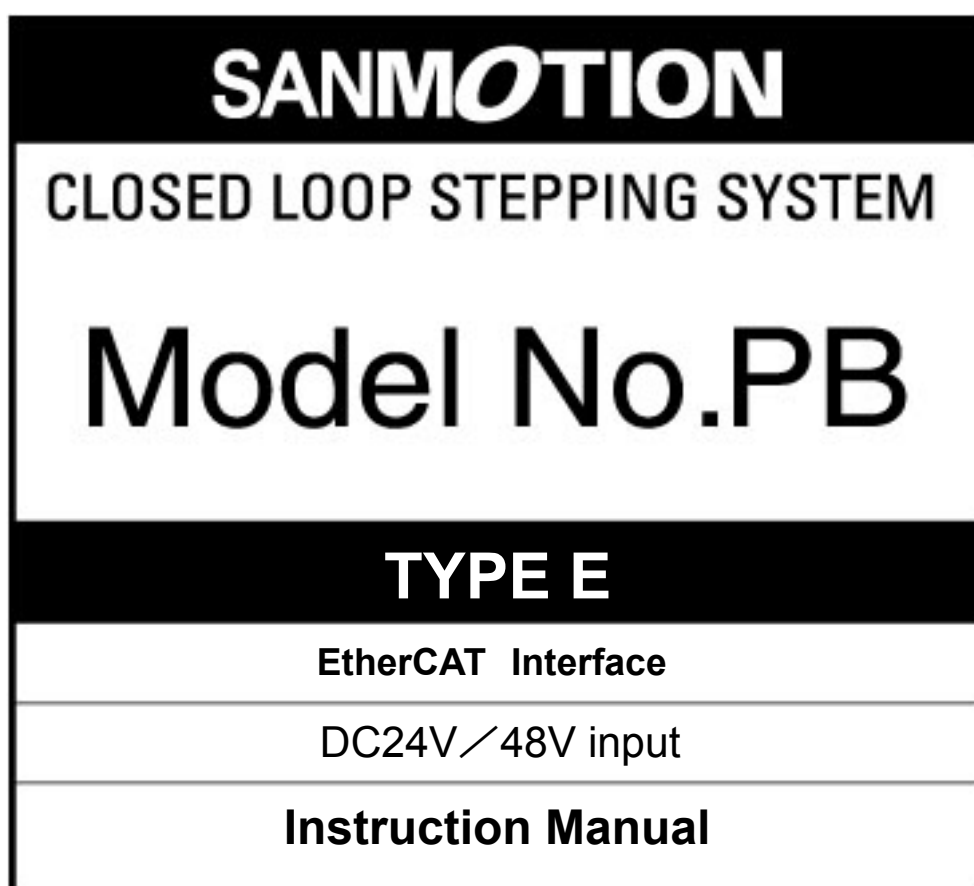




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Safety Precautions

[Make sure to follow.]

This documentation uses the following annotation. Make sure to strictly follow these safety precautions.

- There are four precaution levels.

 Danger	Denotes immediate hazards which WILL probably cause severe bodily injury or death as a result of incorrect operation.
 Caution	Denotes hazards which COULD cause bodily injury and product or property damage as a result of incorrect operation. * Even those hazards denoted by this symbol could lead to a serious accident.
 Prohibited	Indicates actions that must be carried out (mandatory actions).
 Mandatory	Indicates actions that must not be allowed to occur prohibited actions.

- There are eight graphic symbols.

Type	Sample symbols		
Danger symbols	 Danger /Injury	 Electric shock	
Caution symbols	 Caution	 Fire	 Burn
Prohibition symbols	 Prohibited	 Disassembly prohibited	
Mandatory symbol	 Mandatory		



Do not use this device in explosive environment.  Injury or fire could otherwise result.	Do not touch the inside of the amplifier.  Electric shock could otherwise result.
Do not perform any wiring, maintenance or inspection when the device is hot-wired. After switching the power off, wait at least 5 minutes before performing these tasks.  Damage to the motor /amplifier or Electric shock could otherwise result.	Only technically qualified personnel should transport, install, wire, operate, or perform maintenance and inspection on this device.  Electric shock, injury or fire could otherwise result.
Amplifier case must be grounded. When connecting ground wire, always connect one wire to one terminal.  Electric shock could otherwise result.	Do not damage the cable, do not apply unreasonable stress to it, do not place heavy items on it, and do not insert it in between objects.  Electric shock could otherwise result.
Wiring should be done based on the wiring diagram or the user manual.  Electric shock or fire could otherwise result.	Do not touch the rotating part of the motor during operation.  Bodily injury could otherwise result.
Do not touch or get close to the terminal while the device is powered up.  Electric shock could otherwise result.	Do not unplug the connector while the device is powered up or before one (1) minute has elapsed after power shutdown.  Damage to the motor /amplifier or Electric shock could otherwise result.

Safety Precautions

[Make sure to follow.]



Caution

Please read the User Manual carefully before installation, operation, maintenance or inspection, and perform these tasks according to the instructions. Electric shock, injury or fire could otherwise result.	Do not use the amplifier or the motor outside their specifications. Electric shock, injury or damage to the device could otherwise result.
Do not use a defective amplifier or motor. Injury or fire could otherwise result.	Use the amplifier and motor together in the specified combination. Fire or damage to the device could otherwise result.
Be careful of the high temperatures generated by the amplifier/motor and the peripherals. Burn could otherwise result.	Open the box only after checking its top and bottom location. Bodily injury could otherwise result.
Verify that the products correspond to the order sheet/packing list. If the wrong product is installed, injury or damage could result. Injury or damage could result.	Keep the motor's sensor terminals away from static electricity. Damage to the device could otherwise result.
Do not measure the insulation resistance and the pressure resistance. Damage to the device could otherwise result.	Wiring should follow electric equipment technical standards and indoor wiring regulations. An electrical short or fire could otherwise result.
Wiring connections must be secure. Motor interruption or bodily injury could otherwise result.	Keep static electricity and high voltage away from the sensor terminals of the motor. Damage to the device could otherwise result.
Do not stand on the device or place heavy objects on top of it. Bodily injury could otherwise result..	Do not obstruct the air intake and exhaust vents, and keep them free of debris and foreign matter. Fire could otherwise result.
Make sure the mounting orientation is correct. Fire or damage to the device could otherwise result.	Consult the User Manual regarding the required distance between the amplifier, the control panel interior, and other devices. Damage to the device could otherwise result.
Do not subject the device to excessive shock or vibration. Damage to the device could otherwise result.	Secure the device against falling, overturning, or shifting inadvertently during installation. Use the hardware supplied with the motor (if applicable).
Do not expose the device to water, corrosive or flammable gases, or any flammable material. Fire or damage to the device could otherwise result.	Install the device on a metal or other non-flammable support. Fire could otherwise result.



Caution

There is no safeguard on the motor. Use an over-voltage safeguard, short-circuit breaker, overheating safeguard, and emergency stop to ensure safe operation.  Injury or fire could otherwise result.	Do not touch the radiation fin of the amplifier, the regenerative resistor, or the motor while the device is powered up, or immediately after switching the power off, as these parts generate excessive heat.  Burn could otherwise result.
In the case of any irregular operation, stop the device immediately.  Electric shock, injury or fire could otherwise result.	Do not perform extensive adjustments to the device as they may result in unstable operation.  Bodily injury could otherwise result.
Trial runs should be performed with the motor in a fixed position, separated from the mechanism. After verifying successful operation, install the motor on the mechanism.  Bodily injury could otherwise result.	The securing brake is not to be used as a safety stop for the mechanism. Install a safety stop device on the mechanism.  Bodily injury could otherwise result.
In the case of an alarm, first remove the cause of the alarm, and then verify safety. Next, reset the alarm and restart the device.  Bodily injury could otherwise result.	Verify that the power specifications are normal.  Damage to the device could otherwise result
Avoid getting close to the device, as a momentary power outage could cause it to suddenly restart (although it is designed to be safe even in the case of a sudden restart).  Bodily injury could otherwise result.	Standard specification servo amplifiers have a dynamic brake resistor. Do not rotate the motor continuously from the outside when the amplifier is not powered on, because the dynamic brake resistor will heat up, and can be dangerous.  Fire or burn could otherwise result.
Be careful during maintenance and inspection, as the body of the amplifier becomes hot.  Burn could otherwise result.	It is recommended to replace the electrolytic capacitors in the amplifier after 5 years, if used at an average temperature of 40°C year round. The expected life of the cooling fan motor is 10 years, if used at an average temperature of 40°C year round. Regular replacement is recommended.  Damage to the device could otherwise result.
Please contact your distributor or sales office if repairs are necessary. Disassembly could render the device inoperative.  Damage to the device could otherwise result.	Make sure the device does not fall, overturn, or move inadvertently during transportation.  Bodily injury could otherwise result.
Do not hold the device by the cables or the shaft while handling it.  Damage to the device or bodily injury could otherwise result.	If the amplifier or the motor is no longer in use, it should be discarded as general industrial waste. 

Safety Precautions

[Make sure to follow.]



Prohibited

Do not store the device where it could be exposed to rain, water, toxic gases or other liquids.  Damage to the device could otherwise result.	The built-in brake is intended to secure the motor; do not use it for regular control. Damage to the brake could otherwise result.  Damage to the device could otherwise result.
Do not overhaul the device.  Fire or electric shock could otherwise result.	Do not remove the nameplate cover attached to the device. 



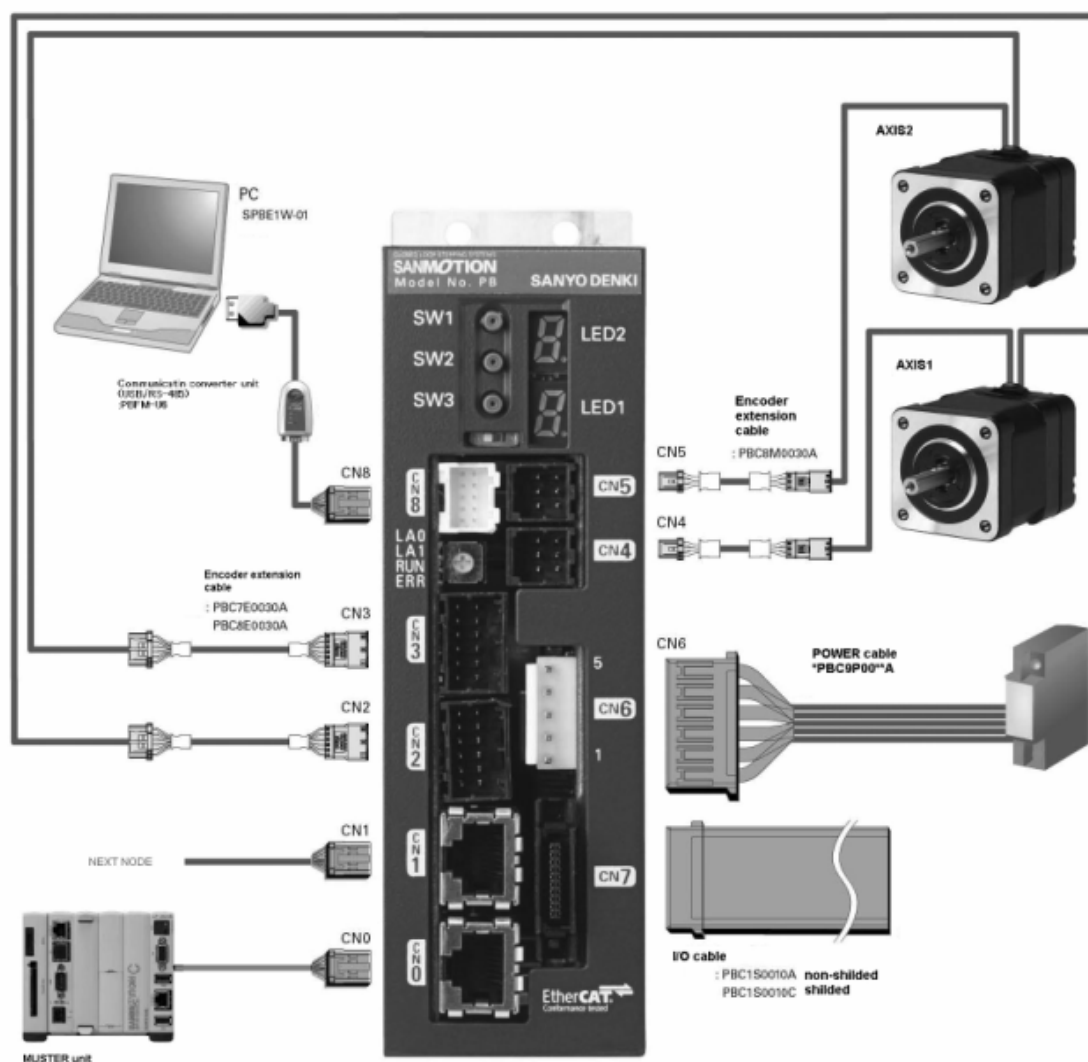
Mandatory

Store the device where it is not exposed to direct sunlight, and within the specified temperature and humidity ranges {−20°C to +65°C, below 90% RH (non-condensing)}. 	Please contact our office if the amplifier is to be stored for a period of 3 years or longer. The capacity of the electrolytic capacitors decreases during long-term storage, and could cause damage to the device.  Damage to the device could otherwise result.
Install an external emergency stop circuit that can stop the device and cut off the power instantaneously. Install an external protective circuit to the amplifier to cut off the power from the main circuit in the case of an alarm. Motor interruption, bodily injury, burnout, fire and secondary damages could otherwise result.  Reckless driving, injury, damage, fire or Second damage could otherwise result.	Operate within the specified temperature and humidity range {Amplifier: Temperature 0°C to 55°C, Humidity below 90% RH (non-condensing); Motor: Temperature 0°C to 40°C, Humidity below 90% RH (non-condensing)}.  Burnout or damage to the device could otherwise result.
Follow the directions written on the outside box. Excess stacking could result in collapse.  Bodily injury could otherwise result.	For power supply, use reinforced and insulated products of IEC or EN standard. 

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1. Prior to Use

1.1 System constitution



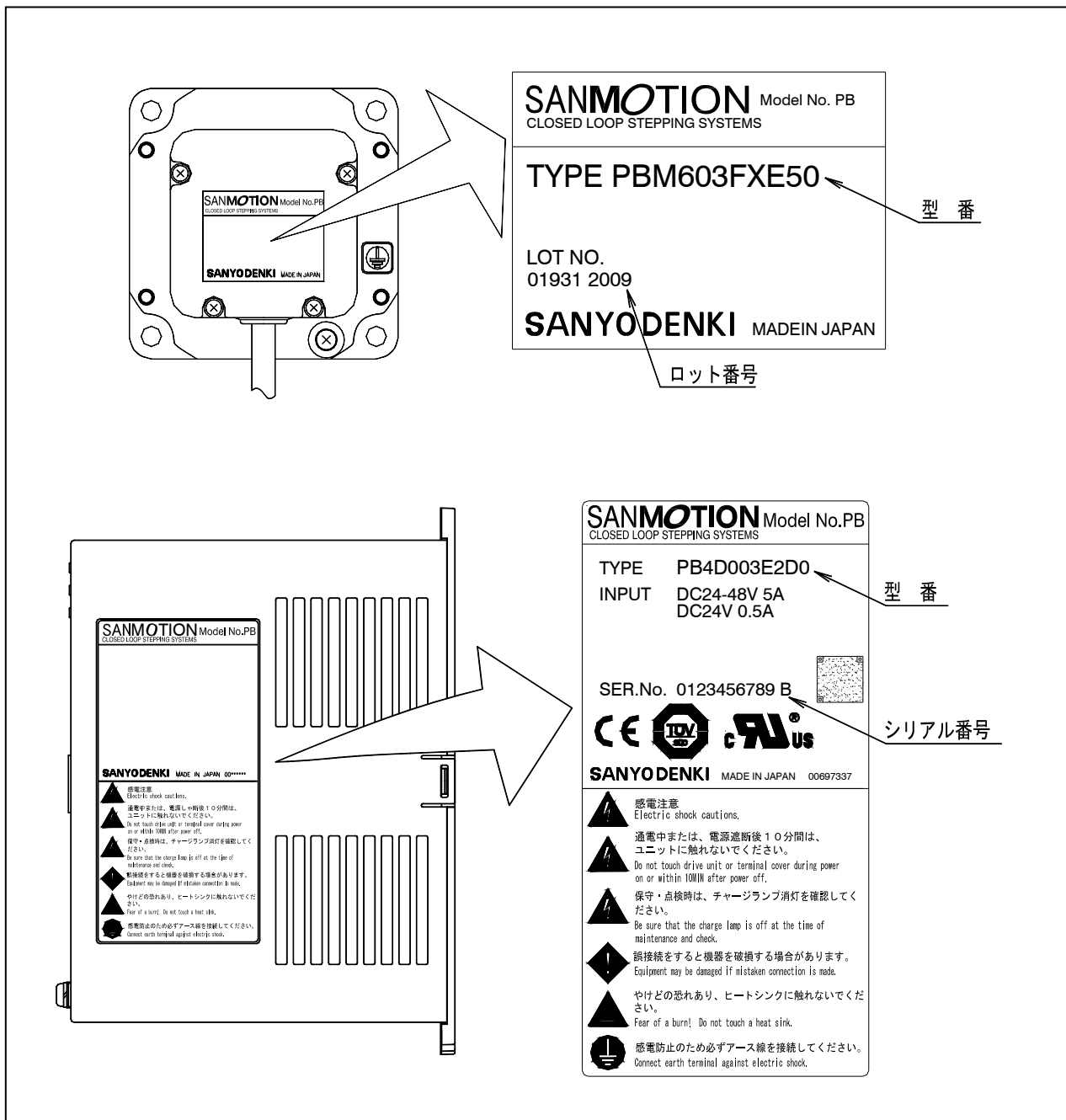
- * Refer to Section 3.2 regarding the connector Type and the appropriate electric wire.
- * PC Interface software as well as the Communication conversion unit will be needed for input/output signal functions setting, waveform monitoring, etc.

1. Prior to Use

1.2 Verifying Package Contents

Verify the followings when the product arrives. If you find any discrepancy, contact your distributor or sales office.

- Verify that the model number of the motor or amplifier is the same as ordered.
(The model number is located on the main name plate, following the word "TYPE".)
- Verify that there are no abnormalities, such as damages to the exterior of the device, or missing accessories.



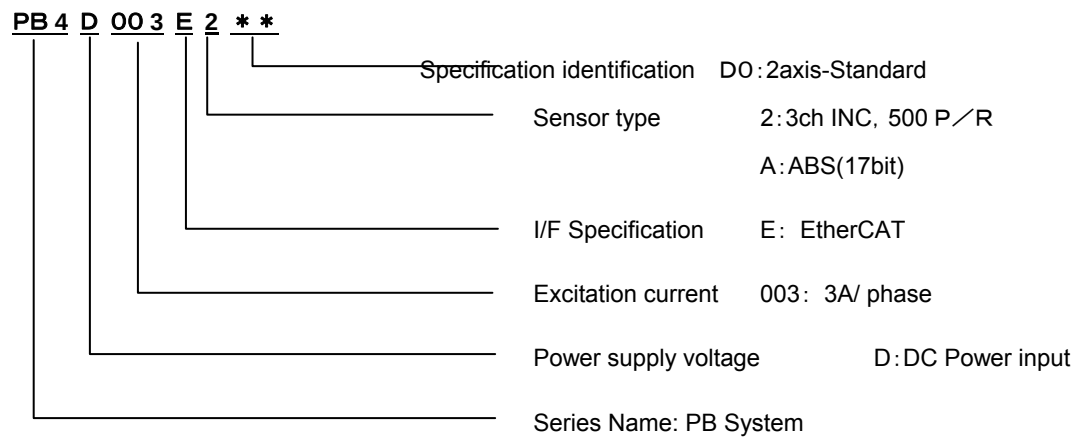
Interpretation of the serial number

Amplifier : Month (2 digits) + Year (2 digits) + Day (2 digits)+ Serial number (4 digits) + Revision ("A" is abbreviated)

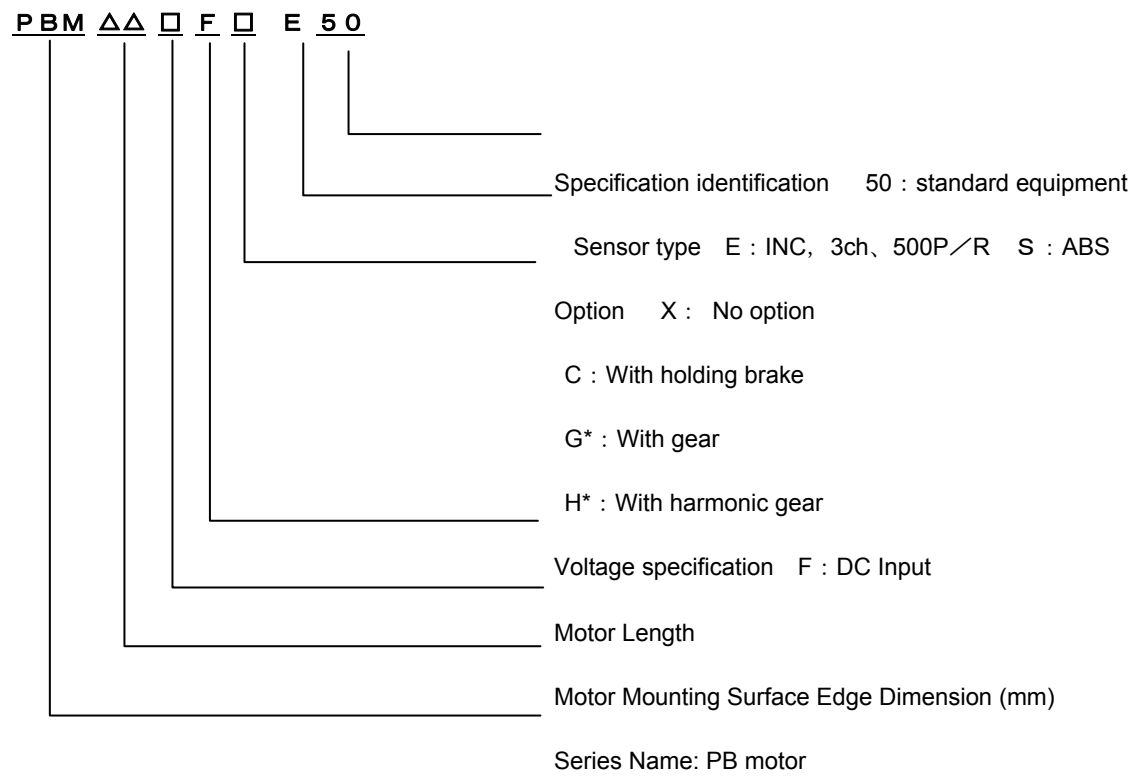
Motor : Month (2 digits) + Year (1 digits) + Day (2 digits)+Year (4 digits)

1. Prior to Use

1.3 Driver Number Specification



1.4 Motor Number Specification



Note 1) Please ask us, when standard authorization of a motor is required.

