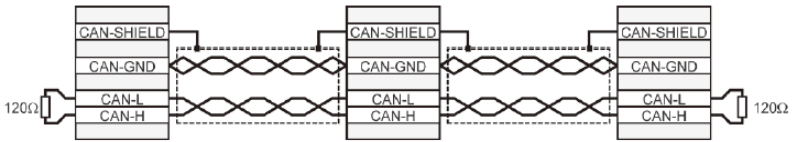
Connector X1

Fig. 6-1 CANopen Wiring

The two ends of the CAN cables have to be terminated by a resistor of 120Ω.

The CAN bus can be closed with a resistance terminator into to the drive using Pin 20. The CAN_T pin has to connect to CAN_H pin on Connector X1.

6-2 CANopen Bitrate and Node ID

Compliance with CiA DS301 v4.02 and DSP402 v2.0 directives.

• CANopen baudrate: 50K,125K, 250K, 500K, 800K, 1000K (initial setting: 1000Kb)

• Node ID (initial setting: 1)

6. CANopen Communication

6-3 CANopen Overview

Features

- TPDO 7, RPDO 7, event timer, access unit 8 bits
- Heartbeat, node guarding
- Baudrate setting: 50K, 125K, 250K, 500K, 800K, 1000K (initial setting: 500K)
- Enable input (standby mode at L-level input, switch ON disabled).
- Node ID setting (default: ID1)
- Parameters are stored in nonvolatile memory (communication + manufacturer name + device profile)
- Load initial CANopen parameter value from ROM by command.

Compliance with CiA DS301 v4.02 and DSP402 v2.0 directives.

See "CiA DS301 Standards" for additional information.

■ Reference Materials

- CANopen Manual (No.DM1803E)
- CiA 301 (310_1v01010005_cor.pdf)
- CiA 402 (CiA® 402 Draft Standard Proposal.pdf)

(1) Object 6040h: Controlword

This object is used in CiA-402 FSA and CiA-402 modes and for control of manufacturer-specific entities. Controlword comprise the following bits.

15		11	10	9	8	7	6	5	4	3	2	1	0
ms			r	oms	h	fr		oms		eo	qs	ev	so

MSB   LSB

ms: manufacturer-specific	h: halt	qs: quick-stop
r: reserved	fr: fault reset	ev: enable voltage
oms: operation mode specific	eo: enable operation	so: switch ON

Command	Controlword Bits					Transition
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	X	1	1	0	2, 6, 8
Switch ON	0	0	1	1	1	3
Switch ON + operation enabled	0	1	1	1	1	3 + 4 Note)
Voltage disabled	0	X	X	0	X	7, 9, 10, 12
Quick stop	0	X	0	1	X	7, 10, 11
Operation disabled	0	0	1	1	1	5
Operation enabled	0	1	1	1	1	4, 16
Fault reset	⤒	X	X	X	X	15

Note: After performing switch ON, operation automatically transfers to enabled. This transition interval requires 20 ms or more.

- Bits 9, 6, 5, 4: Operation mode specific
- Bit 8 (halt function): This is an operation mode specific function.
  At bit 1 commands are interrupted and drive unit execution halts at the defined option code. After canceling the stop function, the command operation continues.
- Bit 10 (reserved): Please set to 0.
- Bit 11 (manufacturer-specific, warning recognition): Setting to 1 clears the statusword warning bit.
- Bits 12, 13, 14, 15 (manufacturer-specific): Not used

(2) Object 6041h: Statusword

This object indicates the current FSA status. There are operation mode and manufacturer-specific bits.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ms		oms		ita	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso

MSB   LSB

Bit	Description	M/O
0	Ready to switch ON	M
1	Switched ON	
2	Operation enabled	
3	Fault	
4	Voltage enabled	
5	Quick stop	
6	Switch ON disabled	
7	Warning	O
8	Manufacturer-specific	
9	Remote	M
10	Target reached	
11	Internal limit operation	
12 - 13	Operation mode specific	O
14 - 15	Manufacturer-specific	

- Bit 4 (voltage enabled): 1 indicates that high voltage is supplied to the drive unit.
- Bit 5 (quick stop): 0 indicates on a quick stop request.
- Bit 7 (warning): 1 indicates that a warning status occurs.
  Note that warnings are not errors or faults (ex: temperature increase, job halt, etc.) The drive unit FSA status therefore does not change.
  Warning definitions can be read from the warning parameter object (2003h).
- Bit 10 (target reached): 1 indicates that the target reached its set value.
  The set value is operation mode specific, and defined in clauses corresponding to some of the profile specifications.
  Bit 10 is set to 1 when the operation mode changes.
  This bit changes on software updates of target value.
- Bit 11 (internal limit active): 1 indicates that the internal limit functions.
- Bits 12, 13: Operation mode specific (depends on profile set).
- Bit 14 (manufacturer specific: safety): 1 indicates that the drive unit is in safety mode.
- Bit 15 (manufacturer specific: fault): 1 indicates that the drive unit faults.

6. CANopen Communication

(3) Object 6060h: Mode of Operation

This object can be used to set operation modes and
shows value for required operation modes. Actual operation modes are reflected in the Modes_of_operation_display object.

Bit definitions are as follows.

Bit	Description	Access
0	No mode change/No mode assignment	
1	Profile position mode (Coming soon)	
2	Reserved	
3	Profile velocity mode	rw
4	Torque profile mode	
5 to 10	Reserved	
-1	Manufacturer specifications	

Usable operation modes
• Mode 3: Profile velocity mode
• Mode 4: Profile torque mode

Note: When setting measurement unit conversion, see chapter 8.

(4) Object 6061h: Mode of Operation Display

This object defines the actual operation mode.

Object description

Index	Object Code	Data Type	Category
6061h	VAR	Integer 8	Mandatory

Entry description

Subindex	Access	PDO Mapping	Value Range	Default Value	Unit
00h	ro	YES (default)	-128 - 10	-	-

Bit definitions are as follows.

Bit	Description	Access
0	No mode change/No mode assignment	
1	Profile position mode (Coming soon)	
2	Reserved	
3	Profile velocity mode	ro
4	Profile torque mode	
5 to 10	Reserved	
-1	Manufacturer specifications	

■ **Control Composition in Profile Velocity Mode**
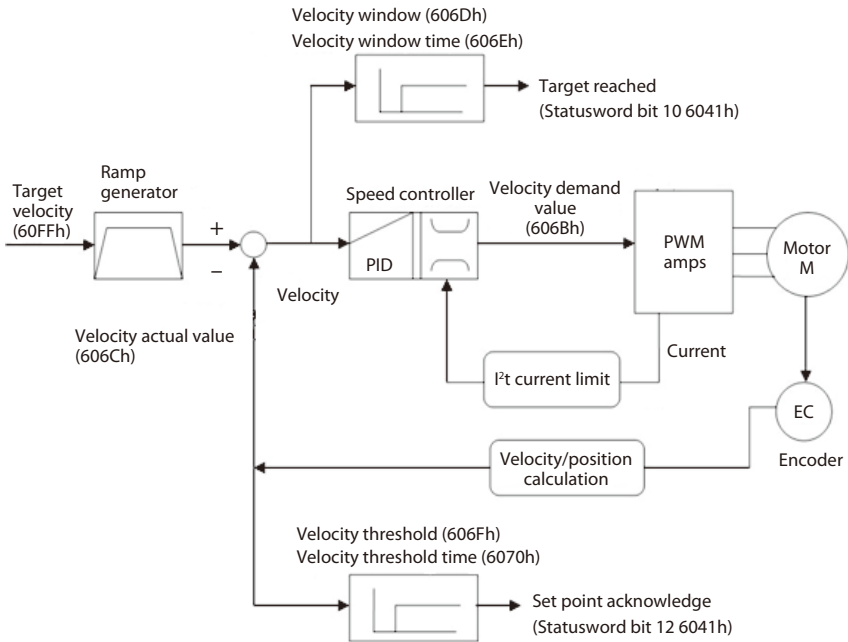
Fig. 6-2 Control Composition in Profile Velocity Mode