1. Prior to Use

1.5 Motor option

Motor size	Driver model		PB4D003E2D*(INC)	PB4D003EAD*(ABS)
	Sensor		500P/R	17bit+16bit
28□	Standard		PBM282FXE50	
			PBM284FXE50	
	Spur Gear	1/3.6	PBM282FGAE50	
		1/7.2	PBM282FGBE50	
		1/10	PBM282FGEE50	
		1/20	PBM282FGGE50	
		1/30	PBM282FGJE50	
		1/50	PBM282FGLE50	
		1/100	PBM282FGME50	
	Harmonic Gear	1/50	PBM282FHLE50	
		1/100	PBM282FHME50	
	Holding brake		PBM282FCE50	
			PBM284FCE50	
42□	Standard		PBM423FXE50	PBM423FXS50
	Low-backlash gear	1/3.6	PBM423FGAE50	
		1/7.2	PBM423FGBE50	
		1/10	PBM423FGEE50	
		1/20	PBM423FGGE50	
		1/30	PBM423FGJE50	
	Harmonic Gear	1/30	PBM423FHJE50	
		1/50	PBM423FHLE50	
		1/100	PBM423FHME50	
	Holding brake		PBM423FCE50	
60□	Standard		PBM603FXE50	PBM603FXS50
			PBM604FXE50	PBM604FXS50
	Low-backlash gear	1/3.6	PBM603FGAE50	
		1/7.2	PBM603FGBE50	
		1/10	PBM603FGEE50	
		1/20	PBM603FGGE50	
		1/30	PBM603FGJE50	
	Harmonic Gear	1/50	PBM603FHLE50	
		1/100	PBM604FHME50	
	Holding brake		PBM603FCE50	
			PBM604FCE50	

2. Installation

2. 1 Driver Installation Precautions

- The driver must be installed in an enclosure. Carefully consider the size of the case, the cooling method, and the location so that the ambient temperature around the driver does not exceed 55°C. For longevity and high reliability, it is recommended to keep the temperature around the driver below 40°C.
- Please attach and take the cooling method into consideration so that the fin temperature of a driver reaches 70 °C or less including ambient air temperature.
- The driver has an internal overheating detection function. Consider the cooling method to be used if an driver overheating error is detected.
- If there is a vibration source nearby, use a shock absorber between the driver and the installation base to prevent the vibration from directly affecting the driver.
- Long-term use in the presence of corrosive gas may cause contact failure on the connectors and on connecting parts. Never use the device where it may be subjected to corrosive gas.
- Do not use the device where explosive or combustible gas is present, as this could cause fire or an explosion.
- Do not use the device where dust or oil mist is present. If dust or oil mist attaches to and accumulates on the device, it can cause insulation deterioration or leakage between the conductive parts, and damage the driver.
- A large noise source may cause inductive noise to enter the input signals or the power circuit, and can cause a malfunction. If there is a possibility of noise, insert a noise filter, inspect the line wiring and take appropriate noise prevention measures.

2. 2 Driver Installation Method

1) Installation dimensions

The driver must be installed using four M4 screws on its rear panel.

2) Installation direction

The driver uses natural convection cooling. The installation direction must be vertical. Do not install the unit upside down.

3) Installing multiple drivers in a row

Leave at least 50mm of space above and below the drivers to ensure unobstructed airflow from the radiator. If heat gets trapped above the driver, use a fan to create airflow. Leave at least 10mm of space between the drivers.

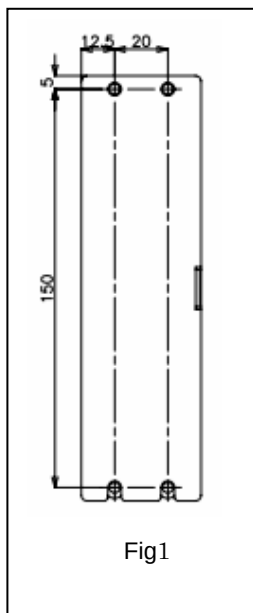


Fig1

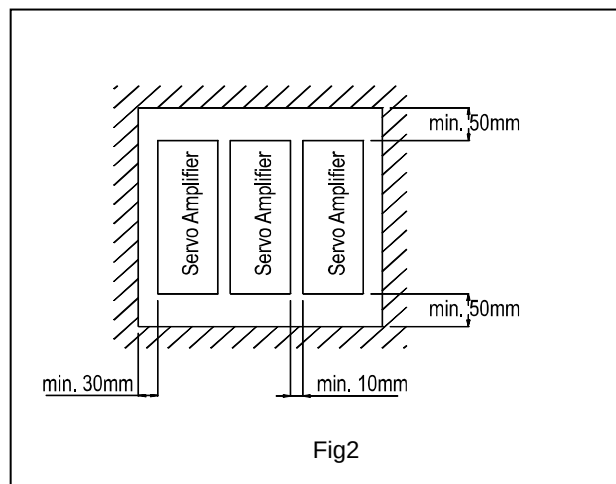


Fig2

* These conditions are recommendation values.

Please check that driver fin temperature turns into 70 degrees or less, and install.

2. Installation

2.3 Motor Installation Precautions

- If the motor is enclosed in an enclosure, consider its size, the use of a heat sink, and ensure the temperature inside the case is between 0 and 40°C.
- Consider a radiation method to ensure that the surface temperature of the motor (end cap surface temperature) does not exceed 85°C.
- If the motor overheating prevention function is working, an ALM will be detected.)
- When installing a pulley or a gear to the motor, avoid methods such as press fitting that apply force in the torque direction. Ensure accurate shaft centering when integrating the rotating shaft of the motor with the target machinery. Incorrect centering can damage the shaft and the bearings.
- Avoid installation in places where the unit may be subjected to water, cutting fluid, rain or conductive particles such as dust and iron filings.
- Never install the unit where it could be subjected to corrosive (acid, alkali, etc.), flammable, explosive liquids or fumes.
- If a belt-drive is used, verify that the gear reduction value of the belt tension does not exceed the thrust load tolerance.

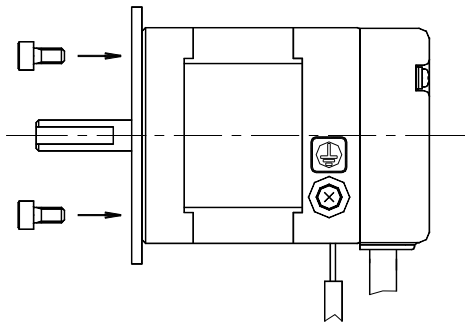
*Please refer to Chapter 9 for Thrust Load Tolerance and the Radial Load Tolerance specification value.

2.4 Installation and consideration of cable

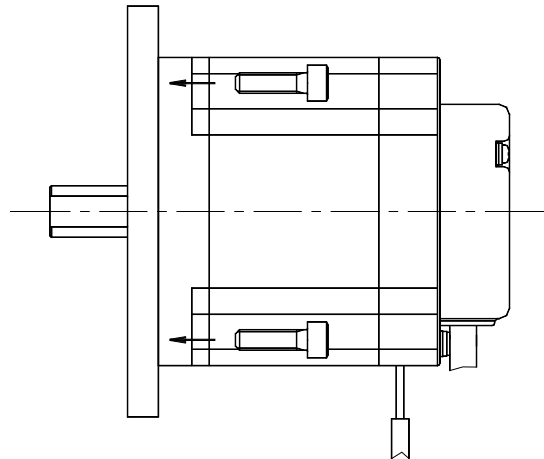
- Be careful not to damage or stress the cable.
- Be careful not to place undue stress on the cable when a motor to the operation part. More than 8 times of the cable dimension is recommended for bending radius.
- Lay cable in a risk-free area so that it will not be damaged by sharp cutting edges, etc. Also, avoid the spots that may possibly come into contact with equipment corners, could fall under the equipment or that may be stepped on by workers.
- Be careful not to incur bending stress or self-weight stress at the connections by taking an active measure such as clamping the cable to the equipment, etc.
- Determine the bend radius depending on the need for flex-life and the type of cable used to move a motor and cable by cableveyor, etc.
- It is recommended to have a structure that can be replaced regularly for the cable where it comes into contact with moving parts. Please contact us when using a recommended cable for moving parts.

2. Installation

2. 5 Motor Installation Method



PBM28□, 423



PBM60□

Use the tap hole or mounting hole on the installation surface and the mounting rabbet for installation. Refer to the outline drawing (Section 9) for the tap hole pitch measurements and the mounting rabbet diameter.

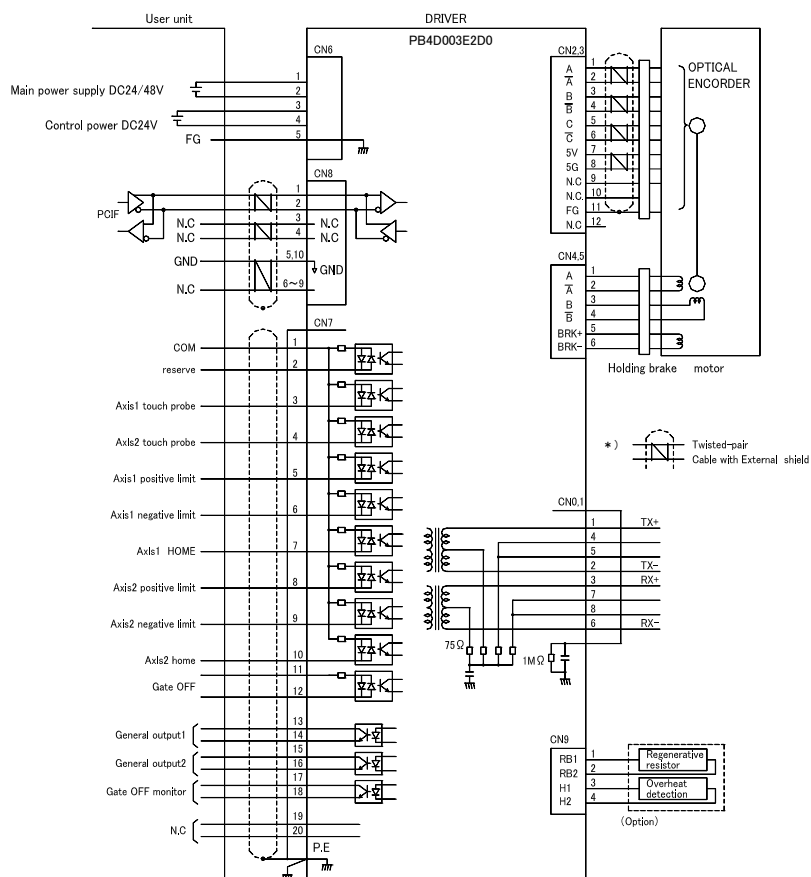
Installation Angle dimensions	Motor Model	Screws to Use	Recommended Tightening Torque(N m)
28 angles	PBM282	M2.6 2	0.4
42 angles	PBM423	M3 4	0.62
60 angles	PBM60*	M4 4	1.43

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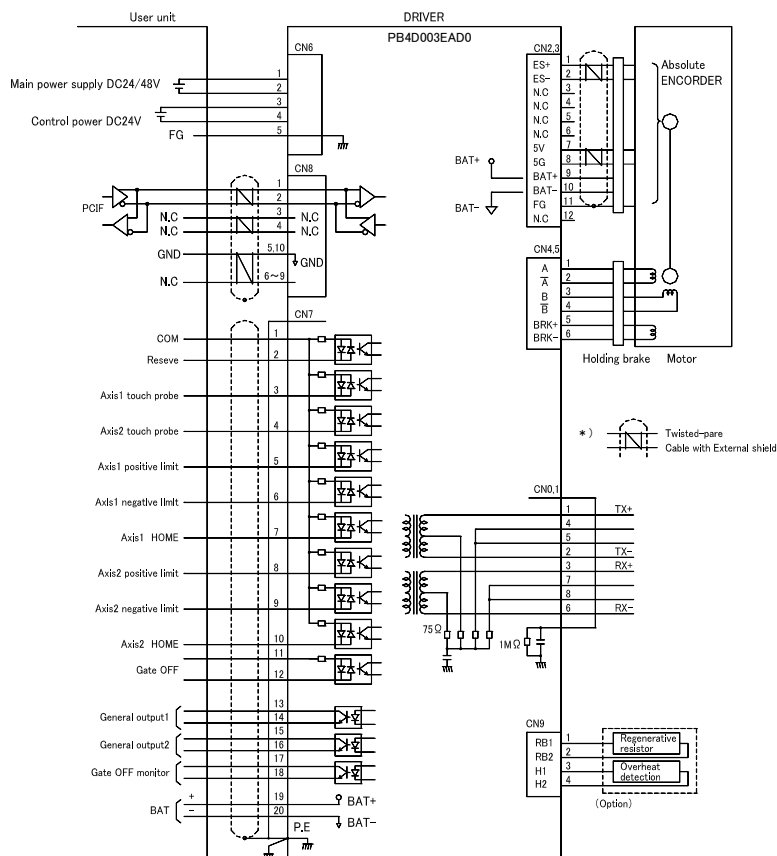
3. WIRING • Input/Output Signal Functions

3.1 External wiring diagram

PB4D003E2D0 (Incremental sensor)

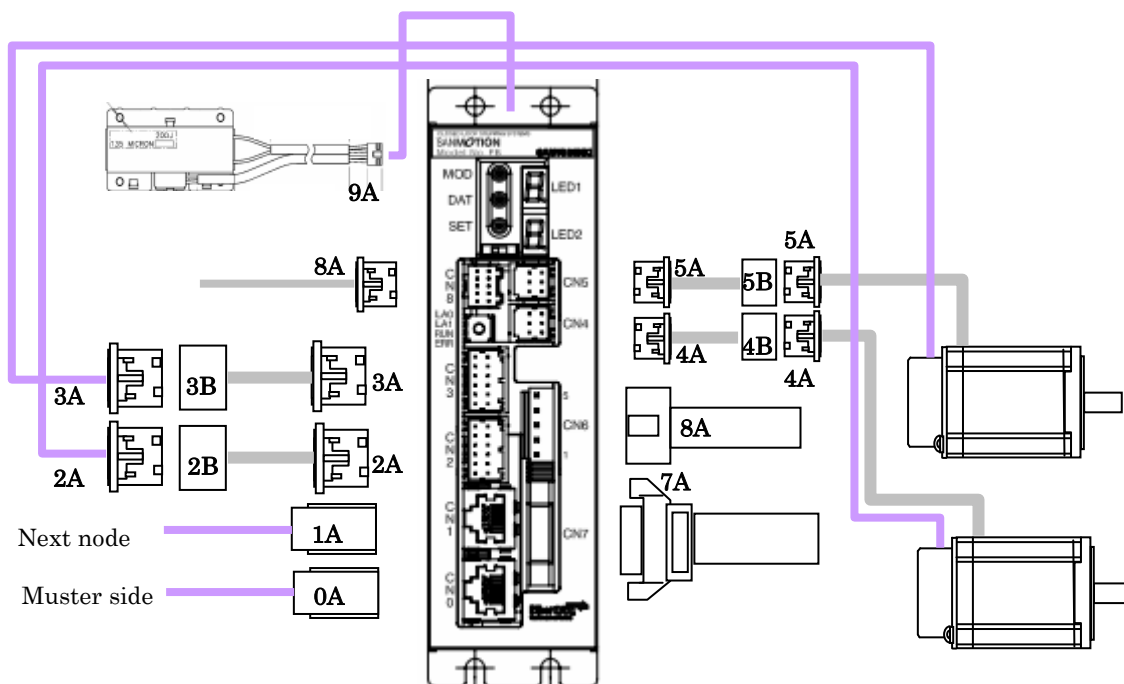


PB4D003EAD0 (Absolute sensor)



3. WIRING • Input/Output Signal Functions

3.2 Connector Model Numbers and Appropriate Electric Wires



Application	Symbol	Name	Model	Appropriate Electric Wire	Maximum Extension length	Manufacturer
EtherCAT	CN0,1	Connect CN0 (Port 0) to the higher-level device and CN1 to the next slave. Use twisted-pair cables that satisfy at least "Category 5e" to connect the cable. When you make cables using exclusive tools, use STP (Shielded twisted pair cable) and RJ-45 modular plug with shield. Either straight or crossed cables can be used for the port connection because an automatic crossover function (Automatic discriminating feature for MDI / MDI-X called Auto MDI / MDI-X) is installed.			It is based on the cable used.	—
Encoder (INC)	CN2,3	Tab header	1-1827876-6	AWG22~28 Twisted pair wire with external shield *The contact model is different depending on the dimensions when wrapped.	20 m	Tyco Electronics
	2A,3A	Receptacle housing	1-1827864-6			
		Receptacle contact	1827569-2 (AWG28~30) 1827570-2 (AWG22~28)			
	2B,3B	Tab housing	1-1903130-6			
		Tab contact	1903111-2 (AWG28~30) 1903112-2 (AWG22~28)			
Encoder (ABS)	CN2,3	Tab header	2-1827876-6			
	2A,3A	Receptacle housing	2-1827864-6			
		Receptacle contact	1827569-2 (AWG28~30) 1827570-2 (AWG22~28)			
	2B,3B	Tab housing	2-1903130-6			
		Tab contact	1903111-2 (AWG28~30) 1903112-2 (AWG22~28)			

3. WIRING • Input/Output Signal Functions

Application	Symbol	Name	Model	Appropriate Electric Wire	Maximum Extension length	Manufacturer
Motor	CN4,5	Tab header	2-1827876-3	AWG18~22 Discrete wire * The contact model is different depending on the dimensions when wrapped.	20m	Tyco Electronics
	4A,5A	Receptacle housing	2-1827864-3			
		Receptacle contact	1827570-2 (AWG22~28) 1827572-2 (AWG18~22)			
	4B,5B	Tab housing	2-1903130-3			
		Tab contact	1903112-2 (AWG22~28) 1903114-2 (AWG18~22)			
Power Supply	CN6	Tab header	B5PS-VH	AWG16~18 Discrete wire	2 m	JST
	6B	Receptacle housing	VHR-5N			
		Receptacle contact	SVH-21T-P1.1			
I/O	CN7	Plug	8830E-020-170LD-F	AWG28 (7/0.127)	2 m	KEL
	7A	Receptacle	8822E-020-171D-F			
PCIF Communication	CN8	Post with base	S10B-PADSS-1GW	AWG28~24	100 m	JST
	8A	Housing	PADP-10V-1-S	Twisted pair wire		
		Contact	SPH-002T-P0.5L	With external shield		
Regenerative Register	CN9	Post with base	S10B-PADSS-1GW	AWG28~24	100 m	JST
	9A	Housing	PADP-10V-1-S	Twisted pair wire		
		Contact	SPH-002T-P0.5L	With external shield		

* Refer to maker catalog for the connector specifications details.

* Take measures against noise so that it does not cause a movement error in case you may exceed the maximum extension length.