6. CANopen Communication
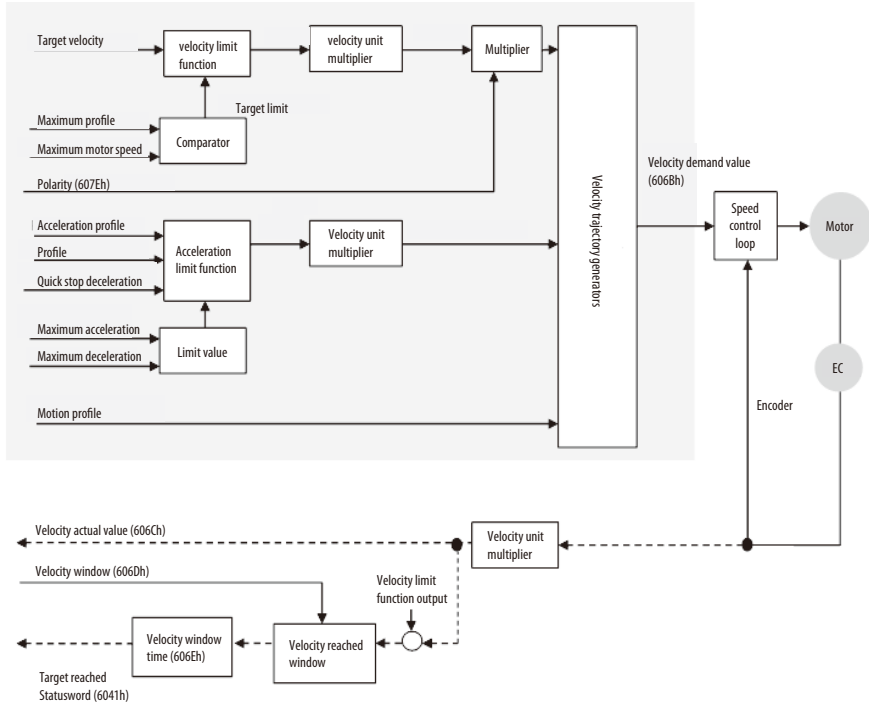
Fig. 6-3 Speed Control Composition

■ **Profile Velocity Mode (3)**

In profile velocity mode, profile movement is defined according to velocity and acceleration/deceleration commands.

Start velocity control profile:

(1) Writing object 6060h = By inputting 3, the drive unit moves to the operation mode of profile velocity mode.

(2) Operation enabled

(3) Set acceleration and deceleration in objects 6083/6084h, respectively.

(4) Operation starts when the target velocity is set in Object 60FFh.

To start operation, clear bit 8 in object 6040h.

The target velocity can be changed during operation. Operation stops when any of the following conditions are satisfied:

・ The target velocity is set to zero.

・ The Halt command is issued.

・ An error occurs.

■ **Profile Velocity Characteristics**
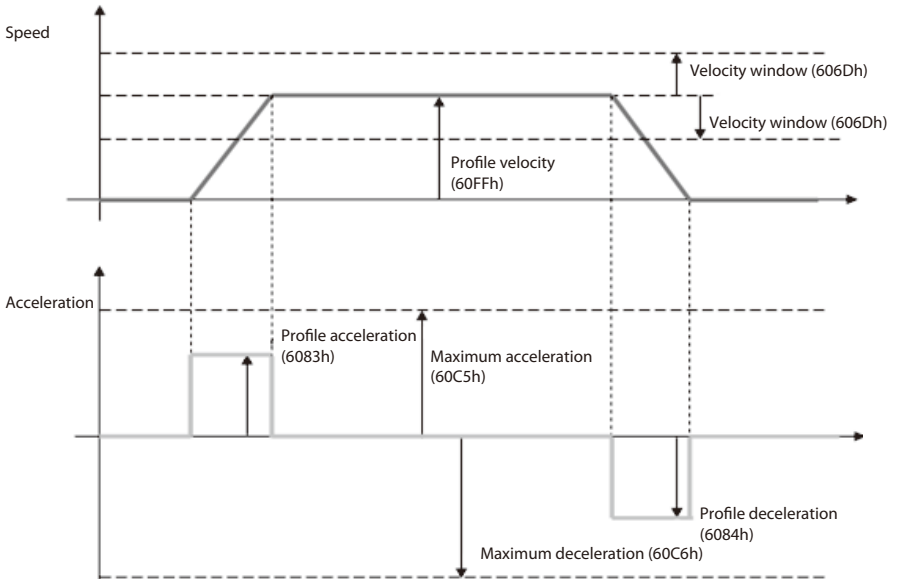
Fig. 6-4 Profile Velocity Characteristics

6. CANopen Communication

■ **Run Sequence**

(1) Power switch ON

(2) Verify LED status 1, 2 initial state (INIT mode)

(3) Configure profile velocity: 0x6060 → 0x03

(4) **Ready to switch ON** setting: Controlword write 0x6040 → 0x06

(5) **Switched ON** setting: Controlword write 0x6040 → 0x07

(6) Verify whether smartris drive state is switched ON: Statusword read 0x6041 → 0x23

(7) **Operation enabled** setting: Controlword write 0x6040 → 0x0F

(8) Verify whether LED status is enabled

Verify whether smartris drive state is enabled: Statusword read 0x6041 → 0x27

Verify brake release.

(9) Read speed command set value 0x60FF → 0x03e8 (Ex: set 1000 r/min)

(10) If motor revolutions are confirmed, verify motor speed (after acceleration is complete):

Read 0x606C → 0x03e8 (Ex: 1000 r/min)

Note: The motor immediately stops upon issuance of the STO safety command (**SAFETY**).

Commands being executed are immediately halted upon issuance of a stop command (**STOP**).

Commands being executed are immediately halted when a fault (**FAULT** ; see 8. Diagnostic Table 8-2) occurs.

Fig. 6-5 CANopen Run Sequence

6. CANopen Communication

6-4 Torque Profile (Add from FW Ver.2.0.1) NOTE

In the profile Torque operating mode, the motor executes a movement according to a target torque or current sent by the master controller. The current regulator (torque control) is specified a current proportional to the target torque. Note: FW ver. is listed in the nameplate. See 10-2 Nameplate and codes.

■ Object Entries

The following objects are available for the control profile velocity and the behavior of the drive.