3. WIRING • Input/Output Signal Functions

3.3 Connector Pin Assignment

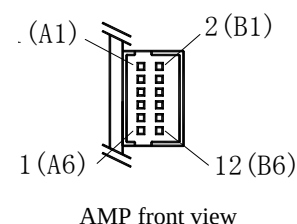
1) CN0, CN1 (EtherCAT Communication connector)

CN0 (Port0), CN1 (Port1)	Terminal number	Signal (Ethernet Connection)	Description
	1	TX +	Transmitting signals +
	2	TX -	Transmitting signals -
	3	RX +	Receiving signals +
	4	—	75Ω Connection
	5	—	75Ω Connection
	6	RX -	Receiving signals -
	7	—	75Ω Connection
	8	—	75Ω Connection

2) Connector2, 3 (Encoder Signal)

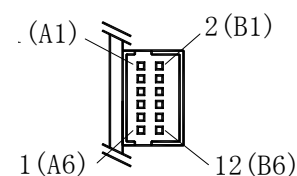
■ Signal name (Incremental sensor)

Pin No	Signal name	Pin No	Signal name
1 (A1)	Phase A+ (Blue)	7 (A4)	VCC (Red)
2 (B1)	Phase A- (Brown)	8 (B4)	GND (Black)
3 (A2)	Phase B+ (Green)	9 (A5)	—
4 (B2)	Phase B- (Purple)	10 (B5)	Motor O · H (Orange)
5 (A3)	Phase C+ (White)	11 (A6)	FG (Black)
6 (B3)	Phase C- (Yellow)	12 (B6)	—



■ Signal name (Absolute sensor)

Pin No	Signal name	Pin No	Signal name
1 (A1)	ES+ (Brown)	7 (A4)	VCC (Red)
2 (B1)	ES- (Blue)	8 (B4)	GND (Black)
3 (A2)	—	9 (A5)	BAT+ (Pink)
4 (B2)	—	10 (B5)	BAT- (Purple)
5 (A3)	—	11 (A6)	FG (Black)
6 (B3)	—	12 (B6)	—

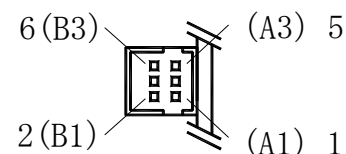


3. WIRING • Input/Output Signal Functions

3) Connector4,5 (Motor Power)

■ Signal name

Pin No	Signal name (Line COLR)	Pin No	Signal name (Line COLR)
1 (A1)	Phase A (Blue)	4 (B2)	Phase B (Yellow)
2 (B1)	Phase A (Orange)	5 (A3)	Brake + (white *1)
3 (A2)	Phase B (Red)	6 (B3)	Brake — (Black *1)



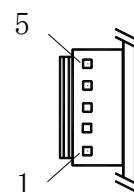
*1 The lead wire color of the holding brake is different depending on if polarity exists. A non-polarity holding brake becomes the same lead wire color.

- * The power source for the holding brake is built into the inside of the amplifier. Also, an amplifier controls the holding brake automatically.
- * Insertion/Extraction of the power line must be done before more than one (1) minute has elapsed after power shutdown. This may cause damage to the amplifier if insertion/extraction is done under active power state.

4) Connector6 (Power Supply)

■ Signal name

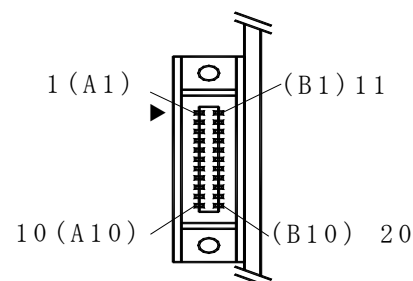
Pin No	Signal name	Pin No	Signal name
1	Main Power 24/48V(Red)	4	GND(Gray)
2	GND(Blue)	5	FG(Green)
3	Control Power 24VDC (Yellow)	—	—



- * Do not wire the power supply cable to the motor power line, IO line and encoder line within the same duct.
- * Insertion/Extraction of the power supply line must be done before one (1) minute has elapsed after power shutdown. This may cause damage to the amplifier if insertion/extraction is done under active power state.
- * Power supply current is different by conditions of operation, load conditions, and control mode.

5) Connector7 (I/O Signal)

Pin No	Signal name	Pin No	Signal name
1	Common for input signals	11	Gate OFF+
2	Reserve	12	Gate OFF-
3	Axis1Touch probe input	13	Out1+
4	Axis2 Touch probe input	14	Out1-
5	Axis 1 Positive Limit Input	15	Out2+
6	Axis 1 Negative Limit Input	16	Out2-
7	Axis 1 HOME Input	17	Gate OFF Mon+
8	Axis 2 Positive Limit Input	18	Gate OFF Mon-
9	Axis 2 Negative Limit Input	19	BAT+(Only ABS)
10	Axis 2 HOME Input	20	BAT-(Only ABS)



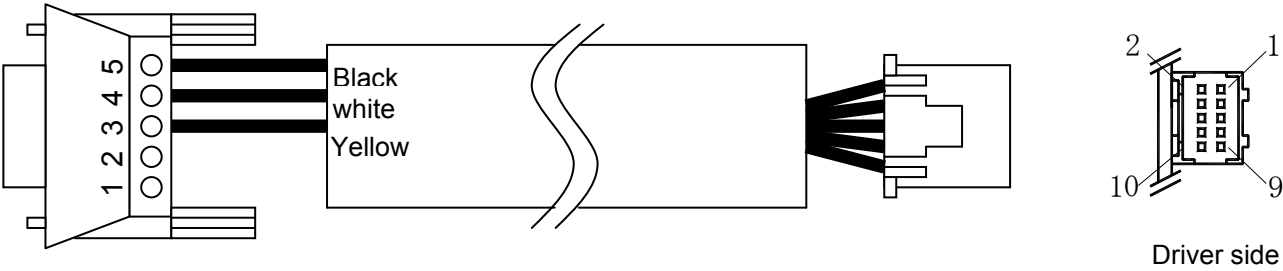
3. WIRING • Input/Output Signal Functions

6) Connector8 (PCIF)

■ Signal nam

Pin No.	Signal name	Pin No.	Signal name
1	A	6	VCC (Connection needlessness)
2	B	7	—
3	Non-connection	8	—
4	Non-connection	9	—
5	GND	10	—

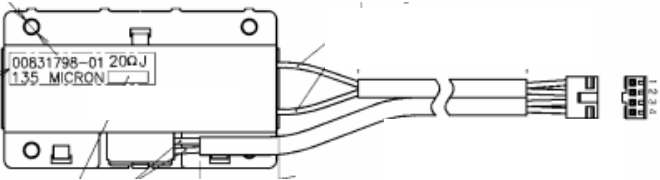
PBFM-U6 (Option)



Terminal Block Pin Function

Terminal Block		Communication
Pin No.	Signal name	Cable
1	T+	N.C.
2	T-	N.C.
3	R+(D+)	Yellow
4	R-(D-)	white
5	GND	Black

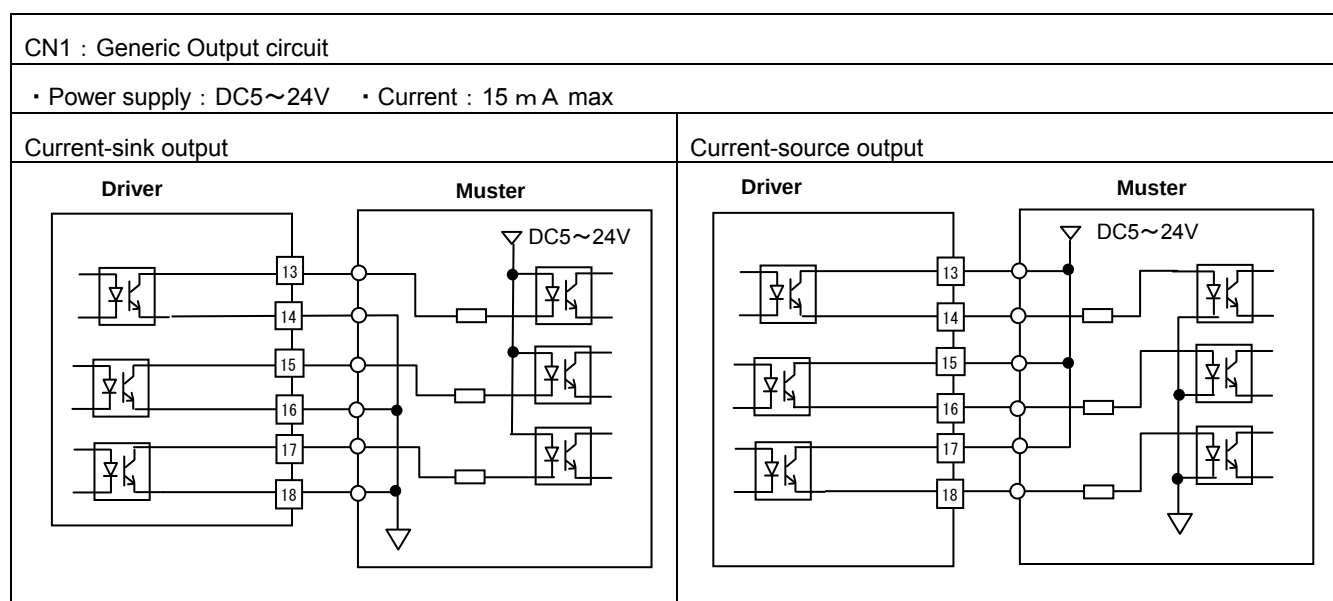
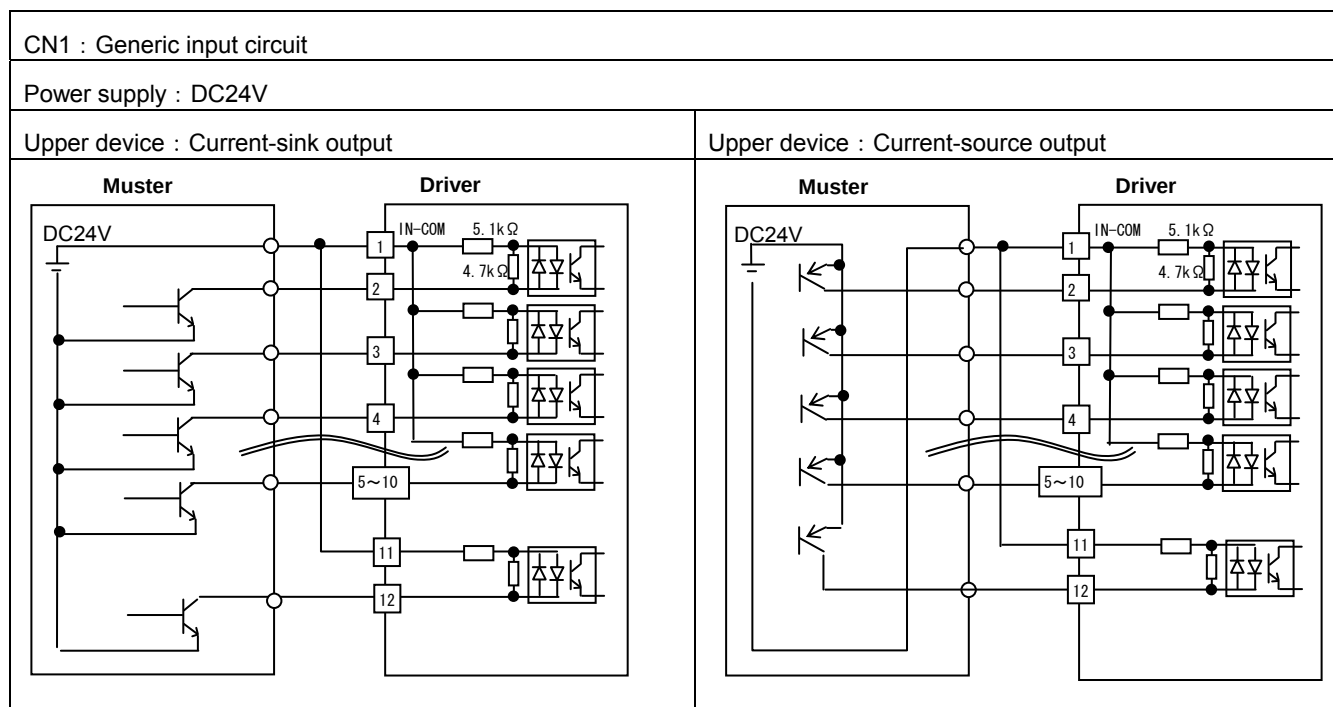
7) Connector8 (Regeneration resistance)



pin No.	Signal name
1	RB1
2	RB2
3	H1
4	H2

3. WIRING • Input/Output Signal Functions

3.4 Connection example with I/O



3. WIRING • Input/Output Signal Functions

3.5 Input/ output signal function

1) Input signal

■ Touch probe-input

This function is to latch sensor position at the moment digital input edge triggered.
Refer to section 7.4 (10) for the details.

- Input logic : Fixed (Edge rises on turning-on of photocoupler, falls on turning-off of photocoupler)
- Related-index : 0x60B8, 0x60B9, 0x60BA, and 0x60BB

■ Limit-input in positive/ negative direction

This is hardware limit signal-input.

Motor stops when Limit detected.

Direction of operation in Limit direction cannot accept after motor stops. Only operation command only in non-Limit direction is accepted.

Behavior when Limit detected in operation mode

In profile position/ velocity mode: Slows down by following the set value of 0x6084, and set the stop position to target position.

In cycle position/ velocity mode: Rapidly slows down with the position when Limit detected set to target position.

- Enabled/ disabled of input logic/ function : Follow the set value of 0x4010
- Definition of direction : Follow the set value of 0x607E

■ HOME-input

This is origin signal-input of device.

Shall be input for the motor of homing type using HOME sensor in homing mode.

- Enabled/ disabled of input logic/function : Follow the set value of 0x4010

■ Gate OFF-input

This is emergency stop-input and effective for two axes.

Interrupts excitation current running to motor and then change the state to "Switch on Disable" on turning-on of Gate OFF-input.

In the case of a motor with a holding brake, a brake will be in a hold state.

- Input logic : Fixed, On-active (on turning-on of photo-coupler)

2) Output signal

■ General output 1, 2

This function is general output with respect to each axis.

Output condition can be controlled by 0x60FE (axis1) and 0x68FE (axis 2).

■ Gate OFF-monitor

This is monitor-output of Gate OFF-input signal.

- Output logic : On = Gate OFF-input turned on

3. WIRING • Input/Output Signal Functions

3.6 Grounding

Amplifier grounding:

- Ground the amplifier using the CN6-5 pin(earth). Use single point grounding with at least AWG18 (0.75 mm^2) wire.

Motor frame grounding:

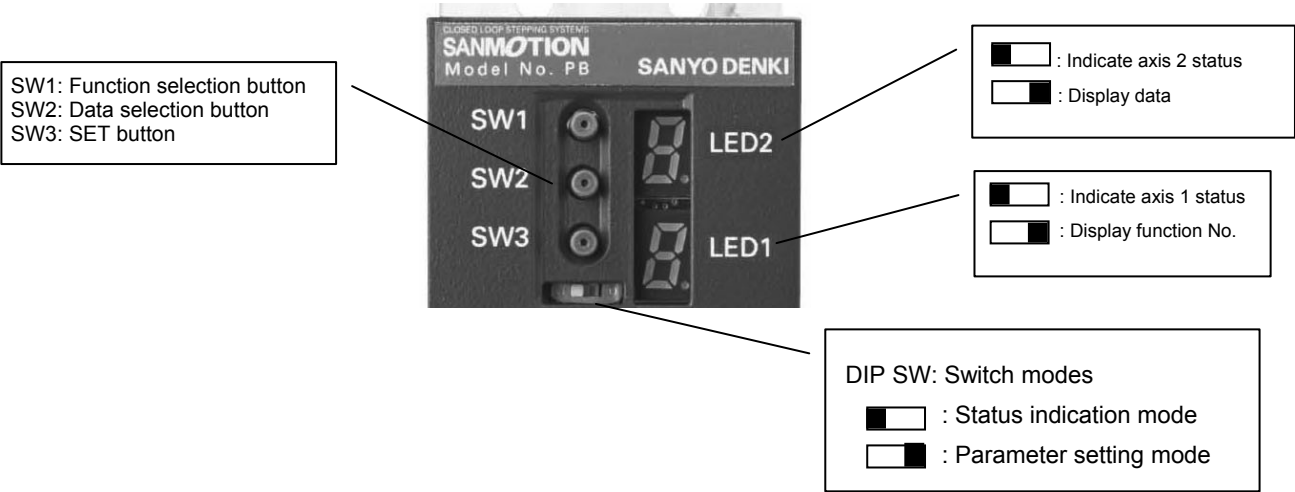
- If the motor is grounded through the frame, then $C_f \times dv/dt$ current flows from the PMW power part of the driver through the motor floating capacitance (C_f). It attaches to the metal side grounded by the power supply ground, or a motor frame is a motor grounding terminal. Please ground one point with a driver ground.
- Use at least AWG18 wire (0.75mm^2) for grounding the motor.
- If the motor is wired to a metal conduit or metal box, the metal must be grounded. Use single-point grounding.

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4. Indication・Digital Operator

4.1 Outline of Digital Operator

Digital operator equipped with driver provides functions of parameter setting and driver status indication. Each part name and the functions are shown below.



■ Switching function per each mode

DIP SW	LED 1	LED 2	SW1	SW2	SW3
	Status display of axis 1	Status display of axis 2	don't care	don't care	don't care
	Mode display	Data display	Mode selection	Data selection	SET button

4. Indication • Digital Operator

4.2 Status indication mode

LED1 displays status of axis 1, LED2 displays status of axis 2, by followings.

Status indication	Status	INC	ABS
-	Switch On disabled	Switch On disabled	Switch On disabled
=	Ready to Switch on	Ready to Switch on	Ready to Switch on
≡	Switch On	Switch On	Switch On
Figure-of-eight	Operation enabled	Operation enabled	Operation enabled
0	Fault	ALM of the other axis	ALM of the other axis
1	Fault	Others	Others
2	Fault	Peripheral circuit	Peripheral circuit
3	Fault	Over voltage	Over voltage
4	Fault	Voltage dropped	Voltage dropped
5	Fault	Regeneration error	Regeneration error
6	Fault	Sensor disconnected	Sensor disconnected
7	Fault	Initialization operation error	Motor code error
8	Fault	Two-axis synchronization error	Two-axis synchronization error
9	Fault	Velocity difference error Position deviation error Overload error	Velocity difference error Position deviation error Overload error
B	Fault	Operation error of travel to fixed stop	Operation error of travel to fixed stop
C	Fault	Origin return error	Origin return error
D	Fault	Winding overcurrent	Winding overcurrent
E	Fault	Bus overcurrent	Bus overcurrent
F	Fault	Memory error	Memory error
H	Fault	Regenerative resistor overheated	Motor/ regenerative resistor overheated
L	Fault	Driver overheated	Driver overheated
U	Fault	-	ABS error
∩	Fault	-	BAT error BAT warning

4. Indication • Digital Operator

4.3 Parameter setting mode

SW1: Selects any of the following functions. LED 1 indication is incremented (0 → 1 → 2) with respect to each time you press the button.

SW2: Sets the data for each function.

SW3: Data are set by pressing button for more two seconds.

Function No 7SEG1	Function	Data range	Function details
0	Set high-order address 4-bit	0 to F	Low-order 8-bit node address is set by rotary switch on the front face of driver and this setting. To get station alias value, add 0x4013: extended station alias to this setting value. The set value becomes effective with the next turning on of the power supply.
1	Jog-velocity (common in two axes)	1 to F (100min-1/LSB)	Sets JOG-velocity used for function 2 and 3 below. The same velocity is set for two axes. The set value is immediately updated.
2	Jog-operation of axis 1	-	This is JOG operation of axis 1. Operates in the positive direction by using SW2, negative direction by using SW3. LED2 displays the velocity set by function 1.
3	Jog-operation of axis 2	-	This is JOG operation of axis 2. Operates in the positive direction by using SW2, negative direction by using SW3. LED2 displays the velocity set by function 1.
4	Release brake of axis 1	1	This is JOG operation of axis 2. Operates in the positive direction by using SW2, negative direction by using SW3. LED2 displays the velocity set by function 1.
5	Release brake of axis 2	2	Releases holding brake of axis 2. Keeps to release while SW2 is being pressed. LED2 displays "2."
6 *1	Axis 1 motor code	0 to 6 (See table 1)	Sets motor code for axis 1 when using incremental sensor. The set value is immediately updated.
7 *1	Axis 2 motor code	0 to 6 (See table 1)	Sets motor code for axis 2 when using incremental sensor. The set value is immediately updated.
8	Regenerative resistor overheat detection allowed	0/1	Set "1" when connecting regenerative resistor. The set value becomes effective with the next turning on of the power supply.
9	Status transition of axis 1	1 to 3	Sets driver status. This setting shall be performed with no communications connected. 1: Transits to "Ready to Switch On"-state 2: Transits to "Switch on"-state 3: Transits to "Operation enable"-state * Status not transited when the transition is not feasible by considering current driver status.
A	Status transition of axis 2	1 to 3	

*1 In ABS, it skips.

Table1 Motor selection

Setting value	Motor model NO.	Setting value	Motor model NO.
0	PBM282	4	PBM565
1	PBM284	5	PBM603
2	PBM423	6	PBM604
3	PBM503	-	-

4. Indication • Digital Operator

List of function selections and switch functions

(Function number can be selected by SW1, and displayed on the LED1.)

Function No.	Function	LED2 indication value	Function of SW2	Function of SW3
0	Set high-order address 4-bit	Address	Select data	SET
1	Jog-velocity (common in two axes)	Jog-velocity	Select data	SET
2	Jog-operation of axis 1	Set value of Jog-velocity	Jog in the positive direction	Jog in the negative direction
3	Jog-velocity of axis 2	Set value of Jog-velocity	Jog in the positive direction	Jog in the negative direction
4	Axis 1-Release brake	1	Release	—
5	Release brake of axis 2	2	Release	—
6	Axis 1-motor code	Motor code	Select data	SET
7	Axis 2-motor code	Motor code	Select data	SET
8	Regenerative resistor overheat detection allowed	0: Prohibited 1: Allowed	Select data	SET
9	Axis1 Status transition	State No.	Select data	SET
A	Axis2 Status transition	State No.	Select data	SET

* Applicable index data are to be automatically updated by operator setting.

4. Indication • Digital Operator

4.4 EtherCAT indicator

There are 4 types of EtherCAT indicator, three green LEDs and one red LED.

- LA 0 indicator : Green LED
- LA1 indicator : Green LED
- RUN indicator : Green LED(GREEN)
- ERR indicator : Red LED(RED)



1) LA0/1, Link/ Activity indicator

With Link/ Activity indicator (green LED), you can check physical linking and operation status of each port, by checking the LED light state of lighted/ lighted-out/ flashing. Each state description of Link/ Activity indicator is shown below.

Explanation of Link/ Activity indicator

Link	Activity	Link/ Activity indicator LED state
Yes	No	ON (Lighted)
Yes	Yes	Flickering (Flashing)
No	-	OFF (Lighted-out)

2) RUN indicator “code: RUN”

With RUN indicator (green LED), you can check the status of state machine (EMS) in EtherCAT communication, by checking the LED light state of lighted/ lighted-out/ flashing. Each state description of RUN indicator is shown below.

Explanation of RUN indicator

RUN state	ESM	Status description
Off (Lighted-out)	INIT	“INIT”-state
Blinking	PRE-OPERATIONAL	“PRE-OPERATIONAL”-state
Single flash	SAFE-OPERATIONAL	“SAFE-OPERATIONAL”-state
On (Lighted)	OPERATIONAL	“OPERATIONAL”-state
Flickering (Flashing)	INITIALISATION or BOOTSTRAP	In the state of initialization, not transit to “INIT”-state. Or in “BOOTSTRAP”-state. (In the firm ware download operation)

4. Indication • Digital Operator

3) Error indicator

With Error indicator (red LED), you can check invalid state machine (ESM) change or watchdog errors, by checking the LED light state of lighted/ lighted-out/ flashing. Each state description of Error indicator is shown below.

Explanation of error indicator

Error state	Status	Description of state
Off (Lighted-out)	No errors	EtherCAT-communication normally works.
Flickering (Flashing)	Boot error	Boot error occurred. • Error is set in AL status register although the state transited to INIT-state.
Blinking	Invalid configuration	General configuration error • The case EDM transition command from Master equipment is disabled due to register or object settings.
Single flash	Invalid ESM change	An error is set in AL status register, because ESM was changed autonomously by Slave equipment. • The case the state automatically transited to Safe-Operational state, due to synchronous errors.
Double flash	Application PDI watchdog timeout	Application watchdog timeout occurred. • SyncManager watchdog timeout occurred.
On (Lighted)	PDI watchdog timeout	PDI watchdog timeout occurred. • CPU application controller does not operate.

5.1 About EtherCAT

This chapter describes the technical specifications for the network communication construction method, physical parameter adjustment method and the function activation method.

An appropriate knowledge of driver, motion control, networking and EtherCAT CoE (CANopen over EtherCAT) is required for the reader of this chapter.

Detailed information of EtherCAT can be obtained from the following ETG(EtherCAT Technology Group)website:

<http://www.ethercat.org/>

■ Trademark

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

1) Overview

Ether CAT is an abbreviation of **Ethernet for Control Automation Technology**. Ether CAT is an open network communication between master and slave units using the real time Ethernet developed at BECKHOFF Automation and is controlled by ETG (Ether CAT Technology Group).

Ether CAT makes various topological configurations possible, such as line, tree, daisy chain, drop line, etc.

Each slave node reads the output data transmitted from the master, while a telegram is forwarded to the next device. Similarly, the input data is inserted while the telegram passes through. Standard Ethernet protocol in accordance with IEEE802.3 maintained as the communication protocol; therefore, a new sub-bus construction is unnecessary for the EtherCAT connection.

This protocol allows transport of control data directly to each Ethernet frame. The frame may consist of multiple sub-telegrams and realized Broadcast and Multicast communications with logical process images up to a possible 4 gigabytes in size.

A cable length of 100m maximum is possible between devices, and the size of the network is virtually unlimited since up to 65535 slaves can be connected under the 100BASE-TX Ethernet.

In addition, a switch-based reciprocal connection with ordinary TCP / IP is also possible.

2) EtherCAT Profile

■ IEC61158 Section12

- IEC61158-2-12 (EtherCAT Physical Layer Specification and service definition)
- IEC61158-3-12 (EtherCAT Data-link service definition)
- IEC61158-5-12 (EtherCAT layer service definition)
- IEC61158-6-12 (EtherCAT layer protocol specification)

IEC61158 is the forms of the international fieldbus standards including Ethernet-based field buses with the descriptions that define the basic communication structure of the networks.

EtherCAT protocol is added as "Type 12" that directs EtherCAT Communication Profiles such as EtherCAT State Machine (ESM), Process Data Communication System using the features of the Fieldbus Memory Management Unit (FMMU), CoE Service Channel maps to the EtherCAT Mailbox, SyncManager (SM) and synchronization structure using Distributed Clocks (DS).

■ IEC61800 Part7 (Adjustable speed electrical power drive systems)

- IEC61800-7-1 (Generic interface and use of profiles for power drive systems - Interface definition)
- IEC61800-7-200 (Generic interface and use of profiles for power drive systems - Profile specifications)
- IEC61800-7-300 (Generic interface and use of profiles for power drive systems - Mapping of profiles to network technologies)

IEC61800 in Part7, Power Drive System(PDS) profile, defines the functional operations of the servo drive systems. Section1 defines the generic interface and use of profiles for PDS.

Section200 defines the specifications of profile types. The object dictionary of data protocol, CiA402, state transition FSA and operation mode functions are explained in Profile type1 (-201) and primarily SERCOS IDN and phase are explained in Profile type4(-204) in detail.

Section300 defines mapping of network technologies. CANopen and CANopen over EtherCAT are explained in the Mapping of profile type1 (-301) and the communication protocols such as SERCOS and Servo drive over EtherCAT are explained in the Mapping of profile type4 (-304).

5.2 Model (Reference Model)

1) OSI Reference Model

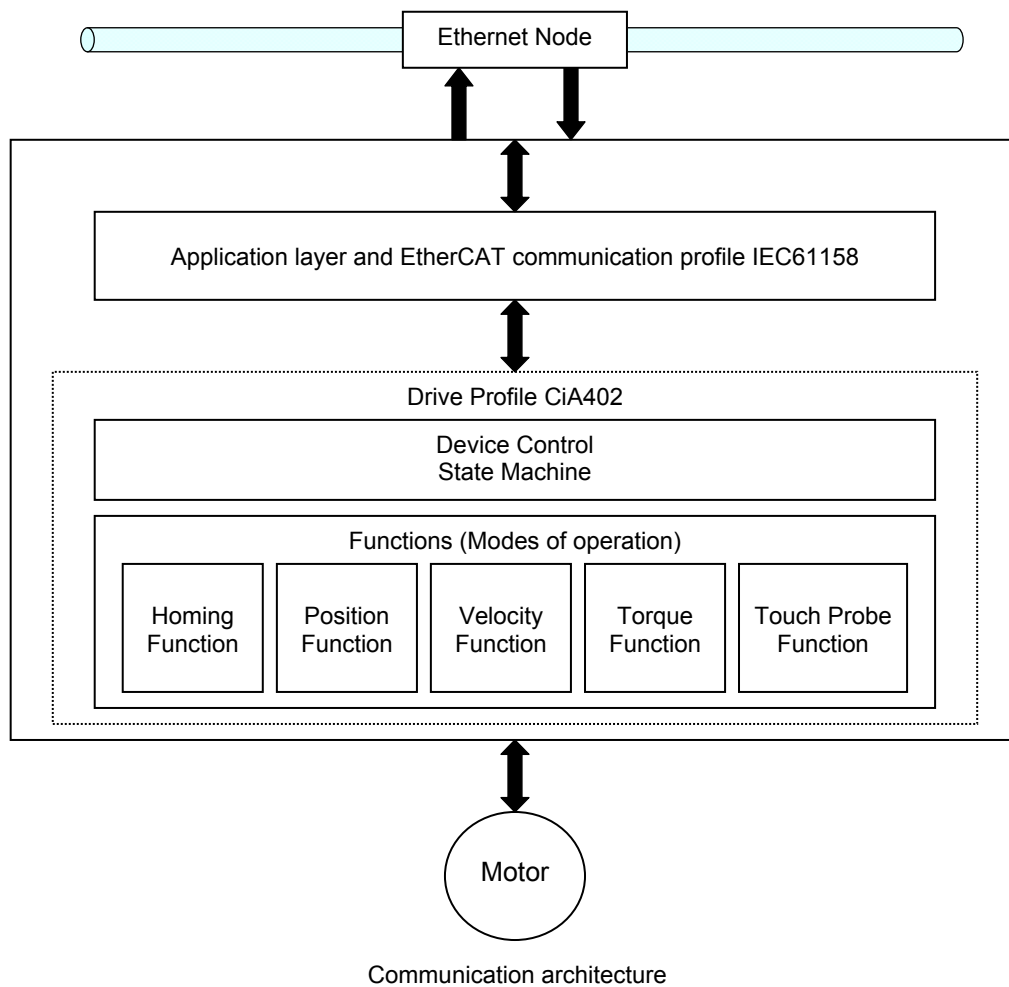
Compared with the OSI (Open Systems Interconnection) reference model, the EtherCAT communication model has no layers in layers 3 - 6.

Comparison of OSI reference model and EtherCAT (CoE) model

Layer	OSI reference model		EtherCAT model
7	Application (Application layer)		SDO (Service Data Object : Mailbox)
			PDO (Process Data Object)
			ESM (EtherCAT State Machine)
			ESI (Slave Information Interface)
6	Presentation (Presentation layer)	}	Empty
5	Session (Session layer)		
4	Transport (Transport layer)		
3	Network (Network layer)		
2	Data link (Data link layer)		SM (Sync Manager)
			FMMU (Field Memory Management Unit)
			PDI (Process Data Interface)
			DC (Distributed Clock)
1	Physical (Physical layer)		100BASE-TX
			E-BUS (LVDS for back plane)

- Layer 1 (Physical layer)
Takes charge of electrical conversion and mechanical work to send out data to communication circuits. The pin shapes and cable characteristics are also specified on this layer.
- Layer 2 (Data link layer)
Ensures the physical communication path and detects data errors passing through the path.
- Layer 3 (Network layer)
Selects the communication path to deliver the data and controls the address inside the path.
- Layer 4 (Transport layer)
Performs data compression, error correction and resends data delivery controls absolutely and efficiently.
- Layer 5 (Session layer)
Establishes and releases virtual connection for sending / receiving data between communication programs.
- Layer 6 (Presentation layer)
Transforms received data from the session layer into an easier to use form and changes the data from the application layer into a form applicable for communication.
- Layer 7 (Application layer)
Provides various services utilizing data communication to users as well as to other programs.

2) Drive Architecture



* Model No.PB not supporting Torque Function.

5.3 Settings

1) Node ID

Each slave drive in the EtherCAT network can have its own respective node ID and the unique node ID setting is basically performed in the position addressing mode.
 Besides, 0 - 65535 axes addresses can be set using the 4 bit rotary switch (0x0 - 0xF:bit 3 - 0) at the front of the amplifier and with a set value of bit 15 – 4, previously written in the non-volatile memory (on R2 setup) inside the amplifier.
 The setting values will be written in the station alias setting register (0x0012) in an address space after the control power has been turned ON.
 When an axis address has changed under the control power ON status, re-input the power to enable the change in axis address.

2) Physical Communication Specifications

Physical Communication Specifications		
Item	Specifications	Notes
Topology	Line	
Data flow	Line: From the master to the first slave and then on to the last slave, shuttling back and forth.	
Communication media	Twisted pair cable	
Communication rate	100 Mbit/s	
Communication parameter settings	Auto-negotiation function with ISO/IEC 8802-3 Auto-crossover function	
Cycle time	Depends on application	
Device address	Selected address	
Synchronization	Special protocol for data change(DC)	
Slave telegram	Mailbox SDO telegram using EtherCAT CoE specifications	
Master telegram	Mailbox SDO telegram using EtherCAT CoE specifications	
Initialization	Input power >> Init >> Pre-Operational >> Safe-Operational >> Operational mode	
Cable length	100m max	Between nodes
Node	65,535 max.	Single segment

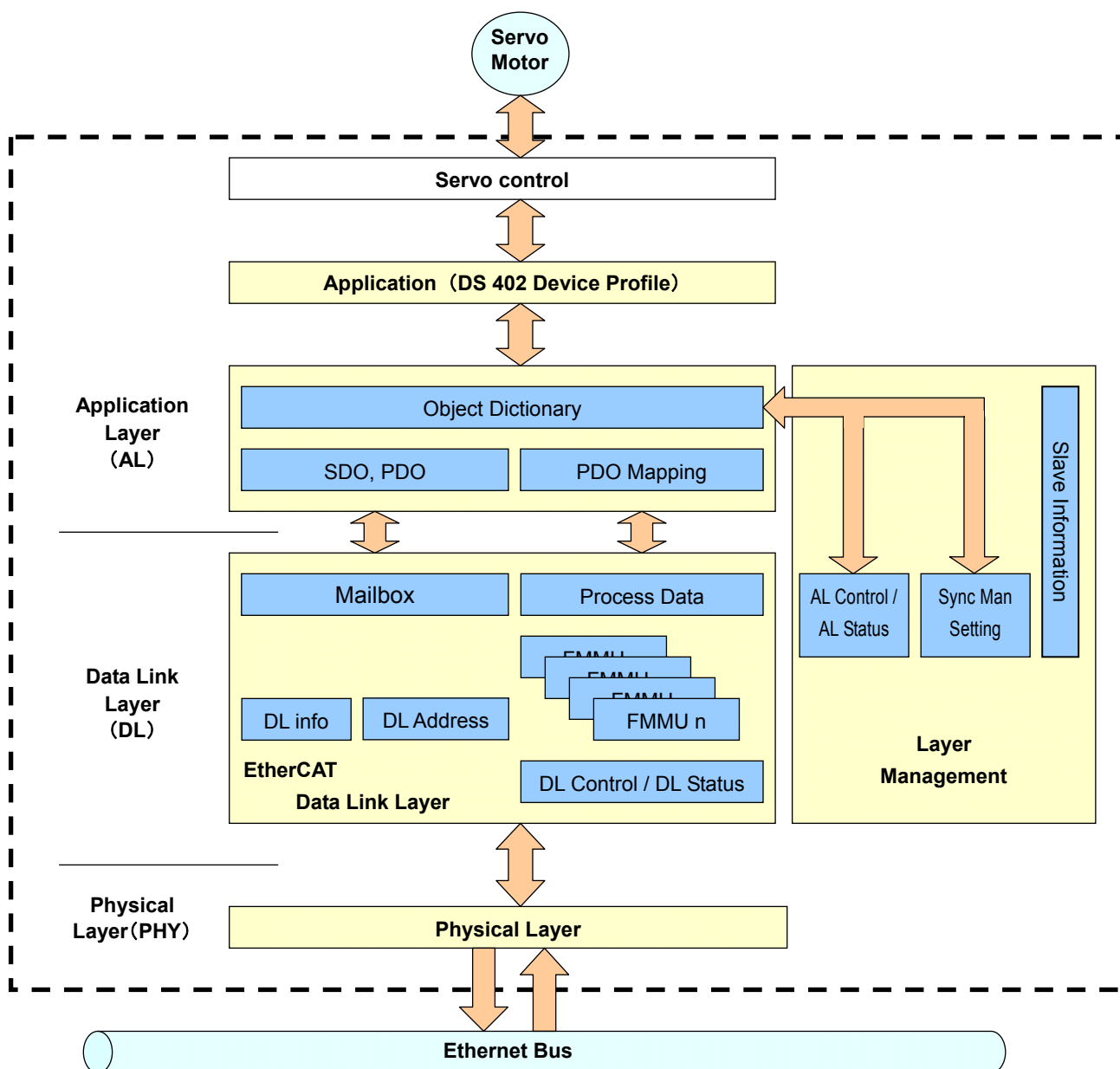
5.4 Communication Specifications

1) Device Model

- **Communication**
This unit includes the data transfer function via the network architecture base.
- **Object Dictionary**
The Object Dictionary affects the application object, the communication object and the state machine operations used in this device.
- **Application**
The communication device function of data conversion, according to the operational environment, is included in the application.

The Object Dictionary has a role as an interface between communication and application.

The explanation of the device application of each data item in the Object Dictionary is called a "Device Profile".



Object Dictionary and Device model

5. EtherCAT Interface

■ Object Index

All objects are addressed with a 16-bit index using a 4-digit hexadecimal number.

Objects are assigned in the Object Dictionary by individual groups.

The Object Dictionary outline prescribed in CoE is as follows:

Object Index Assignment	
Index (Hex)	Object
0x1000 - 0x1FFF	Communication Profile Area
0x2000 - 0x5FFF	Manufacturer Specific Profile Area
0x6000 - 0x9FFF	Standardized Device Profile Area
0xA000 - 0xFFFF	Reserved

2) Communication

■ Ethernet Protocol

Since EtherCAT is adopting IEEE 802.3 as its standard Ethernet frame, a standard network controller can be used.

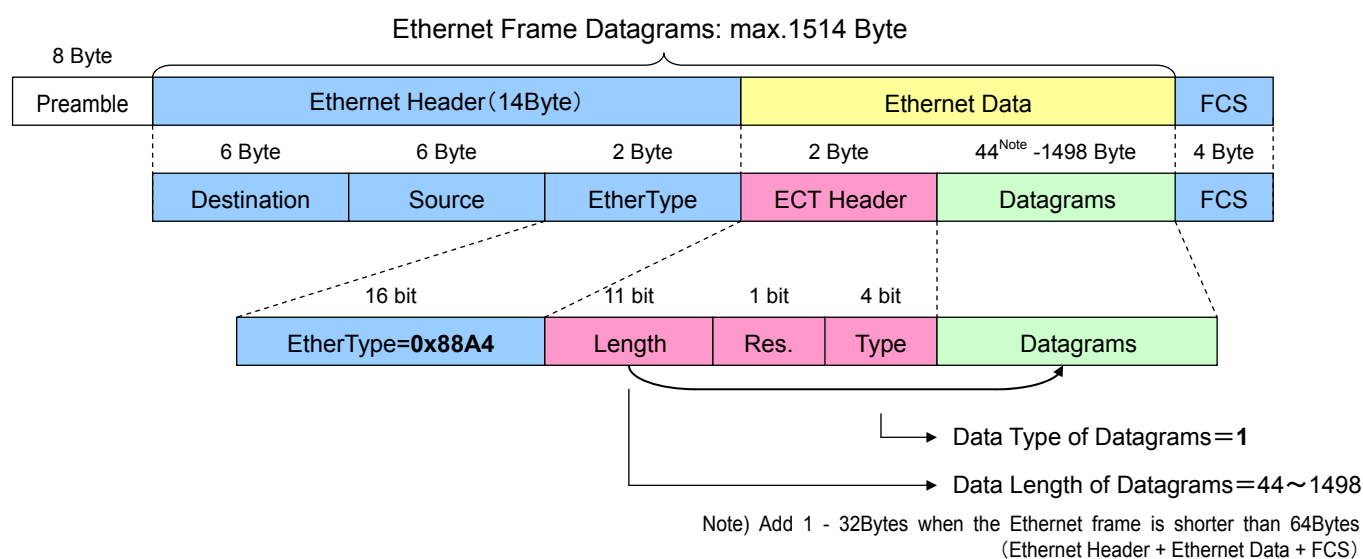
Therefore, system construction is possible on the master side without designing specific hardware.

“0x88A4” is reserved for the Ether type of EtherCAT and is distinguished from the other Ethernet frames.

EtherCAT does not require IP protocol.

The frame defines EtherCAT datagrams and divides them into detailed accounts at the EtherCAT frame header.

Only theType1 EtherCAT frame is processed by the slave in the EtherCAT header.

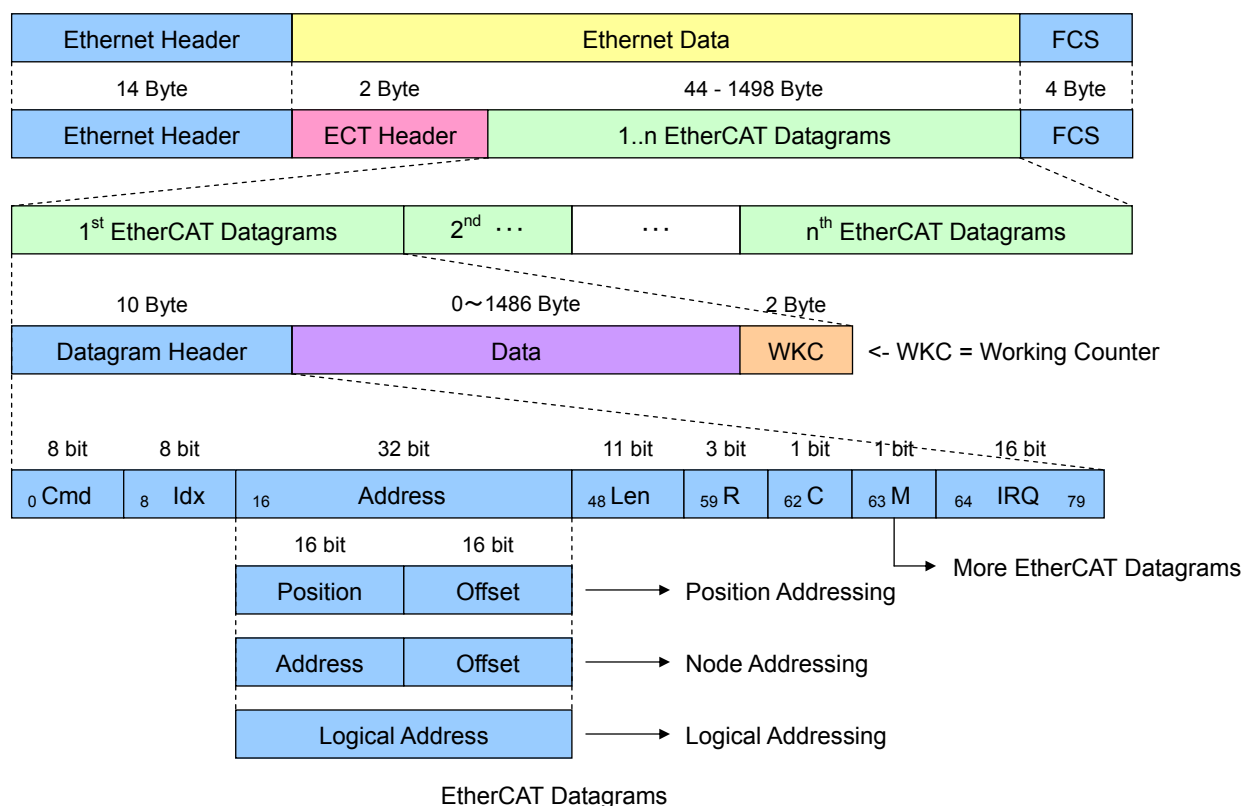


Ether Type and Ethernet Data Headers

5. EtherCAT Interface

3) EtherCAT Protocol

The commands are standardized as default values with the IEC61158 EtherCAT Communication Profile to simplify network structuring. Each node in a segment can be addressed individually and the EtherCAT datagrams can be used by one (1) Ethernet. The frame ends at the EtherCAT datagrams.