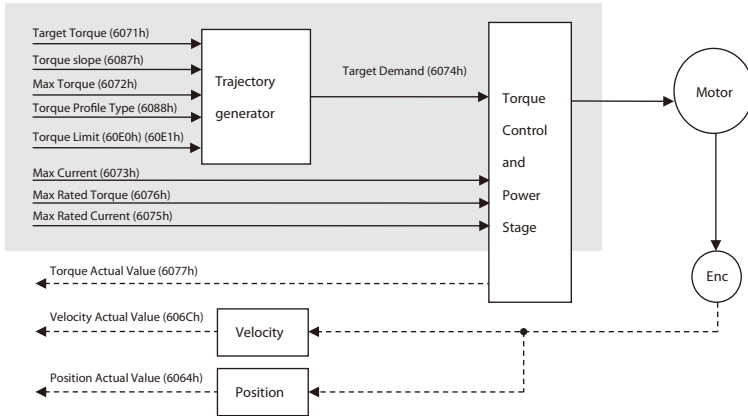| Index	Object	Name	Type	M/O	Attr.	Description
6071h	VAR	Target torque	INT16	M	rw	This object shall indicate the configured input value for the torque controller in profile torque mode. The value shall be given per thousand of rated torque.
6087h	VAR	Torque slope	U32	M	ro	This object shall indicate the configured rate of change of torque. The value shall be given in units of per thousand of rated torque per second.
6088h	VAR	Torque profile type	INT16	O	rw	This object shall indicate the configured type of profile used to perform a torque change.
6073h	VAR	Max current	U16	O	rw	This object shall indicate the configured maximum permissible torque creating current in the motor.
6075h	VAR	Motor rated current	U32	O	rw	This object shall indicate the configured motor rated current. It is taken from the motor's nameplate. Depending on the motor and drive technology, this current is DC, peak or current (rms). All relative current data refers to this value. The value shall be given in mA.
6077h	VAR	Torque actual value	I16	O	ro	This object shall provide the actual value of the torque. It shall correspond to the instantaneous torque in the motor. The value shall be given per thousand of motor nominal current.
6078h	VAR	Current actual value	I16	O	ro	This object shall provide the actual value of the current. It shall correspond to the current in the motor. The value shall be given per thousand of motor nominal current. This value is filtered.
6079h	VAR	DC link circuit voltage	U32	O	ro	This object shall provide the instantaneous DC link current voltage at the drive device. The value shall be given in mV.
6074h	VAR	Torque demand	I16	O	ro	This object shall provide the output value of the trajectory generator. The value shall be given per thousand of rated torque.
60E0h	VAR	Positive torque limit value	U16	O	rw	This object shall indicate the configured maximum positive torque in the motor. The value shall be given percent of rated current. Positive torque takes effect in the case of motive operation is positive velocity or regenerative operation is negative velocity.
60E1h	VAR	Negative torque limit value	U16	O	rw	This object shall indicate the configured maximum negative torque in the motor. The value shall be given percent of rated current. Positive torque takes effect in the case of motive operation is positive velocity or regenerative operation is negative velocity.

Note: Torque profile characteristic depends on the setting of torque profile type (6088h).

● Torque Profile Type"(6088h):"0": Linear Ramp

Actual Torque

Target Torque (6071h)

Torque Slope (6087h)

1sec

1sec
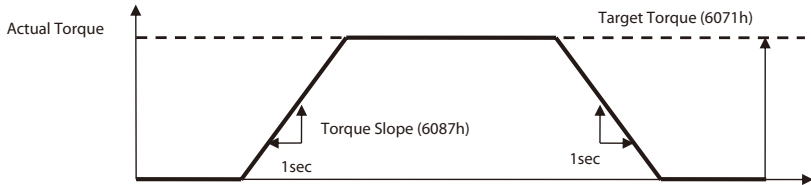
● Torque Profile Type"(6088h):"-1": Immediately

Actual Torque

Target Torque (6071h)

Torque Slope (6087h) Invalid
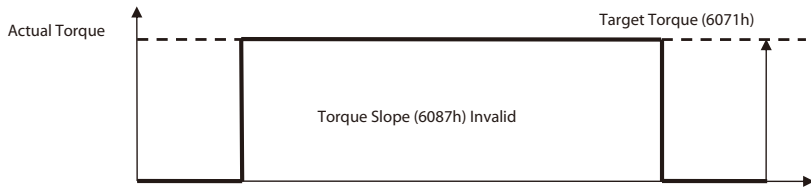
■ **Torque Profile Operation Mode**

In the Profile Torque operation mode, a movement is made with a specified target torque.

To initiate a torque-controlled movement:

・ Switch the operation mode to Profile Torque mode by writing 4 to object 6060h.

・ Enable operation.

・ Start motion by setting the target torque in object 6071h.

Target torque can be changed on-the-fly during motion. The Torque slope can be changed in run time, the other objects must be saved in EEPROM.

If changed, reset is required. (Do not change the other objects during the drive operation.)

The motion ends when one of the following conditions is met:

・ Target torque is set to 0.

・ Stop caused by Halt or Quick Stop

・ Stop caused by an error

6. CANopen Communication

6-4 DSP402 State Machine

For additional information, see definitions in "DSP402 v2.0."
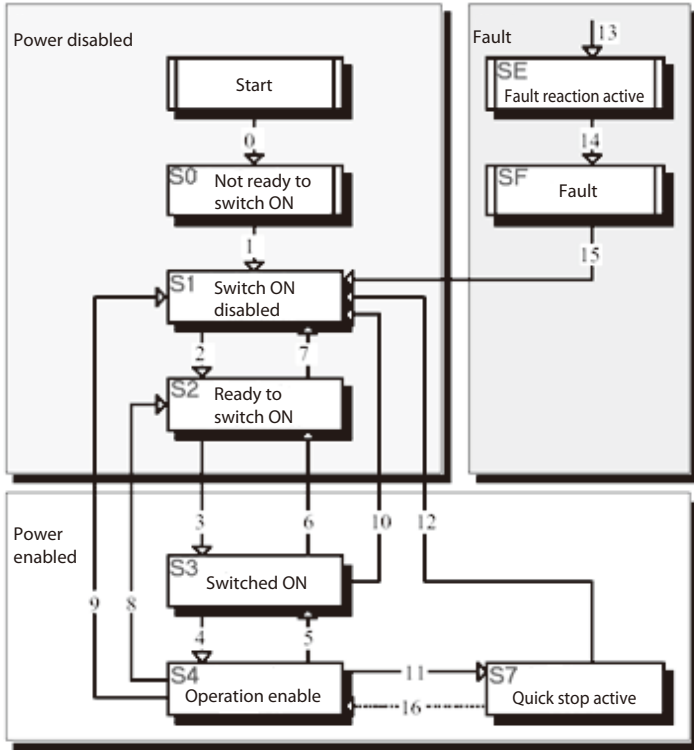
Fig. 6-6 DSP402 State Machine

The actual status can be read from the statusword. (standard code: defined in CiA DSP402).

State	N°	Description
Not ready to switch ON	S0	Performing self-test during drive unit initialization. Brake output status. Drive unit function is disabled. An internal state, where communication is possible only at the end of this state. Users cannot acquire or monitor this state.
Switch ON disabled	S1	Drive unit initialization completed. Drive unit parameter setup is completed. Drive unit parameters are modifiable. Drive unit function is disabled. Note: Errors are not displayed in this state. Application-side state transition processing is required.

State	N°	Description
Ready to switch ON	S2	Drive unit parameters are modifiable. Drive unit function is disabled.
Switched ON	S3	Power amp is standby. Drive unit parameters are modifiable. Drive unit function is disabled.
Operation enabled	S4	No faults are detected. Drive unit functions are enabled and power is supplied to the motor. Drive unit parameters are modifiable. The brake is automatically released at the timing set by brake parameters.
Quick stop active	S7	Drive unit parameters are modifiable. Activating the quick-stop function. Drive unit functions are enabled and power is supplied to the motor. The motor is stopped or is stopping by the quick stop active. Motor deceleration is completed and the drive unit is stopping. If the quick stop active code (object 0X605A) is 0, the state of the drive is switch ON disabled.
Fault reaction active	SE	Drive unit parameters is modifiable. Drive unit fault occurred. Performing fault reaction. Drive unit function is disabled. Users cannot acquire this status. This status automatically transfers to the fault status.
Fault	SF	Drive unit parameters are modifiable. Drive unit fault occurred. Drive unit function is disabled.

6. CANopen Communication

6-5 Speed Polarity

Speed set value can be inverted by a CANopen mode (either clockwise or counterclockwise).
This object affects the signs on "Position_demand_value" and "Velocity_demand_value."

Object description

Index	EDS Name	Object Code	Data Type	Category
607Eh	Polarity	VAR	Unsigned 8	Mandatory

Entry description

Subindex	Description	Access	PDO Mapping	Value Range	Default Value
0	Polarity	rw	None	0 - 192	00h

Bit

7	6	5	4	3	2	1	0
Positional polarity	Speed polarity			Reserved region (0)			
MSB							LSB

The following value definitions are valid:
• Bit value = 0: +1 times the required value
• Bit value = 1: -1 times the required value

6-6 Store and Restore

The CiA CANopen protocol specifications define objects that store and restore parameters.
• Object 1010h: Store parameter
• Object 1011h: Restore parameter
In order to save all parameters, the master writes in the SDO 1010h index the value "save" to one of the subentries of the object.
By this processing, corresponding parameter is written in nonvolatile memory.
Parameters are automatically loaded into the object dictionary after an NMT reset node or NMT reset communication.

The following objects are modified by writing to object 1010h:2h (communication parameters) and saved in EEPROM:
• 1000h: Device type
• 1001h: Error register
• 1002h: Manufacturer-specific status register
• 1003h: Predefined error field (history list)
• 1005h: COB-ID Sync
• 100Ch: Guard time
• 100Dh: Lifetime factor
• 1014h: COB-ID EMCY
• 1017h: Producer heartbeat time
• 1018h: Identity Object

• 1029h: Error behavior
• 1400h: RxPD01 parameter
• 1401h: RxPD02 parameter
• 1402h: RxPD03 parameter
• 1403h: RxPD04 parameter
• 1600h: RxPD01 mapping
• 1601h: RxPD02 mapping
• 1602h: RxPD03 mapping
• 1603h: RxPD04 mapping
• 1800h: TxPD01 parameter
• 1801h: TxPD02 parameter
• 1802h: TxPD03 parameter
• 1803h: TxPD04 parameter
• 1A00h: TxPD01 mapping
• 1A01h: TxPD02 mapping
• 1A02h: TxPD03 mapping
• 1A03h: TxPD04 mapping

The following objects are modified by writing to object 1010h:3h (application parameters) and saved in EEPROM:
• 6073h: Peak current
• 607Eh: Polarity Note
• 607Fh: Maximum profile velocity
• 6080h: Maximum motor speed
• 6083h: Acceleration profile Note
• 6084h: Deceleration profile Note
• 6096H: Velocity factor
• 6097h: Acceleration factor
• 60C5h: Maximum acceleration
• 60C6h: Maximum deceleration

The following objects are modified by writing to object 1010h:4h (manufacturer settings parameters) and saved in EEPROM:
• 2000h: ID Node
• 2001h: Baudrate
• 3002h: Brake parameters Note
• 3007h: : Dynamic Brake parameters Note
• 3200h: PID current Note
• 3201h: PID velocity Note
• 3202h: PID positioner Note
• 3203h: PID decoupling Note
Note: Parameters modifiable in real time that will be lost if the drive unit is shut off.

All parameters can be stored in EEPROM. Modification requests are not accepted until a power reset or

6. CANopen Communication

until the CANopen "RESET COMM (NMT)" message is sent to the drive unit.
Manufacturer setting parameters are stored in a protected EEPROM called "Golden Image."
You can use the restore parameter 0x1011 to return EEPROM parameters to factory parameters.

In order to avoid the restoring of default parameters by mistake, the master sends the SDO 1011h and writes the signature "load" to one of sub-index.

■ **Function Mode for Restoring Factory Parameters:**

```
                        ┌─────────────────────────────┐
                        │  Restore default (Index 1011)│
                        └─────────────────────────────┘
                                      │
                                      ▼
Factory parameters      ┌─────────────────────────────┐
active                  │     Power ON/NMT reset       │
                        └─────────────────────────────┘
                                      │                    If actual settings are not stored, fac-
- - - - - - - - - - - - - - - - - - - - - - - - - - -      tory parameters will be reloaded and
                                      ▼                    enabled before the next reset.
                        ┌─────────────────────────────┐
                        │        Boot up message       │
                        └─────────────────────────────┘
                                      │
                                      ▼
Factory settings stored ┌─────────────────────────────┐
                        │  Parameters store (Index 1010)│
                        └─────────────────────────────┘
```

42
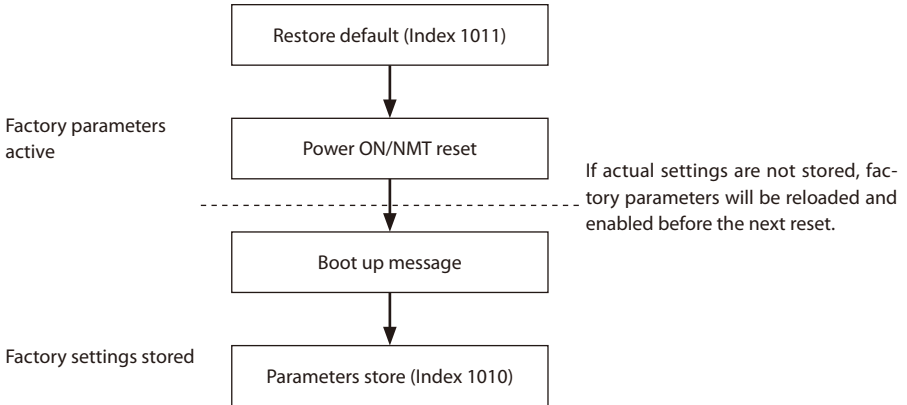
7. Modbus Communication

7-1 Connection for Modbus Communication
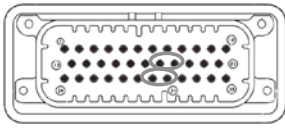
Table 7-1 Modbus Signals

Connector X1

Pin No.	Signal	Description
19	GND_CAN/GND_RS485	GND (CANopen or RS485 Modbus)
20	CAN_T/RS485_T	Termination resistor 120Ω (Connection for CAN_H/RS485+)
30	CAN_L/RS485-	Connection for CAN_L or RS485-
31	CAN_H/RS485+	Connection for CAN_H or RS485+
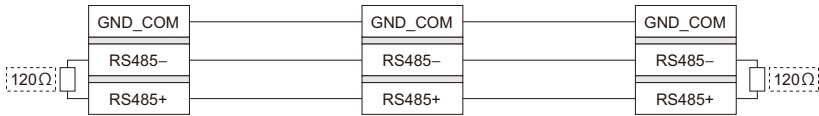
Fig. 7-1 Connection for Modbus Communication

The two ends of the CAN cables must be terminated by a resistor of 120Ω.

The CAN bus can be closed with a resistance terminator into to the drive using Pin 20. The CAN_T pin has to connect to CAN_H pin on Connector X1.

7-2 Modbus Communication Settings

Write Single Holding Resistor (0x06) / Read Holding Resistors (0x03)

Physical Address

Variable	PDU Address (W/R)	Default Value	Choice
Modbus Address	0x0028	1	1 ~ 247

Baud Rate

Variable	PDU Address (W/R)	Default Value	Choice
Modbus Baud Rate	0x0035	192 → 19200	96 → 9600 b
			192 → 19200 b
			384 → 38400 b
			576 → 57600 b
			1152 → 115200 b

Communication Settings

Variable	PDU Address (W/R)	Default Value	Choice
Parity Stop Bits Data Bits	0x002B	0	0 → NO parity/ 2 Stop Bits/ 8 Data Bits
			1 → ODD Parity/1 Stop bit/ 8 Data bits
			2 → EVEN Parity/1 Stop Bit/8 Data Bits

⚠WARNING

- The Modbus Address is the physical address and depends if there are more devices together.
- The modifies of Baud rate or Parity can cause communication issues.
- They depend to Hardware connection.
- The smartris drive is always set as a slave.