4) Datagram Header

A 10 Byte datagram header at the beginning of the datagram determines how to handle the following data:

EtherCAT Datagram Header		
Field	Data Type	Value / Explanation
Cmd	BYTE	EtherCAT command type
Idx	BYTE	Index is handled by the master for copy / datagram identification. This is a numeric identifier. It cannot be changed in a slave.
Address	BYTE [4]	Indicates the access method of the slave with a 32-bit address. · Auto-increment address (16bit device address+16bit offset address) · Node address (16bit device address+16bit offset address) · Logical address(32bit logical address)
Len	11bit	Data length following these datagrams
R	3bit	Reserved, 0
C	1bit	Circulating frame 0 : Frame is not circulating 1 : Frame was circulated before
M	1bit	Contiguous EtherCAT datagrams 0 : The last EtherCAT datagram (n th EtherCAT Datagrams) 1 : EtherCAT provide further contiguity (Example: 2 nd EtherCAT Datagrams will about the 1 st EtherCAT Datagrams)
IRQ	WORD	EtherCAT interrupt request register for all slaves is interlocked with the logic OR
Data	BYTE [n]	Read / Write data
WKC	WORD	Working counter

5. EtherCAT Interface

5) Command Type

Address and access method are determined by the 8-bit command at the head of the EtherCAT datagram. EtherCAT command types are listed below.

Read / Write operations and Read operation are executed before Write operation.

EtherCAT Command Types

CMD	Abbreviation	Name	Explanation
0 (0x00)	NOP	No Operation	Disregard commands
1 (0x01)	APRD	Auto Increment Read	Creates the increment address Sets Read data in the datagram when the receive address is 0.
2 (0x02)	APWR	Auto Increment Write	Creates the increment address. Writes data in the memory domain when the receive address is 0.
3 (0x03)	APRW	Auto Increment Read Write	Creates the increment address. Sets Read data in datagrams and writes the data in the same memory domain.
4 (0x04)	FPRD	Configured Address Read	Sets Read data in datagrams when address is matched.
5 (0x05)	FPWR	Configured Address Write	Writes data in datagrams when address is matched.
6 (0x06)	FPRW	Configured Address Read Write	Sets Read data in the EtherCAT datagrams and writes the data in the same memory domain when the address is matched.
7 (0x07)	BRD	Broadcast Read	All slaves set the logical OR of the memory domain data and datagrams data.
8 (0x08)	BWR	Broadcast Write	All slaves write data in the memory domain.
9 (0x09)	BRW	Broadcast Read Write	All slaves set the logical OR of the memory domain data and the datagram data then write the data in the memory domain (BWR is not generally used).
10 (0x0A)	LRD	Logical Memory Read	Sets read data for the datagrams when the receive address is matched with read setting FMMU
11 (0x0B)	LWR	Logical Memory Write	Writes the data in the memory domain when the receive address is matched with write setting FMMU.
12 (0x0C)	LRW	Logical Memory Read Write	Sets read data for the datagrams when the receive address is matched with read setting FMMU. Writes the data in the memory domain when the receive address is matched with write setting FMMU.
13 (0x0D)	ARMW	Auto Increment Read Multiple Write	Creates increment address. Inputs read data to the datagrams when receive address is 0. Other slaves write data in the memory domain.
14 (0x0E)	FRMW	Configured Read Multiple Write	Sets read data to the datagrams when address is matched. Other slaves write data in the memory domain.
15~255(0x0F - 0xFF)			Reserved

Addressing mode of EtherCAT datagrams 32bit Address is explained in the following table (1-7)

EtherCAT Addressing Mode

Mode	Field	Data Type	Value / Explanation
Auto Increment Address	Position	WORD	Each slave increment is respective to its position, and the slave at Position = 0 will be addressed.
	Offset	WORD	ESC Local register or Memory address
Configured Station Address	Address	WORD	Slave will be addressed when the set axis address matches the set station address (under the enabled condition)
	Offset	WORD	ESC Local register or Memory address
Logical Address	Address	DWORD	Slave will be addressed when the logical address (set by FMMU) FMMU configuration matches the address.

5. EtherCAT Interface

6) WKC (Working Counter)

Each EtherCAT datagram will end with a 16 bit working counter (WKC).
The working counter counts the device number normally accessed by EtherCAT datagrams.
Also, the working counter is incremented by the ESC (hardware) in which the slave amplifier is loaded.
Each datagram should have an estimated working counter value calculated in the master.
The master can confirm if EtherCAT datagrams have executed processing or not by comparing the estimated value to counted by the WKC and the result of the commands to each slave.

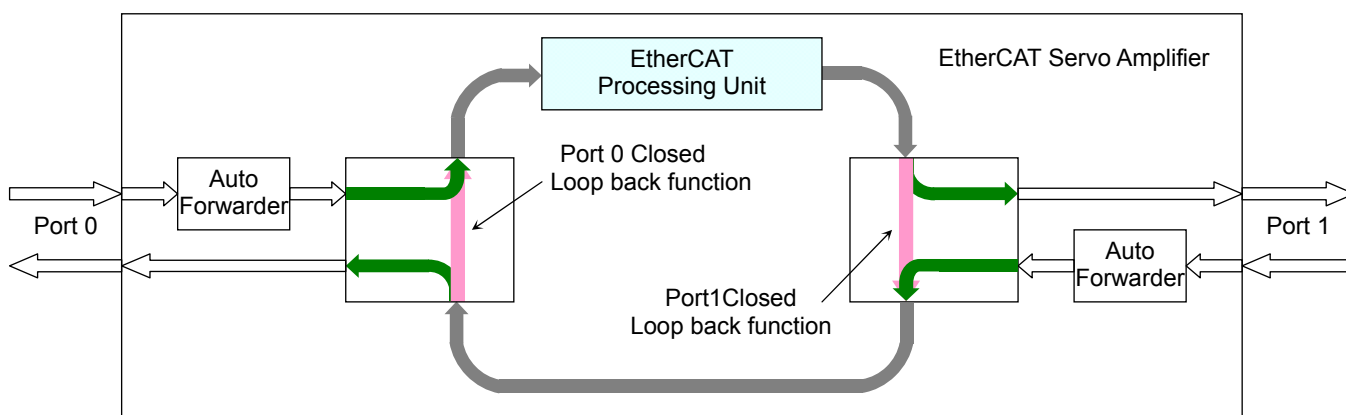
Working Counter Increment		
Command	Data Type	Increment
Read Command	Failed	No change
	Read succeeded	+1
Write Command	Failed	No change
	Write succeeded	+1
Read / Write Command	Failed	No change
	Read succeeded	+1
	Write succeeded	+2
	Read / Write succeeded	+3

7) Frame Processing

R-ADVANCED EtherCAT amplifier has two (2) parts and the frame processing order (processing) is according to the logical port number.

Usage Port		Frame Processing Order	
1 Port	Port0 -> Processing -> Port 0		
	Port1 -> Processing -> Port 1		
2 Ports	Port0 -> Processing -> Port 1 =>	Port 1 -> -> -> Port 0	
	Port1 -> -> -> Port 0 =>	Port 0 -> Processing -> Port 1	

The direction via the EtherCAT processing unit is called "Processing" and the direction that does not pass through the processing unit is called "Forwarding".



Frame Processing of R-ADVANCED EtherCAT Amplifier

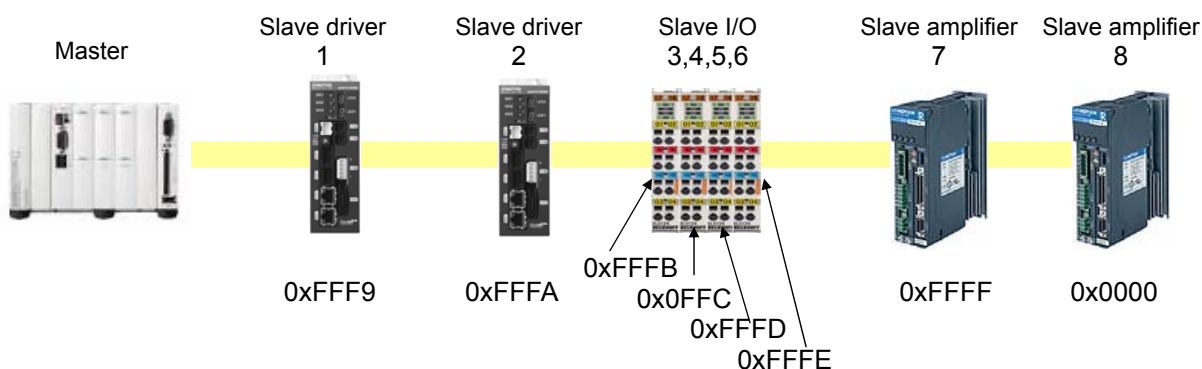
5.5 Addressing Image

1) Position Addressing (Auto-Increment Addressing)

Position addressing is a command to access slaves from the master according to the connection order (physical position).

Each slave device provides one (1) 16-bit address field every time datagrams pass through and a slave "0x0000" will be addressed and will respond when receiving the address field.

Position addressing image is as follows: Frame must be transmitted under the position setting of "0x0000" when addressing the 1st axis and "0xFFFF" when addressing the 8th axis.



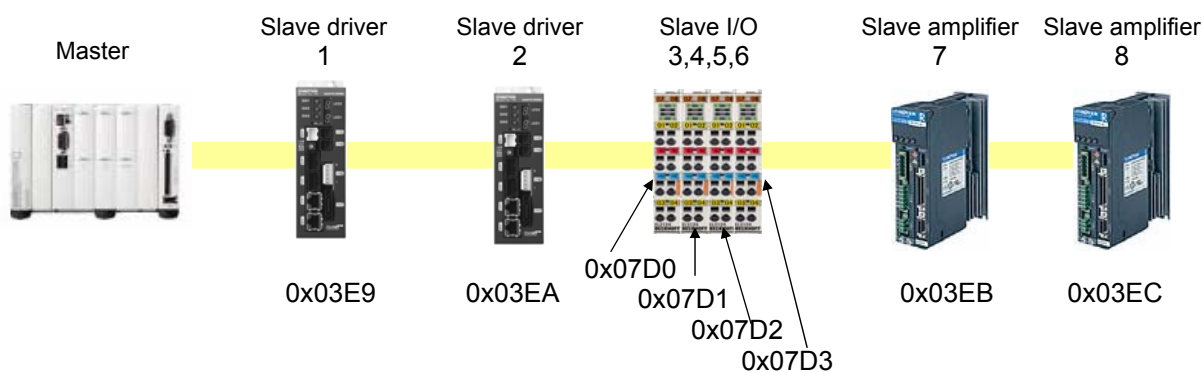
Position Addressing Image (Example: Addressing the 8th axis)

2) Node Addressing (Fixed Addressing)

The slave matched to the address set at station register (0x0010) from the master by position addressing is normally addressed in node addressing.

This enables access without fail even when a device is added, the segment topology has changed and/or the slave has been removed.

The respective slave node address is set with the rotary switch at the front of the amplifier and CoE Object Dictionary: an added value of the extension station alias (0x20FA) in the station alias. Therefore, identification is possible even if the connection order differs. Also, this address pattern is accessible by setting in DL Control.



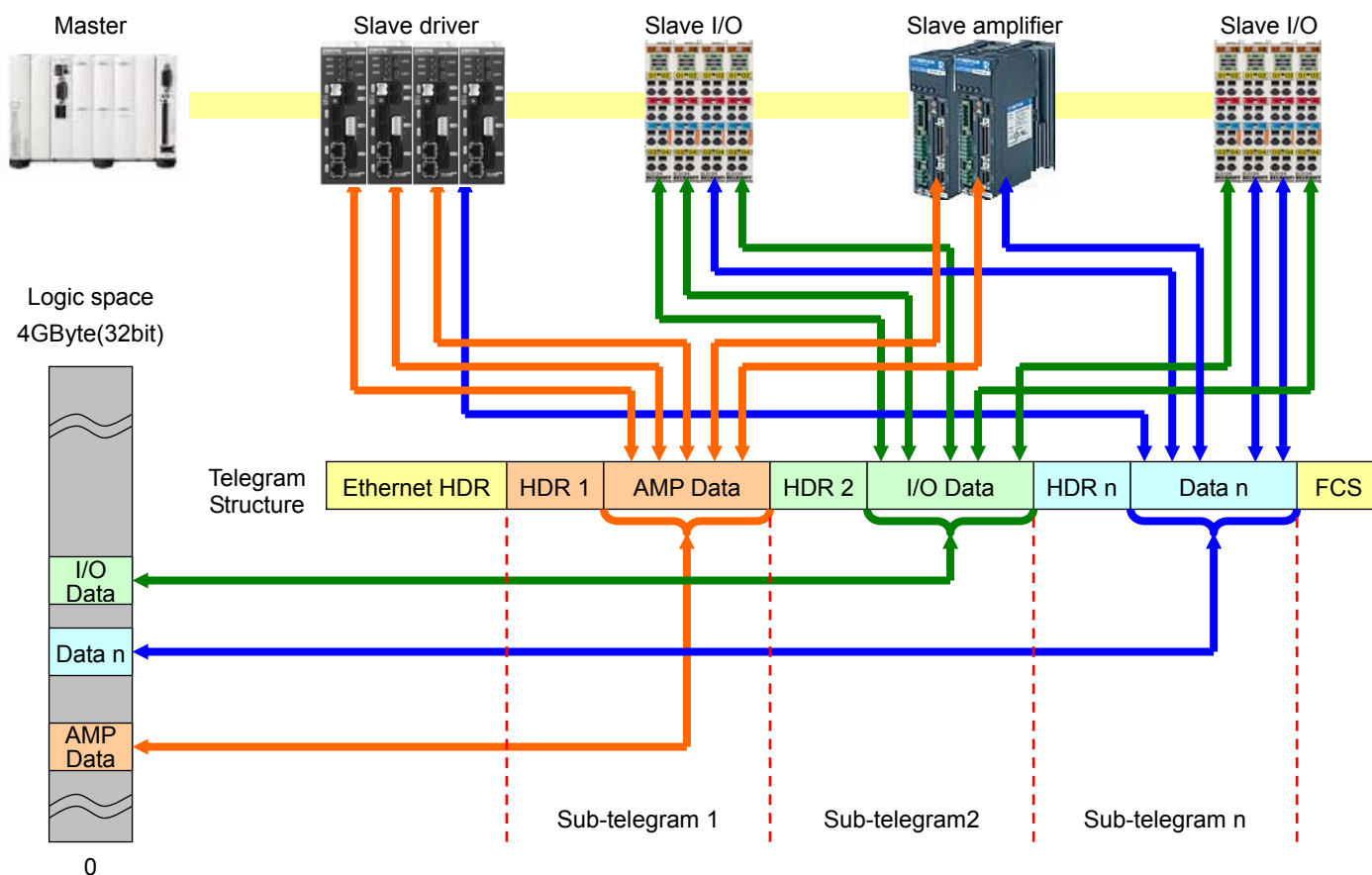
Node Addressing Image

5. EtherCAT Interface

3) Logical Addressing

A 32-bit address field for logical addressing inside the segment is used as one (1) address value. Logical addressing is not done individually but addresses the 4GB segment width of the logical address space. This section can be used for any slave number and can translate the 32 bit logical address to a physical address using the internal address mapping method of the Fieldbus Memory Management Unit (FMMU). Each FMMU channel maps the logical address space that abuts the contiguous physical address space of one of the slaves.

Logical addressing image is shown below.



Logical Addressing Image

4) FMMU(Fieldbus Memory Management Unit)

FMMU (Fieldbus Memory Management Unit) translates the ESC physical address and the 4GB (32bit channel) master logical address.

Each FMMU channel can manage a logical address controlled in the master and physical address extending over the respective slave in batch by allocating the contiguous logical address space of the master to the contiguous physical address space of the slaves.

The types of access configurations supported by FMMU are "Read", "Write" and "Read / Write".

5) SM (SyncManager)

ESC memory can be used for data conversion between the master and the slave *M*-controller without any limitation; however, it has some weak points because the internal ESC is addressed for using communication memory.

- The data integrity will not be guaranteed.
Signals must be executed with software for coordinate data conversion.
- The data security will not be guaranteed.
It is necessary to process the data security mechanism with the software.
- Both the EtherCAT master and slave (s) must poll the memory until either master or slave has confirmed the access completion notification.

Definite SM enable and normal data reception are converted between the master and slave and generate change notification interrupts to both sides.

SM is set in the master and uses a buffer set in the memory area for data conversion.

The communication direction is configured the same as the buffer and mailbox modes.

Access to this buffer is controlled by SM hardware, and it is necessary to access the Start address first. If not, access will be refused.

The entire buffer will be accessible after the start address is accessed.

The buffer ends with access to the end address and the buffer status will change. An interrupt will also be generated when the watchdog trigger pulse has been set.

The end address cannot be accessed twice in one frame.

Two (2) communication modes are supported in SM.

- **Buffer Mode**
Buffer mode enables access to the communication buffer at any time on both the EtherCAT master and slave side.
The reception side can always Read the latest buffer written on the transmission side. The transmission side can always update the buffer value.
However, old data will be dropped when the Write buffer is faster than the Read.
Buffer mode is generally used for PDO communications of $T \times \text{PDO} \cdot R \times \text{PDO}$.
- **Mailbox Mode**
Data will not be lost in mailbox mode because of the handshaking mechanism associated with data conversion.
Either the EtherCAT master or slave can access the buffer, but only when the other side has ended its access.
To begin, the transmission side Writes on the buffer, and the next Write command is locked until Read by the reception side.
Mailbox mode is generally used as an application layer protocol. The SM reception buffer will change in the master only when FCS (Frame Check Sequence) is normal. Therefore, the buffer will respond immediately after the frame ends.
The SM setting register is assigned from the address 0x0800.

6) Buffer Mode (3 Buffer Mode)

Buffer mode enables simultaneous data Read/Write on both the master and slave and is called 3 Buffer Mode.

Physically, three (3) same-sized buffers are allocated in this buffer mode and these set the start address as well as the first buffer size at configuration register SM 0-7 of 0x0800.

This buffer address will be defined for data Read/Write to be used for the master and slave.

Accessing the first (0) address width is performed by SM with automatic switching accessing to one of the three buffers.

Therefore, the master and slave only need to access the buffer (0) address.

Also, the memory to be used for buffers (1) and (2) will be reserved automatically and disabled. Please consider this domain carefully when setting another SM.

Generally, one buffer among the three is for Write use, one for Read use and another is reserved for Write use.