7. Modbus Communication

7-3 List of Read Input Registers

Read from Drive (0x04)			Default Value	Unit
HEX	DEC	Name		
0x0042	66	Speed setpoint	0	RPM
0x0047	71	Current torque setpoint	0	Arms/100
0X005E	94	Digital inputs	-	-
0X005F	95	Digital outputs		
0x0060	96	Drive status		
0x0061	97	Warning code Low		
0x0062	98	Warning code High		
0x0063	99	Error code		
0x0064	100	Bus DC Link	-	V/100
0x0065	101	Motor temperature	-	℃ /10
0x0066	102	Heat-sink temperature		
0x0067	103	Board temperature		
0x0068	104	Motor speed	0	RPM
0x0069	105	Torque current	0	A/100
0x006A	106	I²T Energy value	0	%
0x006B	107	Axis position Low	0	Pulse
0x006C	108	Axis position High		
0X006D	109	Feedback pulse	-	
0x006E	110	Filtered velocity	0	RPM

7-4 List of Read Holding Registers

Read Only (0x03)			Default Value	Unit
HEX	DEC	Name		
0x0001	1	Controlword	-	-
0x0003	3	Full scale velocity	L=3000, M=4500, S=4500	RPM
0x0028	40	Modbus address	1	-
0x002B	43	Communication settings	0	
0x0035	53	Modbus baud rate	192	
0x0036	54	Communication loss time	0	
0x003C	60	PID velocity KP	L=300, M=200, S=70	i.u.
0x003D	61	PID velocity KI	L=700, M=400, S=300	
0x003E	62	PID velocity KV	L=1000, M=600, S=500	
0x003F	63	Speed ramp state	1: Ramp enable	-
0x0040	64	Speed ramp up time	2000	ms
0x0041	65	Speed ramp down time		
0x0043	67	Speed/Torque polarity	0	-
0x0044	68	Limit torque positive	100	%
0x0045	69	Limit torque negative		
0x0046	70	Slope ramp (Torque)	0	(Motor rated current/1000)/s
0x004E	78	Brake managed	1: Blake enable	-
0x004F	79	Brake mode	1: Manual brake enable	
0x0050	80	Brake type	Depend on brake type	-
0x0051	81	Dynamic brake enable	1: Dynamic brake enable	
0x01FF	511	FW release customer	Depend on FW release	
0x0201	513	HW release	Depend on HW release	
0x0202	514	Parameter release	Depend on parameter release	
0x0203	515	Motor type	Depend on motor	
0x0204	516	STO check	Depend on drive	
0x0205	517	Feedback		
0x0207	519	Operation mode	-	

7-5 List of Write Single Holding Registers

| Write Parameters (0x06)			Default Value	Unit
HEX	DEC	Name		
0x0000	0	Store EEPROM	-	
0x0001	1	Controlword	0	
0x0028	40	Modbus address	1	-
0x002B	43	Communication settings	0	
0x0035	53	Modbus baud rate	192	
0x0036	54	Communication loss time	0	ms
0x003C	60	PID velocity KP	L=300, M=200, S=70	
0x003D	61	PID velocity KI	L=700, M=400, S=300	i.u.
0x003E	62	PID velocity KV	L=1000, M=600, S=500	
0x003F	63	Ramp enable	1: Ramp enable	-
0x0040	64	Speed ramp up time	2000	ms
0x0041	65	Speed ramp down time		
0x0042	66	Speed setpoint	0	RPM
0x0043	67	Speed/Torque polarity	0	-
0x0044	68	Limit torque positive	100	%
0x0045	69	Limit torque negative		
0x0046	70	Slope ramp (Torque)	1000	(Motor rated current/1000)/s
0x0047	71	Current torque setpoint	0	Arms/100
0x004E	78	Brake managed	1: Blake enable	
0x004F	79	Brake mode	1: Manual brake enable	
0x0051	81	Dynamic brake enable	1: Dynamic brake enable	-
0X0207	519	Operation Mode		
0x5A5A	23130	Restore manufacturer data	-	
0xA5A5	42405	Reset Drive		

7. Modbus Communication
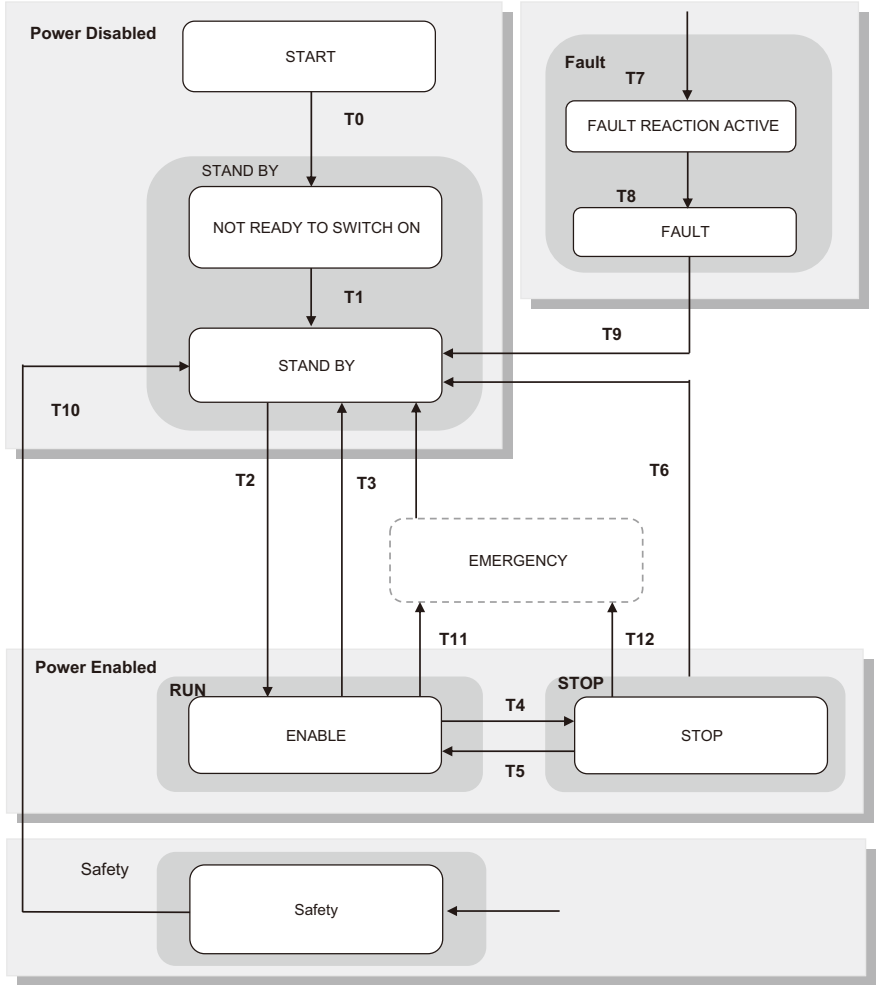
Fig. 7-2 Modbus State Machine (With Safety State)

■ **Run Sequence**

(1) Switch ON Power Supply [T0]

(2) Wait Standby (SWITCHED ON) State [T1]

(3) Verify Operation Mode by reading [Func. 0x03 – Addr. 0x0207] Operation Mode:
- ・ Value equal to 1 → Torque mode
- ・ Value equal to 2 → Velocity mode

⚠️**WARNING**

If the customer wants to switch from Torque Mode to velocity Mode or vice-versa he must set it by write to [Func.06 – Addr.0x0207] Operation Mode.

To make changes effective, the customer must first save to memory with command [Func.06 – Addr. 0x0000] Store EEPROM Data and then reset drive with command [Func.06 – Addr.0xA5A5] System Reset.

---

(4) Verify that the smartris drive is in SWITCHED ON. (See chapter 9)

(5) Set OPERATION ENABLED State : write [0x06] Controlword → 0x0001 = 0x0003 [T2]

(6) Verify that the brake is released.

(7) Verify LED STATUS ENABLED. (See chapter 9)

Verify by read [Func. 0x03 - Addr. 0x0060], that the Smartris Drive is in ENABLED [Drive Status = 0x0001 → RUN)]

(8) Set velocity or torque command and drive the motor.

If [Func. 0x06 - Addr. 0x0207] - Operation Mode = 2 – Velocity mode → Write to [Func.0x06 – Addr. 0x0042] Speed Set Point → i.e. 0x03e8 (1000 → 1000 rpm)

If [Func. 0x06 - Addr. 0x0207] - Operation Mode = 1 – Torque mode → Write to [Func.0x06 – Addr. 0x0047] Torque Set Point → i.e. 0x03e8 (1000 → 10 Arms)

(9) Verify if the motor is running

・Verify the motor speed (after ramp) by read to [Func. 0x04 – Addr. 0x0068] Motor Speed.

・Verify the motor current by read to [Func. 0x04 – Addr. 0x0069] Torque Current.

(10) Stop the motor with Stop Command → write to [Func. 0x06 - Addr. 0x0001] - Control Word → 0x0001 [T4] – Drive goes immediately in Stop state with MAX torque (it is equal to a STOP command).

If you want to Stop the motor with ramp, just write to [Func.06 – Addr.0x0042] Speed Set Point the value 0 (0 rpm).

Stop the motor with Standby Command → write to [Func. 0x06 - Addr. 0x0001] - Control Word → 0x0002 [T3] – The motor brake is ON after the motor ramp stop, Drive goes in Standby state.

Table 7-2 Transfer Description - State Machine

Transfer	Description	Transfer	Description
T0	Switch ON – Supply to drive	T7	Fault reaction active
T1	Standby – No Alarm	T8	Fault - Drive in Alarm
T2	Run command – Drive Enabled Standby - Run	T9	Reset command Fault - Standby
T3	Standby command – Drive Disabled	T10	STO (SAFETY) Command
T4	Stop command – Drive Run - Stop	T11	Emergency (If active) - the motor will dec-
T5	Run command - Drive Enabled Stop - Run		rement speed with a programmed ramp.
T6	Standby command – Stop - Standby	T12	Emergency (If active)

Note: The STO (SAFETY) and the stop command may can stop the running command immediately.

A FAULT (see table in Diagnostic) can stop the running command immediately.

8. Measurement Unit Conversion

This chapter is relevant to CANopen communication when setting measurement unit conversion.

To more easily set parameters in different applications, you can use the measurement unit conversion module to convert user parameters into units used within the drive unit.
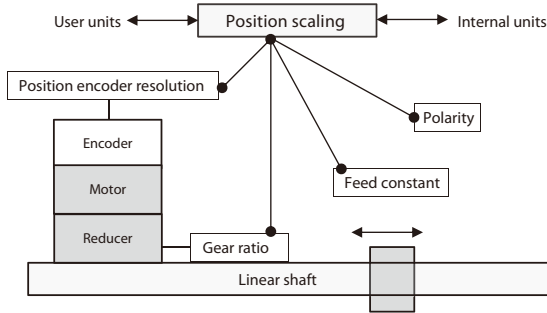

Fig. 8-1 Factor Groups

Factor group objects convert internal position value, speed value, and acceleration/deceleration value into user-defined units.

Internal position value are entered as increments and depend on the resolution of the feedback used.

User-defined units depend on the encoder resolution and the mounted linear moving device (the linear shaft).
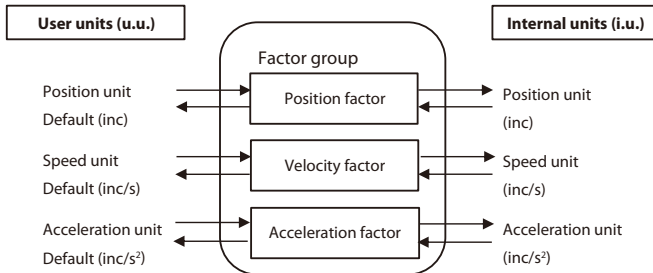
Fig. 8-2 Factor Group Units

All parameters are recorded by using internal units.

Parameters can be converted using factor-group values on a per-user basis.

Default is as follows.

Object	Name	User Units	Description
Length	Position unit	Inc	Increment/gear ratio
Speed	Speed unit	Inc/s	Increment/s
Acceleration	Acceleration unit	Inc/s^2	Increment/s/s

Factors defined in factor groups set relations between internal units (increments) and physical units.

User units are defined as [uu] and internal units are defined as [iu].

8. Measurement Unit Conversion

8-1 Conversion Parameters for Measurement Unit

The factor is the result calculated from numerator and denominator parameters.

Index	Name	Object Code	Data Type	Attribute	Remarks
608Fh	Encoder resolution (position)	ARRAY	Unsigned 32	rw	Unused
6090h	Encoder resolution (velocity)				
6091h	Gear ratio				
6092h	Feed constant				
6096h	Velocity factor				Used
6097h	Acceleration factor				

■ Object 6096h: Velocity Factor

This object can be used to match velocity units with user-defined velocity units.

Object description:

Index	EDS Name	Object Code	Data Type	Category
6096h	Velocity factor	ARRAY	Unsigned 32	Mandatory

Entry description:

Subindex	Description	Access	PDO Mapping	Data Type	Default Value
0	Highest subindex	ro	None	Unsigned 32	2
1	Numerator	rw			1
2	Denominator	rw			1

Velocity factor numerators and denominators are input separately.

　　Velocity factor = (numerator / denominator)

Default for user units [inc/s] is 1 for both numerator and denominator.

　　Velocity [iu] = velocity [uu] × (60 / resolution) × (numerator / denominator)

Resolution is one rotation of the encoder, or a measurement segment at a 1 in/mm linear scale, or the number of units.

e.g.: Velocity settings are defined as revolutions/min (rpm).

　　Velocity [inc/s] = velocity [rpm] × (60 / resolution) × (numerator / denominator)

　　If the encoder resolution is 2^{13} bits = 16,384, the numerator is 16,384 and the denominator is 60.

Factor groups are used for the following objects:

・60FFh: Target velocity

・606Dh: Velocity window

・606Fh: Velocity threshold

8. Measurement Unit Conversion

■ **Object 6097h: Acceleration Factor**

This object can be used to match acceleration units with user-defined acceleration units.

Object description

Index	EDS Name	Object Code	Data Type	Category
6097h	Acceleration factor	Array	Unsigned 32	Mandatory

Entry description

Subindex	Description	Access	PDO Mapping	Value Range	Default Value
0	Highest subindex	ro			2
1	Numerator	rw	None	Unsigned 32	1
2	Denominator	rw			1

Acceleration factor numerators and denominators are input separately.

Acceleration factor = (numerator / denominator)

Default for user units [inc/s^2] is 1 for both numerator and denominator.

Acceleration [iu] = velocity [uu] × (60 / resolution) × (numerator / denominator)

Resolution is one rotation of the encoder, or a measurement segment at a 1 in/mm linear scale, or the number of units.

e.g.: Acceleration settings are defined as revolutions/min (rpm).