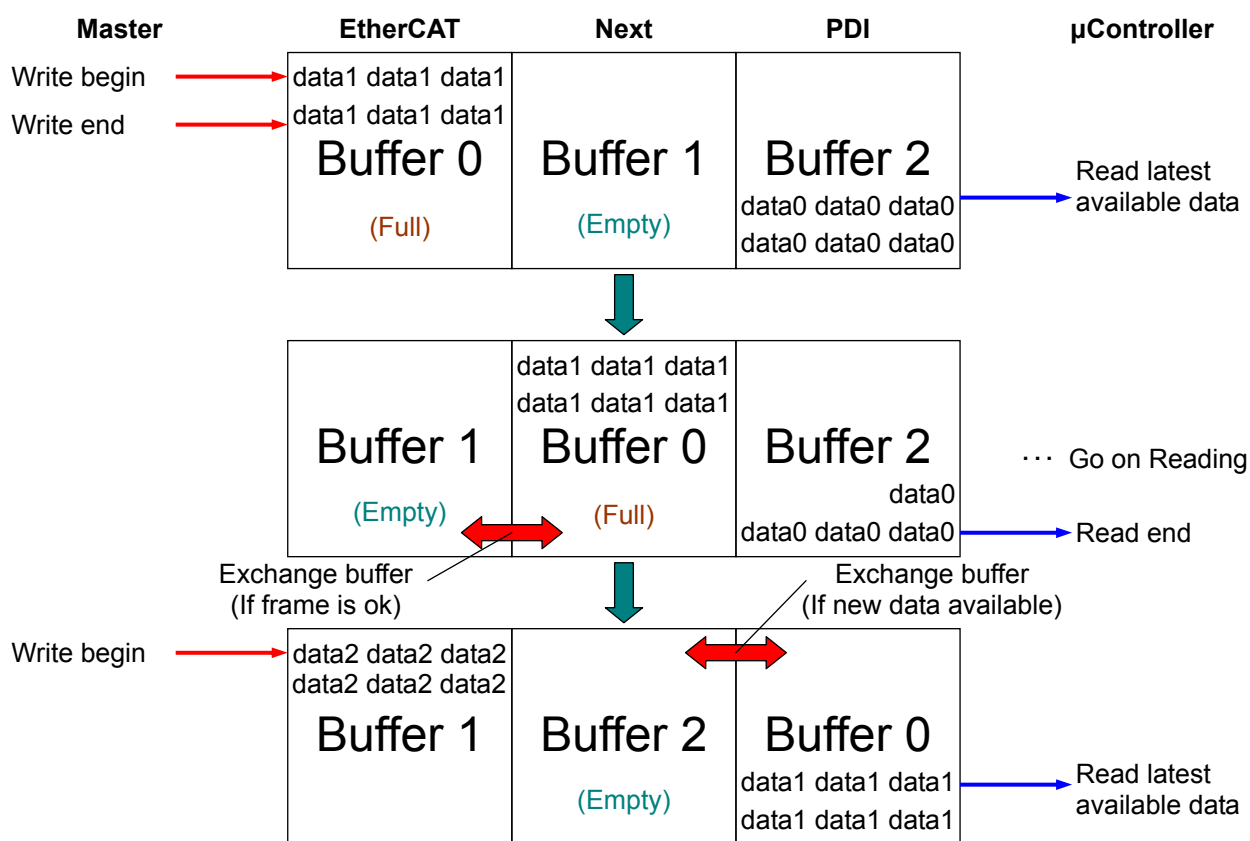
5. EtherCAT Interface

Shows the definition and data conversion example under the setting of: Start address: 0x0100 Data length: 0x0100

Buffer address	Object index
0x1000 - 0x10FF	Buffer 0 (Visible)
0x1100 - 0x11FF	Buffer 1 (Invisible disable)
0x1200 - 0x12FF	Buffer 2 (Invisible disable)
0x1300 -	Next useable domain

Both the master and slave access Buffer 0 because SM controls all buffers. Sets only Buffer 0 for SM setting.

Buffer Allocation for SyncManager Buffer Mode



Conversion example of SyncManager Buffer Mode (Master => Slave)

SM status register reflects the current status and the latest Write buffer status is displayed as in interrupt status. The latest Write buffer status shows "3" until the first Write of the SM buffer.

7) Mailbox Mode

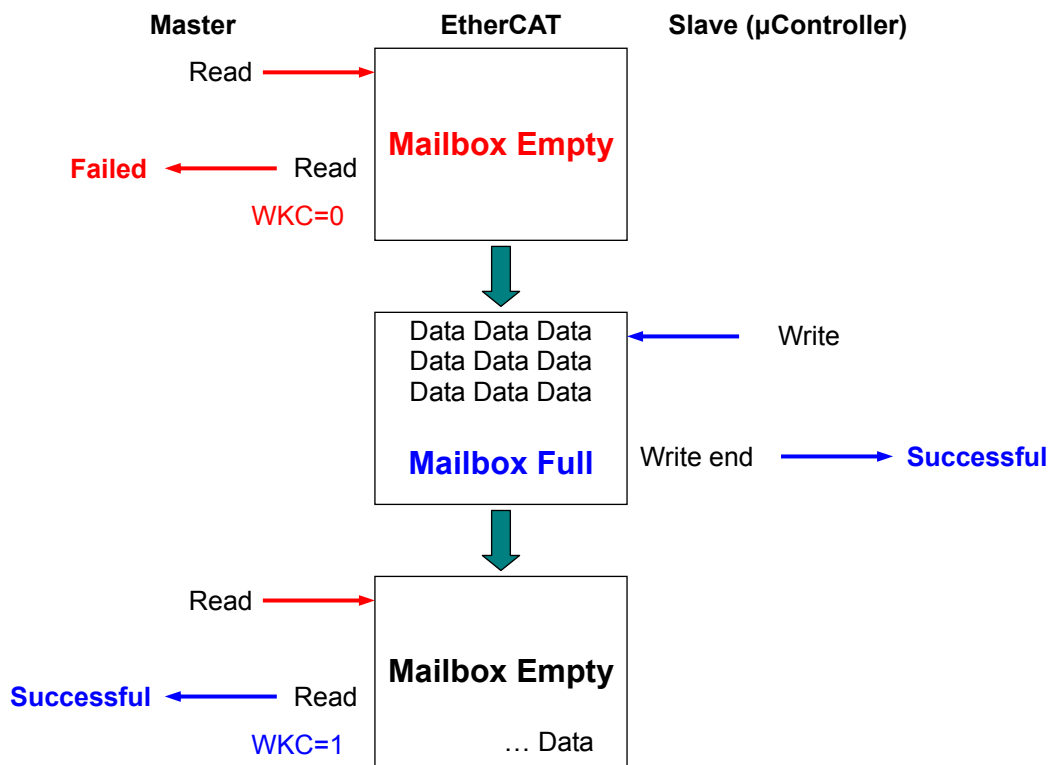
It is guaranteed that all transmitted data will be delivered to the reception side because the Write/Read are converted with handshaking in the mailbox mode.

Mailbox mode uses only one (1) size buffer set in advance and will be able to be used as a mailbox buffer after the initial settings and boot to SM.

When the initial data writing to the data is complete, write access will be blocked and the data can be read on the reception side.

After the data has been read normally, writing access to the buffer is permitted again.

The time required for data Read/Write is not important in this mode.



Mailbox Mode data conversion example (Master => Slave)

5. EtherCAT Interface

5.6 Accessing to Object Dictionary

R-ADVANCED EtherCAT amplifier supports CoE (CANopen over EtherCAT) with two (2) methods provided for accessing the Object Dictionary device.

- Service Data Object (SDO)
- Process Data Object (PDO)

1) Service Data Object (SDO)

The master can control many of the slave amplifier parameters such as device settings and the monitor, through Read/Write in the Object Dictionary entry, using SDO transfer.

The master, supporting EtherCAT CoE, performs SDO transfer to each slave device.

The data changes and the Read R_SDO is requested by T_SDO and transmitted from the SDO master.

2) Mailbox Protocol

The mailbox functions as a communication direction of master to slave / slave to master and supports various DL user protocols with an independent communication system differing from logical addressing.

Data transfer from slave to slave must be processed by the master.

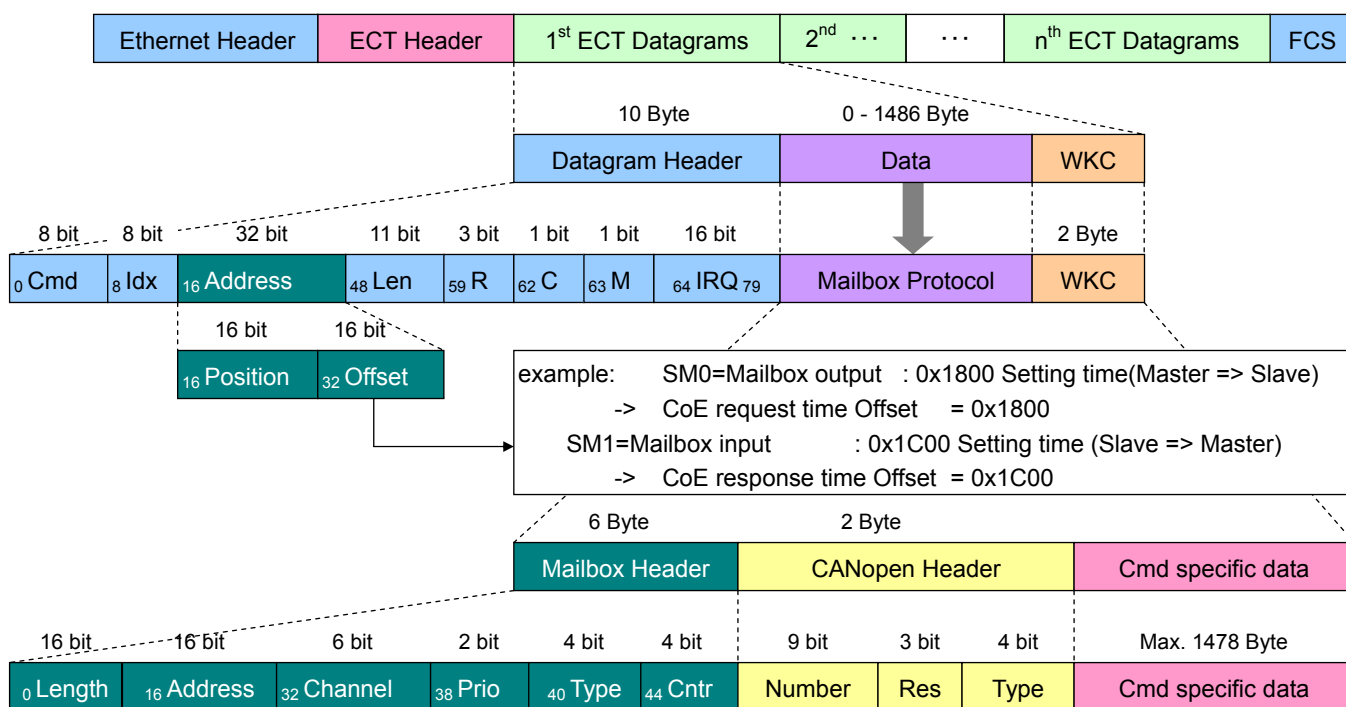
The Mailbox Header has an address field in the master that enables re-direction service.

Mailbox uses two (2) SyncManager (SM) channels: one (1) in each direction.

(Example: SM0: Master -> Slave direction, SM1: Slave -> Master direction)

The physical addressing method, with no FMMU, is necessary in mailbox communication instead of logical addressing because mailbox communication addresses a single slave intermittently.

Diagram for Mailbox - Interface and protocol configurations are shown below.



Mailbox - Interface

5. EtherCAT Interface

Mailbox Header Configurations

Name (Abbreviation)	Data Length	Explanation
Length (Len)	2 Byte	Data length to about the next
Address (Ad)	2 Byte	Sender's station address
Channel (Ch)	6 bit	Reserved (0x00)
Priority (Pr)	2 bit	Reserved Priority(0x00 - 0x03)
Type (Typ)	4 bit	Mailbox type. Protocol identifier for contiguous data 0 : Mailbox Error 3 : CoE (CAN open over EtherCAT)
Counter (Ct)	4 bit	Sequence number Incremented in every mailbox service as a duplicate detection. (Only 1 – 7 can be used because of compatibility to an old version)

3) CANopen Header Protocol

"CANopen Header" is configured with a 2Byte identifier composed of "Number" and "Type".
"CANopen Header" configuration is shown below.

CoE Command Configuration

Name (Abbreviation)	Data Length	Explanation
Number (Num)	9 bit	PDO number (PDO Use only in transmission time) 0x000 - 0x1FF
Type (Type)	4 bit	Message Type 0 : Reserved 1 : Emergency Message 2 : SDO Request 3 : SDO Response 4 : Reserved (TxPDO) 5 : Reserved (RxPDO) 6 : Reserved (Remote transmission Request of TxPDO) 7 : Reserved (Remote transmission Request of RxPDO) 8 : SDO Information 9 - 15 : Reserved

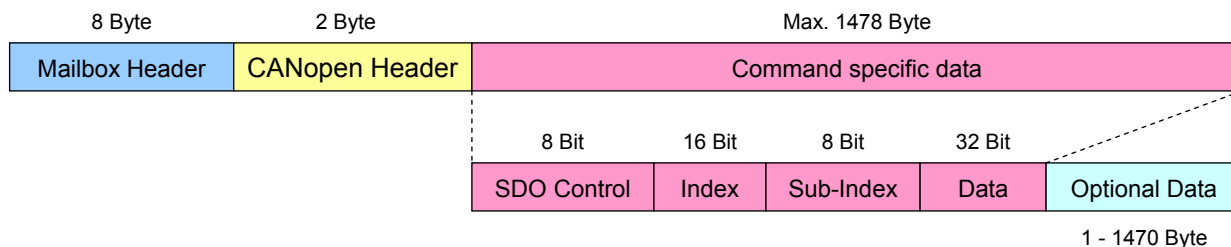
5. EtherCAT Interface

4) SDO Message

SDO message is configured by "CANopen Header" and "SDO Data frame".

Data transfer capacity is up to 4Byte standard and is possible for up to 1470Byte using the "optional Data" domain. Since most of them are smaller than 4Byte in the R-ADVANCED EtherCAT CoE amplifier, an expedited SDO transfer is possible.

SDO message configuration is shown below.



SDO Message List (example)

SDO Message Configuration

Name (Abbreviation)	Data Length	Explanation
SDO Control	1 Byte	Standard CANopen SDO service
Index	2 Byte	Object address by index
Sub-index	1 Byte	Object address by sub-index
Data	4 Byte	Data for SDO service
Option Data	1 - 1470 Byte	Transmission possible for heavier than 4Byte data with 1 frame at the time of Option command (Can be used up to full mailbox size)

■ SDO Command

Data Read / Write by the master begins by transmitting a command code "Index" and "Sub-index".

The slave responds to the request by returning the request data.

The same "Index" and "Sub-Index (Sub-idx)" of the request are added to the SDO response.

The response data length is determined by the SDO Command (cmd).

The slave returns an error message when the message is not accepted (Refer to SDO error messages).

The explanation for each command will be shown starting on the next page.

SDO Message List

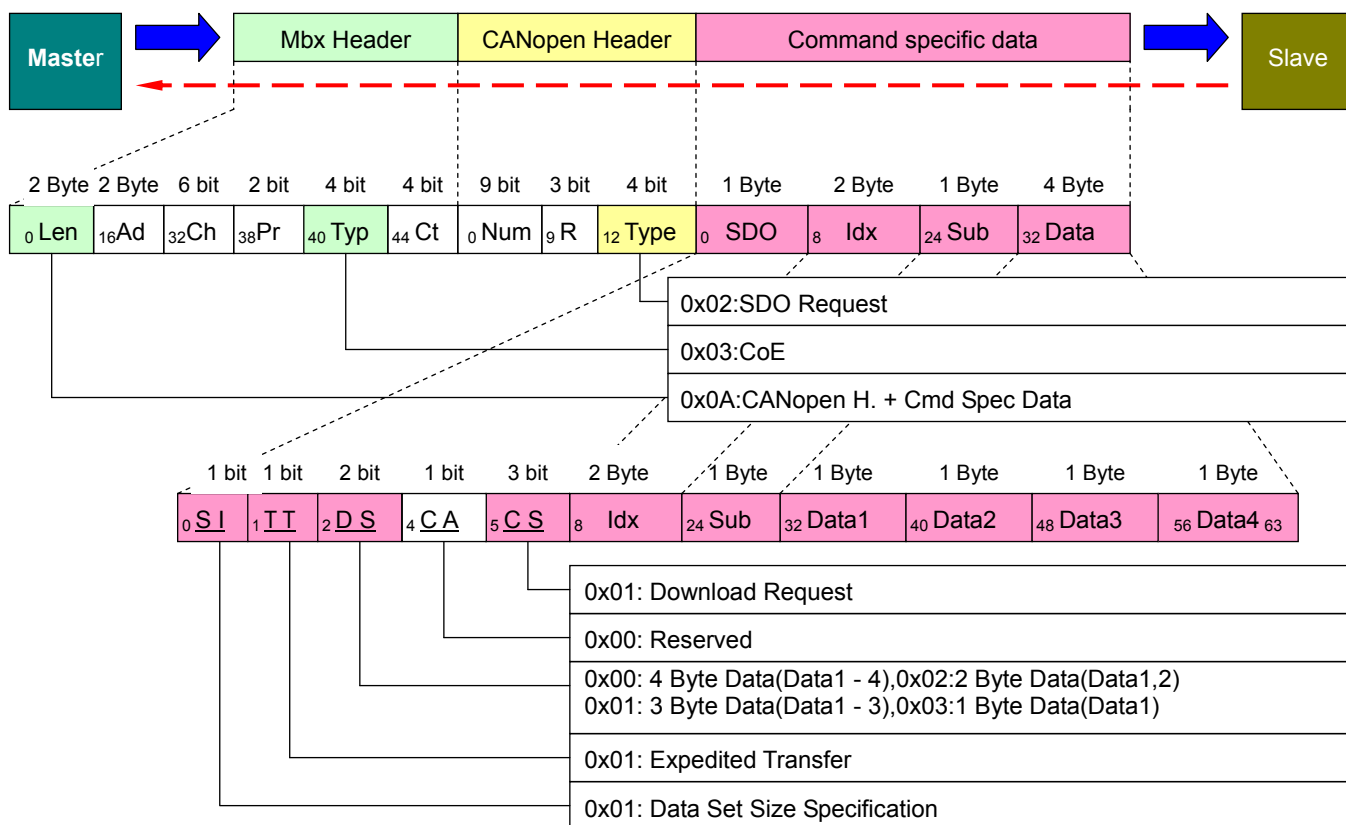
Command	Page/Diagram	Notes
SDO Download Expedited Request	Diagram 1	
SDO Download Expedited Response	Diagram 2	
SDO Upload Expedited Request	Diagram 3	
SDO Upload Expedited Response	Diagram 4	
SDO Download Normal Request	Diagram 5	
SDO Download Normal Response	Diagram 2	Same as Diagram 2
SDO Upload Normal Request	Diagram 3	Same as Diagram 3
SDO Upload Normal Response	Diagram 6	

Command specific Abbreviation Definition List

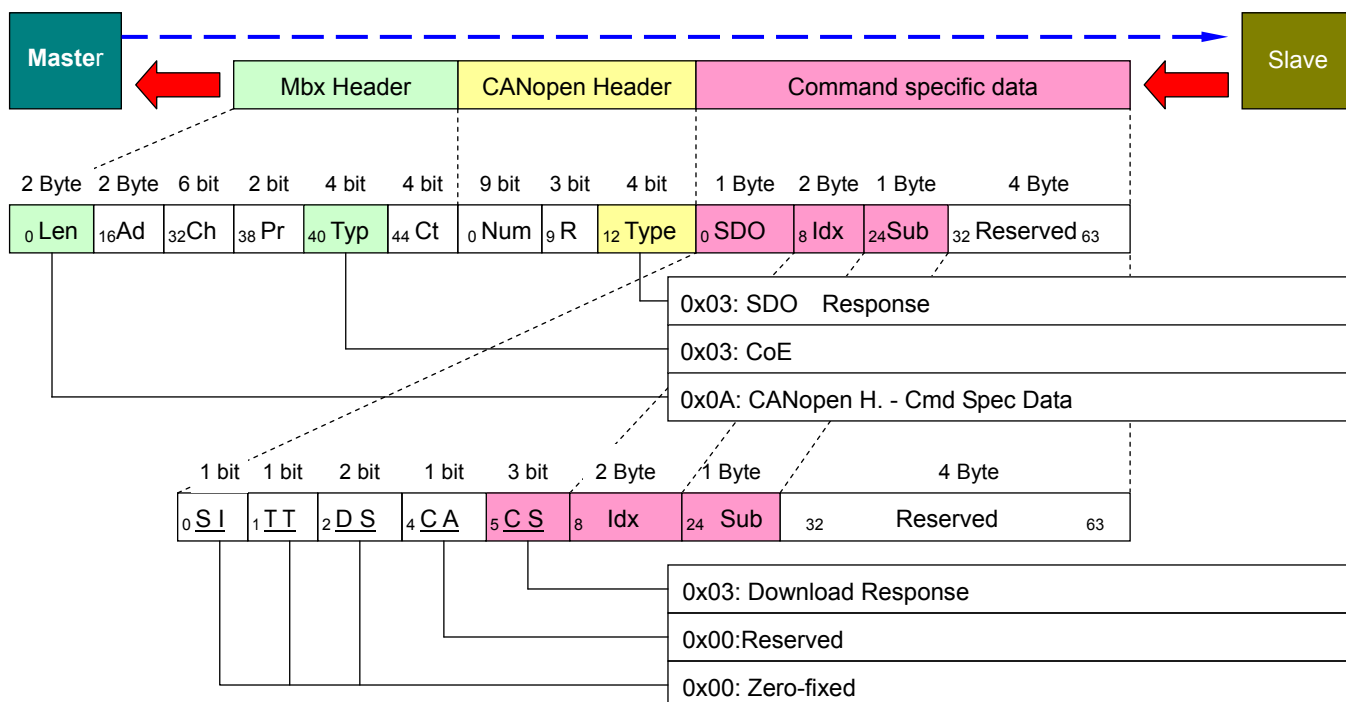
₀ Size Indicator	: ₀ S I	₁ Transfer Type	: ₁ T T
₂ Data Set Size	: ₂ D S	₄ Complete Access	: ₄ C A
₅ Command Specific	: ₅ C S	₀ SDO Control	: ₀ SDO
₈ Index	: ₈ Idx	₂₄ Sub-Index	: ₂₄ Sub
₃₂ Complet Size	: ₃₂ Cmp S		

5. EtherCAT Interface

■ SDO Download Expedited Request



■ SDO Download Expedited Response



5. EtherCAT Interface

■ SDO Upload Expedited Request

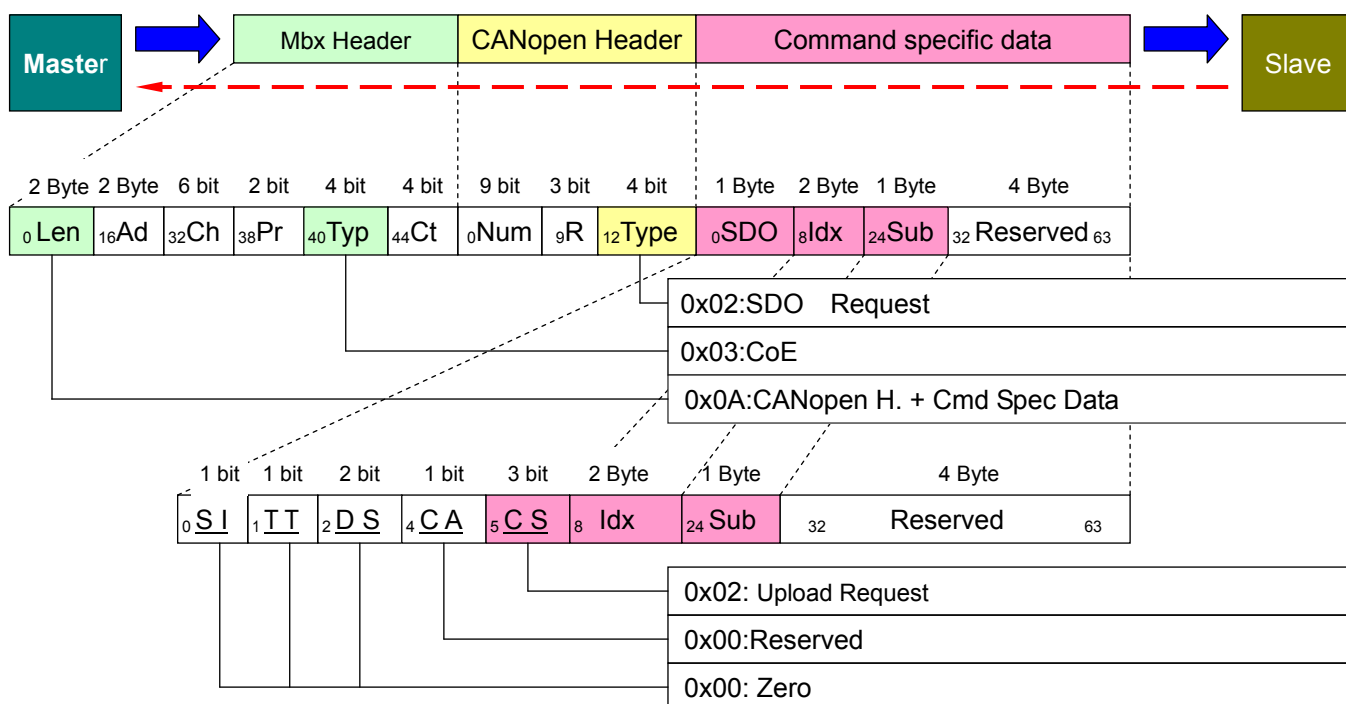


Diagram 3 : SDO Upload Expedited Request

■ SDO Upload Expedited Response

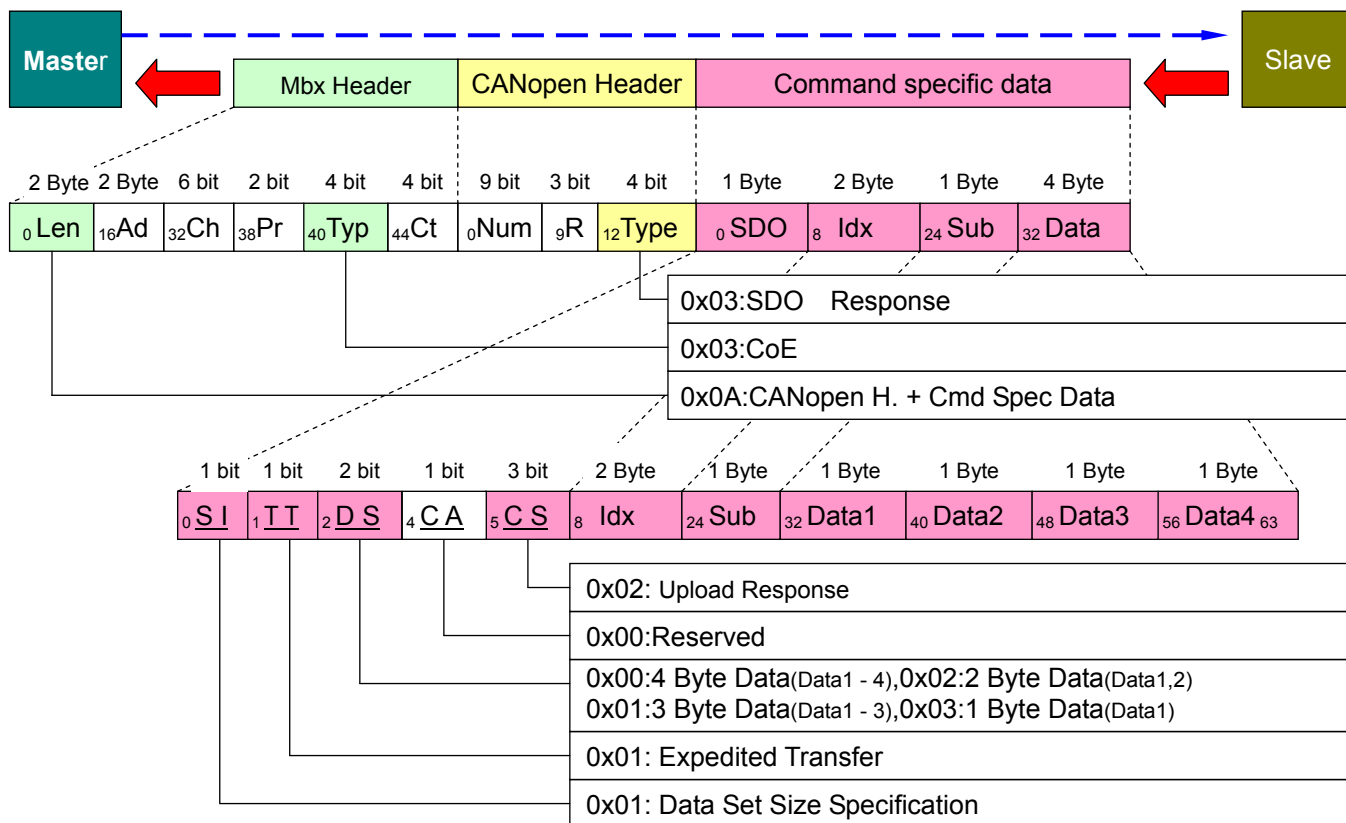


Diagram 4 : SDO Upload Expedited Response

5. EtherCAT Interface

■ SDO Download Normal Request

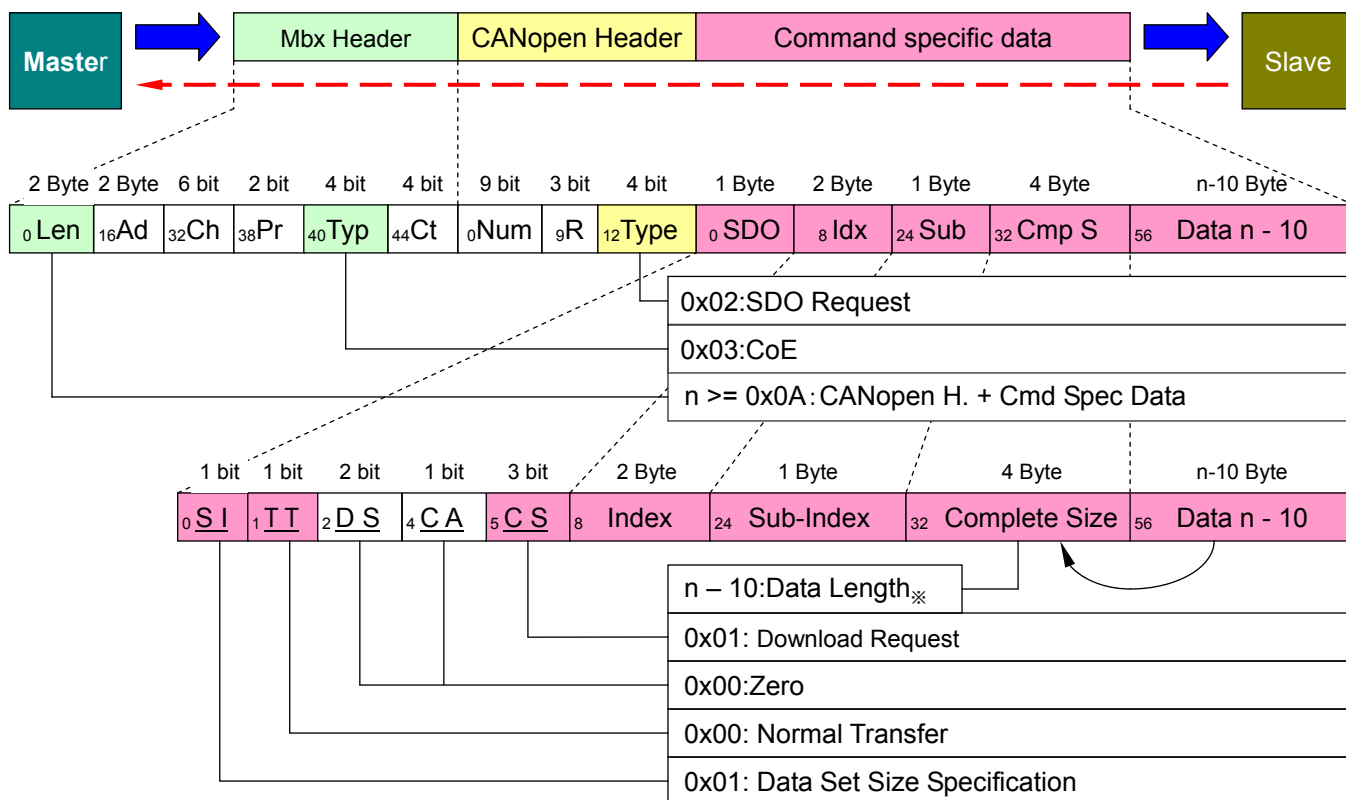


Diagram 5 : SDO Download Normal Request

■ SDO Download Normal Response

SDO Download Normal Response has the same configuration as SDO Download Expedited Response
Please refer to Diagram 2: SDO Download Expedited Response

5. EtherCAT Interface

- SDO Upload Normal Request
“SDO Download Normal Response” has the same frame configuration as “SDO Upload Expedited Request”.
Please refer to Diagram 3 : SDO Upload Expedited Request

- SDO Upload Normal Response

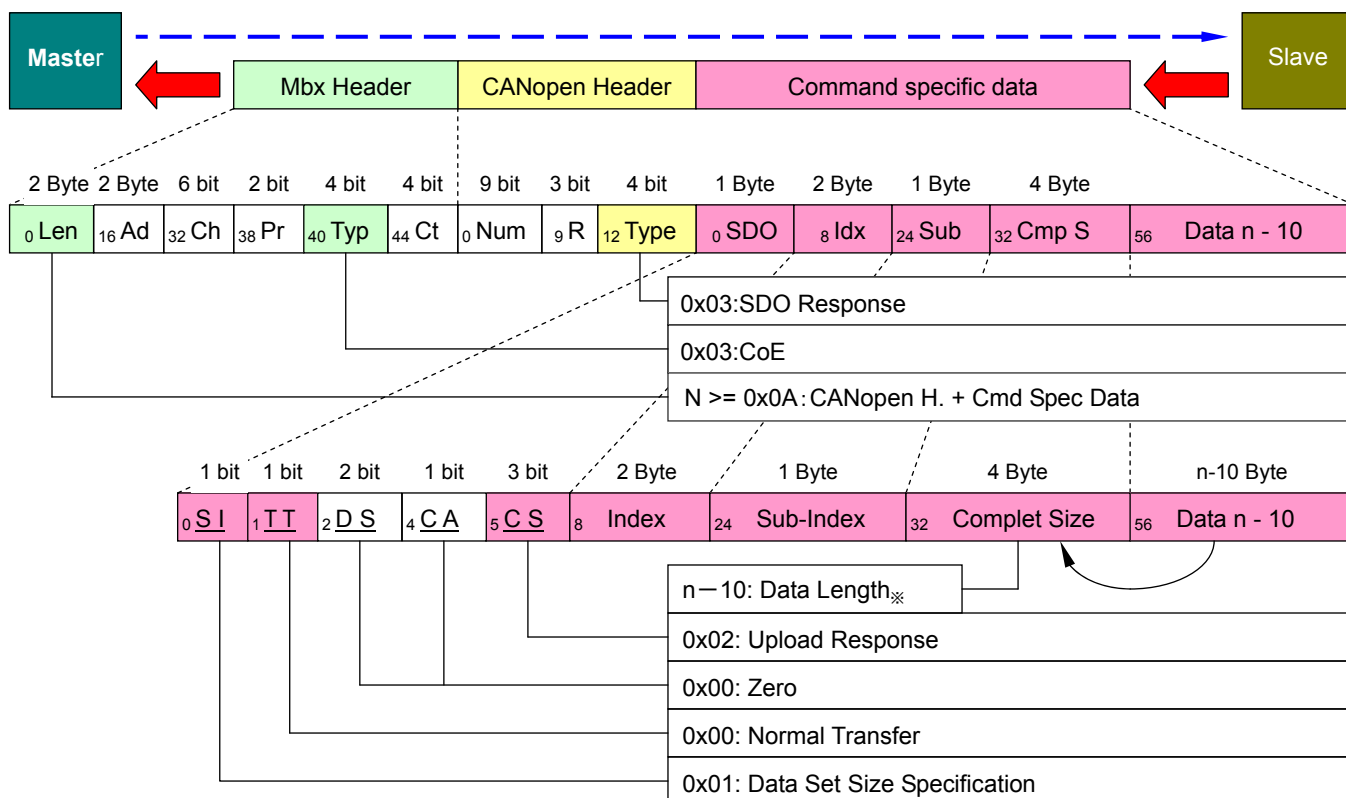


Diagram 6 : SDO Upload Normal Response

5. EtherCAT Interface

■ Abort SDO Transfer

The slave returns an error message as a response to the SDO request when the SDO message has not been accepted for some reason (value is out of set range, etc.)
The Abort SDO message structure details and abort code list are as follows:

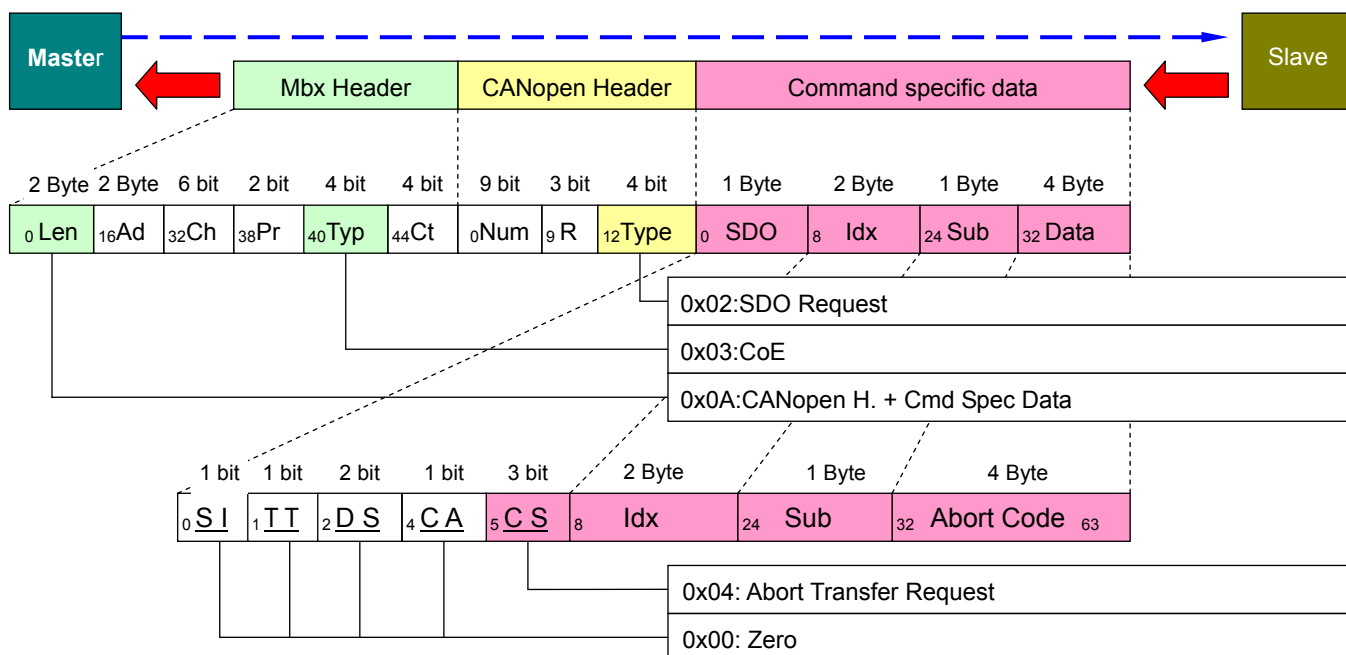


Diagram7 : Abort SDO Transfer Request

SDO Abort Code

SDO Error Code	Explanation
0x05 03 00 00	Toggle bit did not change
0x05 04 00 00	SDO Protocol Timeout
0x05 04 00 01	Client/Server Command Code disability unknown
0x05 04 00 05	Out of memory range
0x06 01 00 00	An access is not corresponding to the object
0x06 01 00 01	Read has been executed to the object corresponding to Write only
0x06 01 00 02	Write has been executed to the object corresponding to Read only
0x06 02 00 00	The object does not exist in the Object Dictionary
0x06 04 00 41	Cannot map the object with PDO
0x06 04 00 42	The number of mapping objects or the data length has exceeded PDO limitation
0x06 04 00 43	Non-compatibility of generic parameters
0x06 04 00 47	Non-compatibility of generic internals of device
0x06 06 00 00	Access failure because of hardware error
0x06 07 00 10	Data type not coordinated because service parameter length does not match
0x06 07 00 12	Data type not coordinated because service parameter length is too long
0x06 07 00 13	Data type not coordinated because service parameter length is too short
0x06 09 00 11	Sub-index does not exist
0x06 09 00 30	Exceeds the parameter value range (Exclusive for Write access)
0x06 09 00 31	Write parameter is too large
0x06 09 00 32	Write parameter is too small
0x06 09 00 36	The maximum value is smaller than the minimum value
0x08 00 00 00	General error
0x08 00 00 20	Cannot transfer or store data into an application
0x08 00 00 21	Cannot transfer or store data into an application because of local control
0x08 00 00 22	Cannot transfer or store data into an application under present device state
0x08 00 00 23	Object Dictionary does not exist

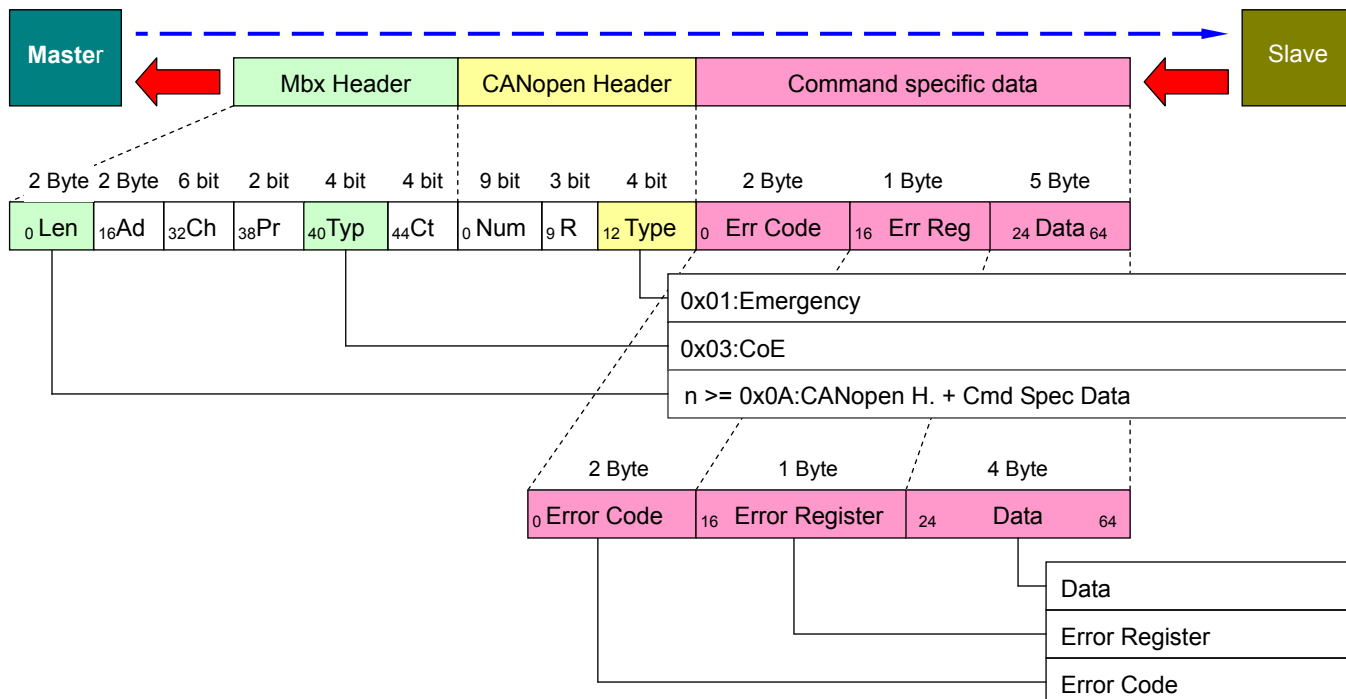
5. EtherCAT Interface

■ Emergency (EMCY)

Emergency object will be transferred by the master to the request command for mailbox input at the time of error occurrence inside the device.