Acceleration [inc/s^2] = acceleration [rpm/s] × (60 / resolution) × (numerator / denominator)
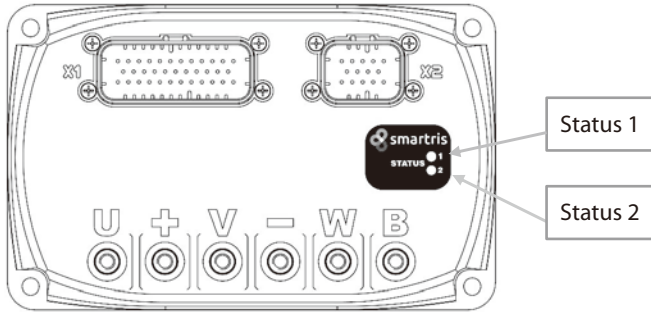
If the encoder resolution is 2^{13} bits = 16,384, the numerator is 16,384 and the denominator is 60.

Factor groups are used for the following objects:

• 6083h: Profile acceleration
• 6084h: Profile deceleration
• 60C5h: Maximum acceleration
• 60C6h: Maximum deceleration

9-1 Diagnostic

- LEDs 1 and 2 on the right side of the main unit show the drive status;
  the green LED shows status 1, and the yellow LED shows status 2

Table 9-1 Status LEDs

Drive State	CANopen Status	Status 1 LED (Green)	Status 2 LED (Yellow)	LED Display
INIT	Not ready to switch ON	"Blink"	"Blink"	1 Simultaneously blink 2 Simultaneously blink
	Not ready to switch ON Switch ON disabled Ready to switch ON	Alternately "Blink"	Alternately "Blink"	1 Alternately blink 2 Alternately blink
STANDBY	Switched ON	"Blink"	OFF	1 Blink 50% 2 OFF
FAULT	Fault Fault reaction fault	"Blink" Code [x]	"Blink" Code [y]	1 See Fig. 8-2 2
RUN	Operation enabled	ON	OFF	1 ON 2 OFF
STOP	Quick stop active	ON	ON	1 ON 2 ON
SAFETY	-	OFF	"Blink"	1 OFF 2 Blink

9. Diagnostic

Table 9-2 List of Alarms

Category	Alarm	Status 1 LED (Green) Code [x]	Status 2 LED (Yellow) Code [y]	Alarm Description
A Temperature	Motor over temperature	1	10	Motor temperature exceeds the temperature setting. Operation is impossible due to high motor temperature.
	Heat sink over temperature		1	Heat sink temperature exceeds the temperature setting. Operation is impossible due to high heat sink tempera-ture.
	Heat sink temperature out of range		3	Heat sink temperature is beyond range of the tempera-ture sensor. Temperature sensor malfunction
	PCB over temperature		4	PCB temperature exceeds the temperature setting. Operation is impossible due to high PCB temperature.
	PCB temperature out of range		5	PCB temperature is beyond range of the temperature sensor. Temperature sensor malfunction
	Motor temperature out of range		6	Motor temperature sensor is out of range. Temperature sensor malfunction
B Feedback	Resolver	2	10	Check resolver connector and wiring
	Resolver initialization		4	Resolver initialization error
	Absolute encoder		6	Absolute encoder fault
C Current	Current sensor offset	3	10	Current sensor offset is out of range
	Overcurrent		1	Motor overcurrent Check motor wiring for shorts
D Voltage	Undervoltage	4	1	DC bus voltage is below set value Check +/− power terminal voltages
	Overvoltage		2	DC bus voltage exceeds set value Check +/− power terminal voltages
E Functionality	Speed fault	5	10	Large error between commanded speed and actual speed
	Overload protection (I^{2}T)		2	Motor overload protection (I^{2}T)
	Hardware		3	Hardware fault
	External hardware		4	CANopen interface fault
	Overspeed		8	CANopen overspeed fault
F Communica-tion	EEPROM	6	1	Erroneous parameter stored in EEPROM
	Canopen		2	Canopen communication fault
	Absolute fault		3	Internal communication fault
	Parameter initialization		4	Parameter initialization fault
	Profile		5	Profile setting fault
	Torque profile		6	Torque profile fault
	Velocity profile		7	Velocity profile fault
G Configuration	Program fault	7	×	Code Programming Fault
	Manufacturer	8	1	Data Manufacturer image is not written.
	Store/Restore		2	General Error for Store and Restore Process
	Modbus error	9	1	Communication Fault with Modbus

10-1 Connections Diagram
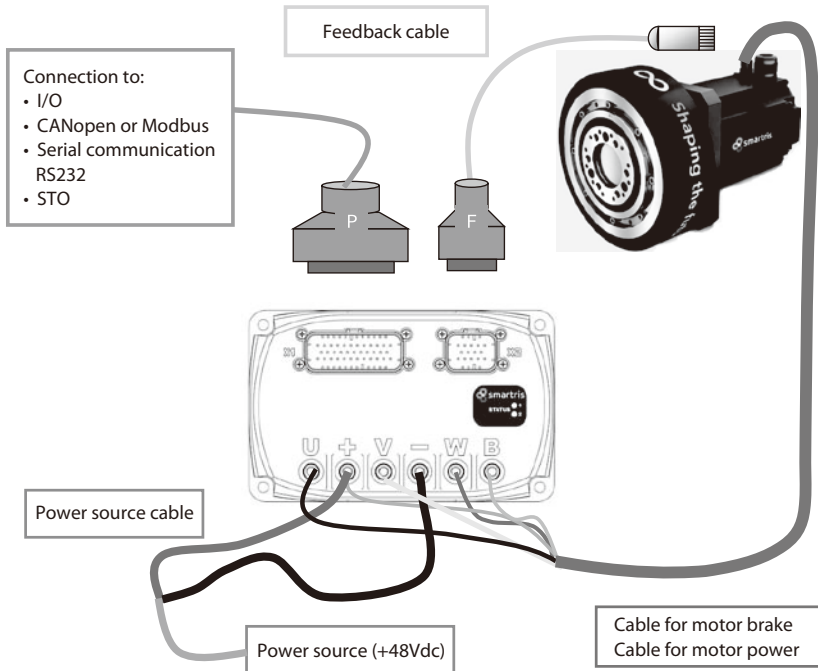
Note: Also see "1-5. Installation and Terminal Connections" regarding cable wiring.

The figure above is a block diagram for easier understanding of wiring.

Cable for motor power and brake is connected to the motor through the cable ground. (Cable length: 1m)

Table 10-1 Power Connections

Pin No.	Signal Name	Description	Color (Example)
+	+VBUS	Connection to +VBUS (+48 Vdc)	Red
—	-VBUS	Connection to –VBUS	Black

Table 10-2 Motor Connections

Pin No.	Signal Name	Description	Color (Example)
U	phase U	Motor phase U	Black
V	phase V	Motor phase V	White
W	phase W	Motor phase W	Red

Table 10-3 Brake Connections

Pin No.	Signal Name	Description	Color (Example)
+	+VBUS	Connection to "Brake +" and +VBUS	Orange
B	BRAKE	Connection to "Brake –" and B	Gray

10. Connections

10-2 Nameplate and Codes

■ **Nameplate**

Model number

Serial number

HW (hardware) version
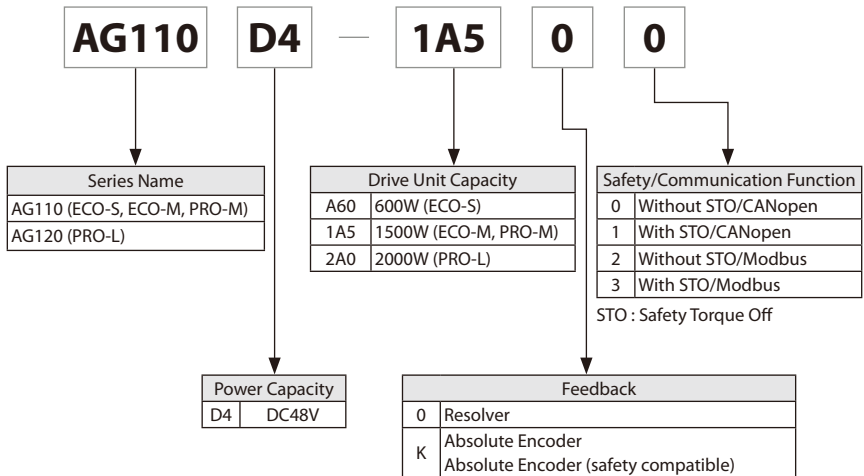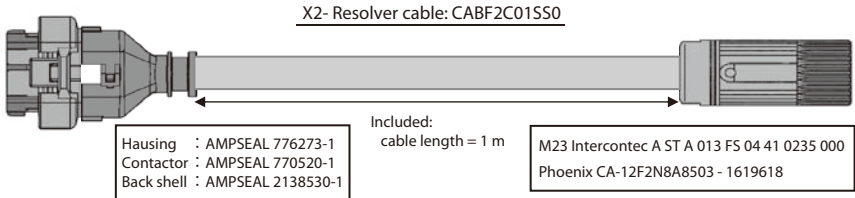FW (firmware) version

Input voltage

Output current

Ambient temperature
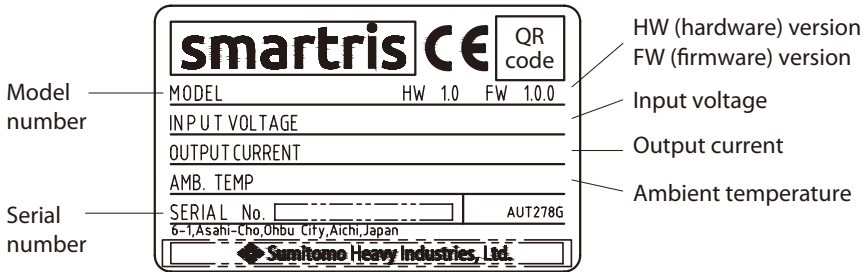
Fig. 10-1 Nameplate of smartris

■ **Nomenclature**

Series Name
AG110 (ECO-S, ECO-M, PRO-M)
AG120 (PRO-L)

Drive Unit Capacity	
A60	600W (ECO-S)
1A5	1500W (ECO-M, PRO-M)
2A0	2000W (PRO-L)

Safety/Communication Function	
0	Without STO/CANopen
1	With STO/CANopen
2	Without STO/Modbus
3	With STO/Modbus

STO : Safety Torque Off

Power Capacity	
D4	DC48V

Feedback	
0	Resolver
K	Absolute Encoder
	Absolute Encoder (safety compatible)

X1- control cable: supplied by customer

10 cm (Unsheathed cable)

Hausing	: AMPSEAL 776164-1
Contactor	: AMPSEAL 770520-1
Back shell	: AMPSEAL 776463-1

X2- Resolver cable: CABF2C01SS0

Included:
cable length = 1 m

Hausing	: AMPSEAL 776273-1
Contactor	: AMPSEAL 770520-1
Back shell	: AMPSEAL 2138530-1

M23 Intercontec A ST A 013 FS 04 41 0235 000

Phoenix CA-12F2N8A8503 - 1619618

Pin 1

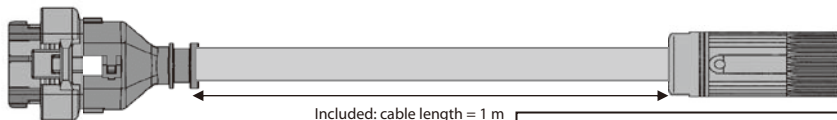| 776273-1 (14 pins)	Signal	Color	M23 (12 pins)
1	S2	White	1
2	S1	Green	2
7	S3	Yellow	3
-	NC	-	4
-	NC	-	5
6	S4	Brown	6
3	R1	Red	7
5	Shield	-	8
12	NTC1a	Pink	9
13	NTC1b	Gray	10
8	R2	Blue	11
-	NC	-	12
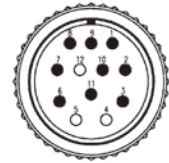
Connector pin topology

Note: Twisted pair (white–brown) (green–yellow) (gray–pink) (blue-red)
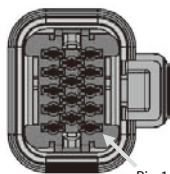
11. Cables (Optional)

X2— Absolute encoder cable: CABF6C01SS0


Included: cable length = 1 m

Hausing : AMPSEAL 776273-1
Contactor : AMPSEAL 770520-1
Back shell : AMPSEAL 2138530-1

M23 Intercontec A ST A 013 FS 04 41 0235 000
Phoenix CA-12F2N8A8503 - 1619618

776273-1 (14 pins)	Name	Color	M23 (12 pins)
1	+SIN	Brown	7
6	REF SIN	Green	3
2	+COS	Blue	8
7	REF COS	Violet	4
3	DATA+	Red	5
8	DATA-	Black	6
10	+V	Brown (0.5 mm^2)	1
11	GND	White (0.5 mm^2)	2
12	NTC1a	Pink	9
13	NTC1b	Gray	10
5	Shield	-	NC
1	+SIN	Brown	7

Pin 1
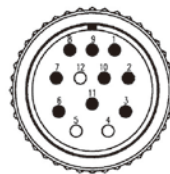
Connector pin topology

Note: Twisted pair (green–brown) (blue–violet) (red–black) (gray–pink) (brown 0.5–white 0.5)

12. Warranty

The scope of warranty of our delivered products is limited only to what we manufactured.

Warranty (period and description)

Period	The warranty period applies only to new products and represents 18 months after the shipment or 12 months after the actual operation, whichever is shorter.
Description	If the product failed within the warranty period, in the case where mounting is done properly, connection and maintenance & administration are followed according to the maintenance manual, and the product is properly run based on the specification on the catalog or under conditions agreed between us, we will repair or provide an alternative product at our discretion for free of charge, except the exclusions below. However, as far as the product is connected with customers' other devices, we will not indemnify those expenses on dismounting from/mounting on the devices, etc. and other associated construction expenses, transportation expenses and opportunity loss and operation loss the customers suffered from, and other indirect damages.
Exclusion from the warranty	The following items will be excluded from the warranty: 1. A breakdown resulting from defects in the mounting of the product and connection with other devices, etc. 2. A breakdown resulting from insufficient maintenance & administration and improper handling of the product, including a case that the product is not stored according to our defined storage manual. 3. A breakdown resulting from operation which does not fall within our specification and other operation conditions and use status we hardly can know or a failure caused by the use of lubricant which we do not recommended. 4. A breakdown resulting from defects, special specification, etc of device prepared and connected by customer. 5. A breakdown resulting from modification or reconstruction of the product. 6. A secondary breakdown occurring in our product due to defects in sequence circuits. 7. A breakdown resulting from defects in parts supplied or specified by customers. 8. A breakdown caused by inevitable force including earthquake, fire, flood disaster, salt damage, gas damage, and lightning strike, etc. 9. Warranty of natural wear and tear, abrasion, and deterioration of consumable parts such as Aluminum electrolytic capacitor etc. under normal usage. 10. A breakdown caused for reasons not attributable to each of the above item.

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Specifications, dimensions, and other items are subject to change without prior notice.

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