This object permits transfer only once to one error event.

In other words, an emergency object will not be transferred unless a new error occurs in the device.



Error Code List

Error Code	Explanation
0x0000	Error reset or No error
0x1001	SOE Invalid service
0x1002	SOE Unsupported
0x1101	SDO Invalid command
0x1102	SDO Invalid header
0x1103	SDO Unsupported
0xA000	SM Transfer Error: Transition from PRE-OP to SAFE-OP unsuccessful
0xA001	SM Transfer Error: Transition from SAFE-OP to OP unsuccessful

5. EtherCAT Interface

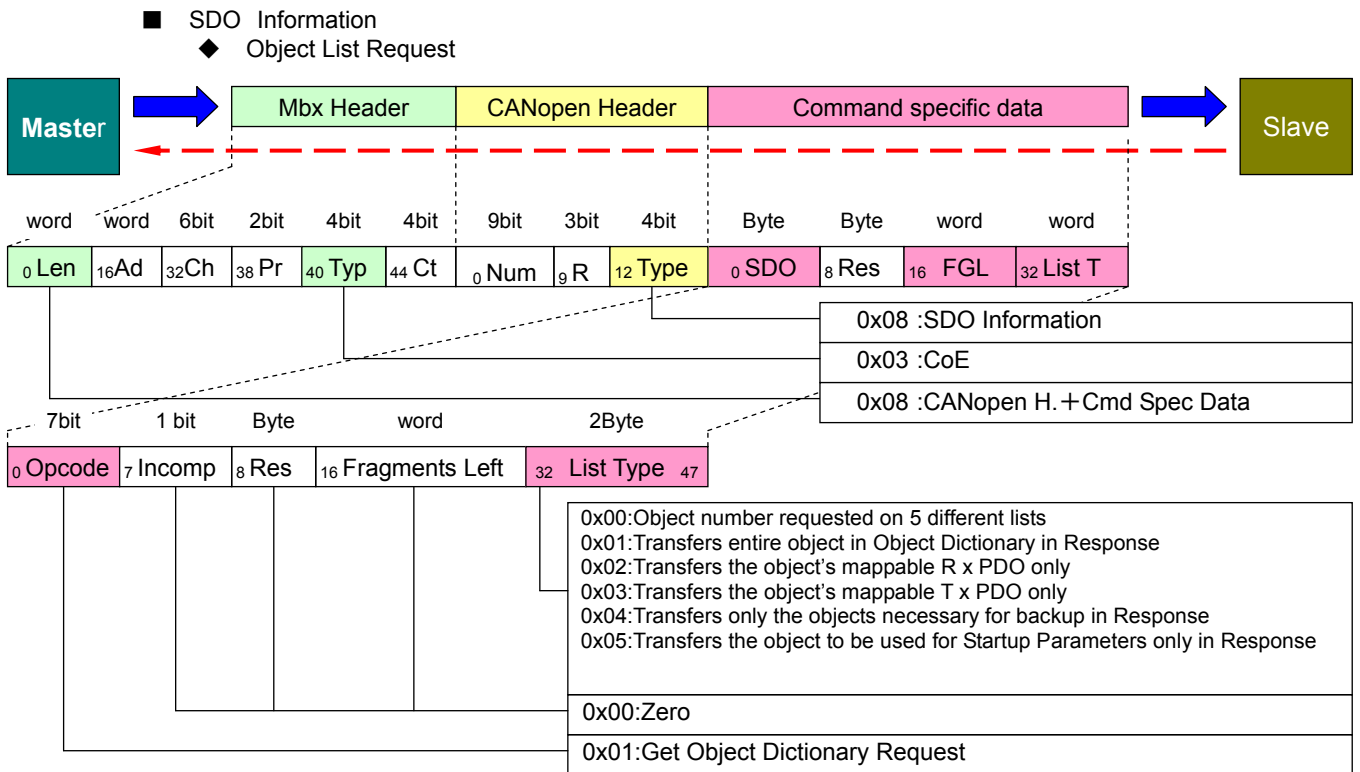


Diagram 9 : Get OD List Request (Object Dictionary Request)

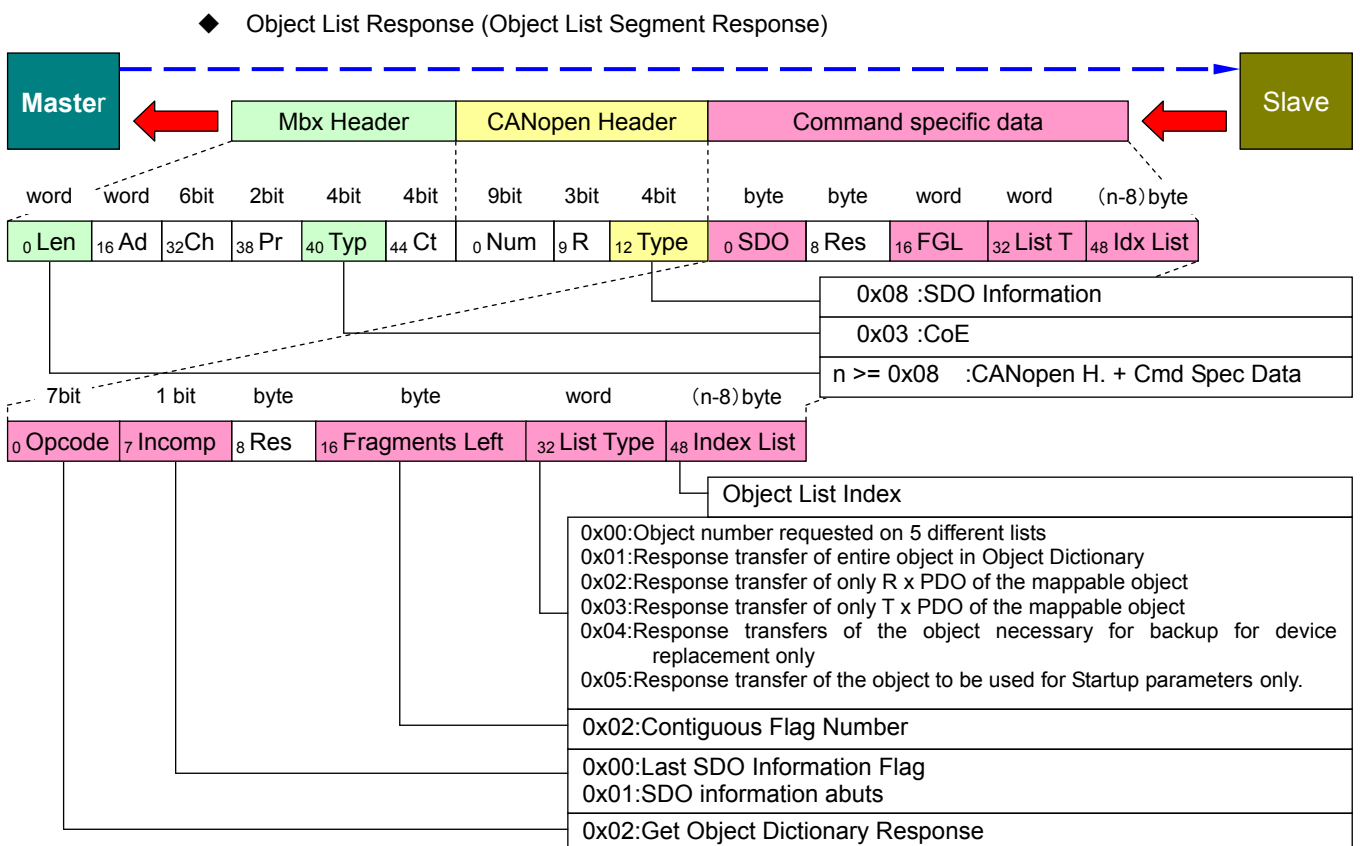


Diagram 10 : Get OD List Response (Object Dictionary Response)

5. EtherCAT Interface

◆ Object Dictionary Request

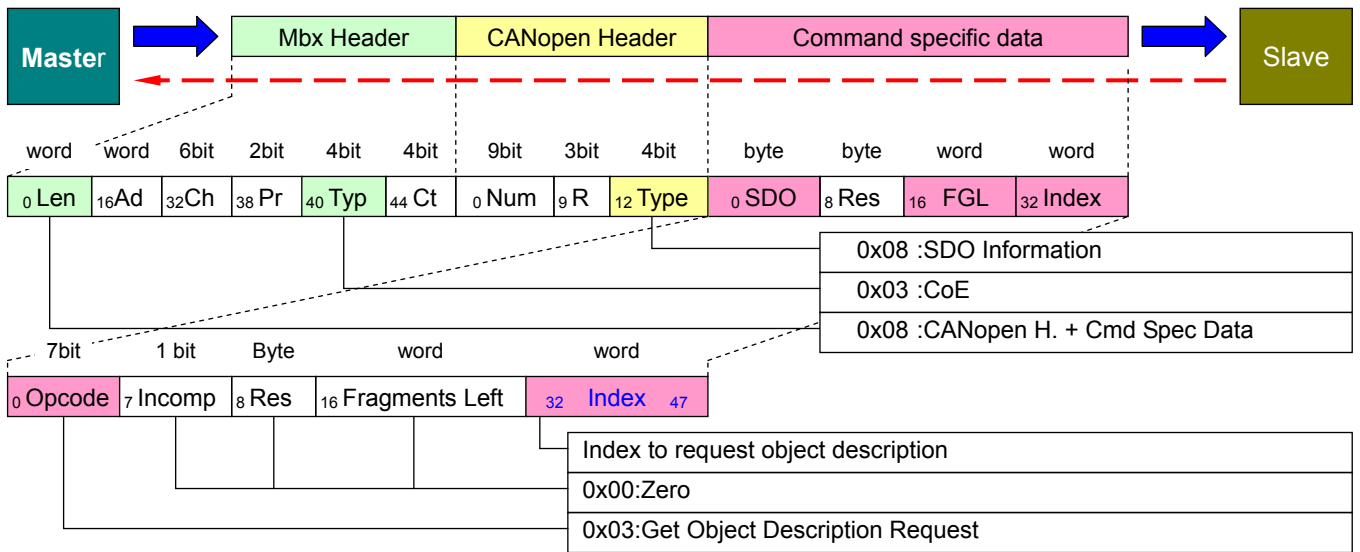


Diagram 11 : Get Object Description Request (Object Description Request)

◆ Object Description Response

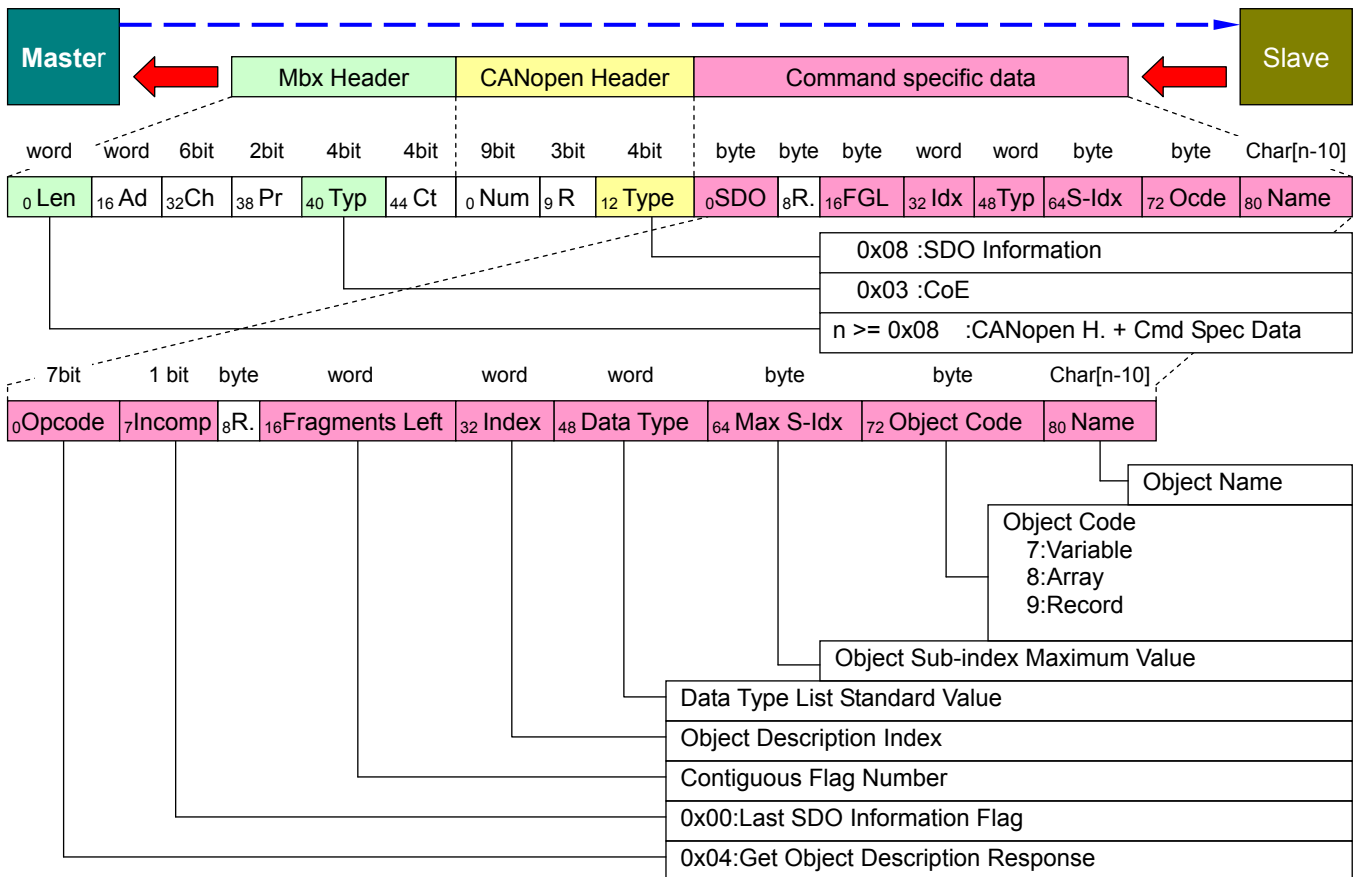
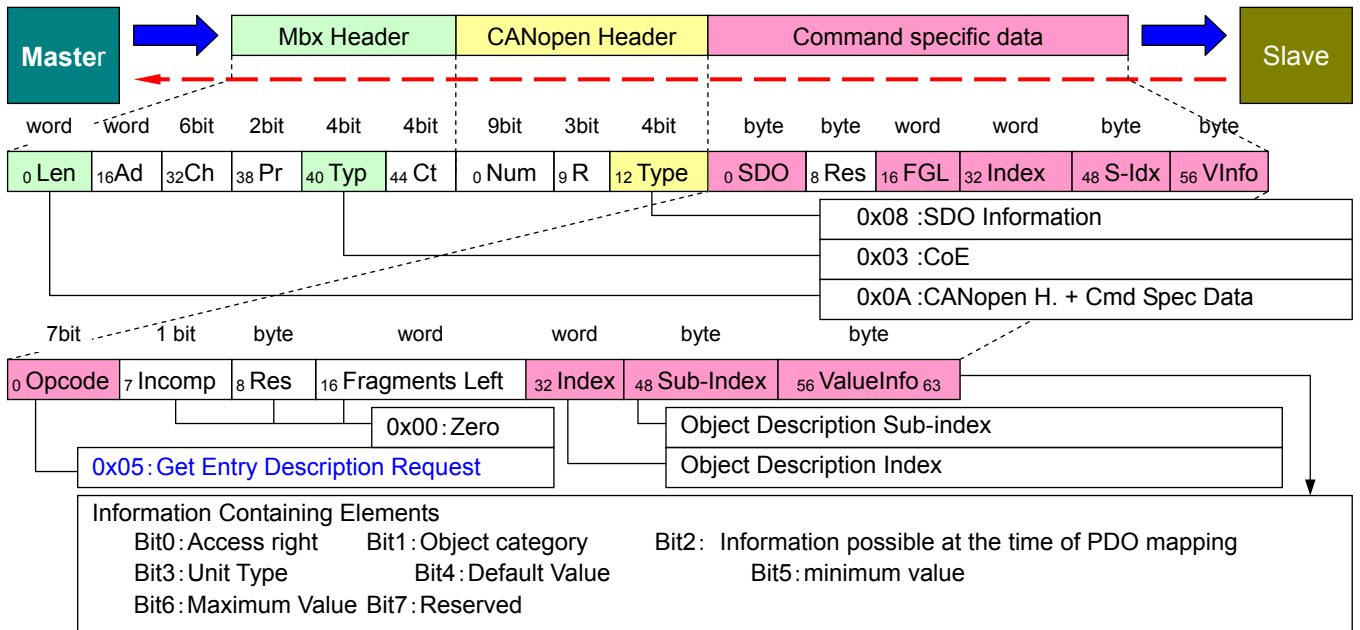


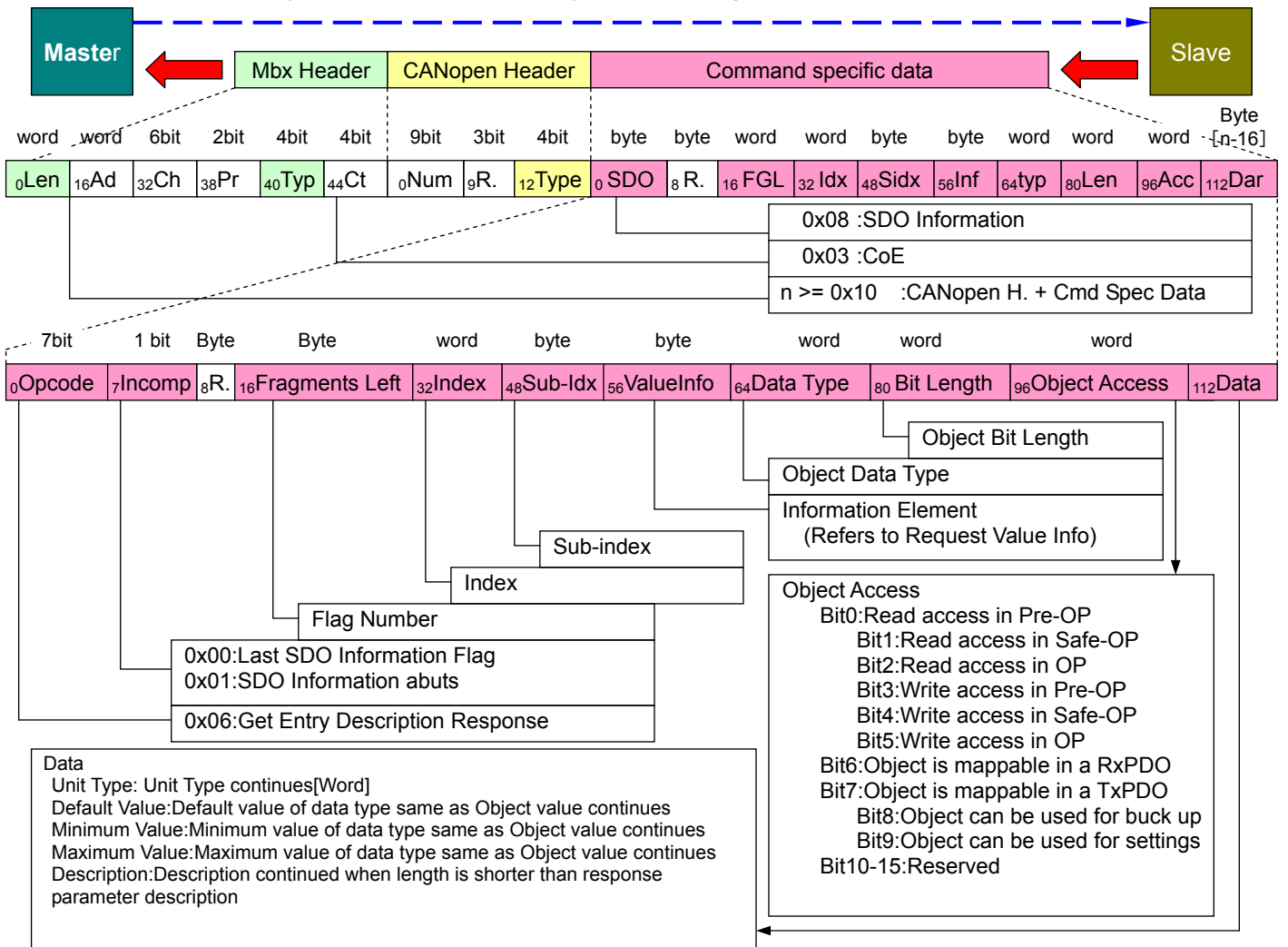
Diagram 12 : Get Object Description Response (Object Dictionary Response)

5. EtherCAT Interface

◆ Entry Description Request



◆ Entry Description Response (Entry Description Segment)



5. EtherCAT Interface

◆ SDO information Error Request

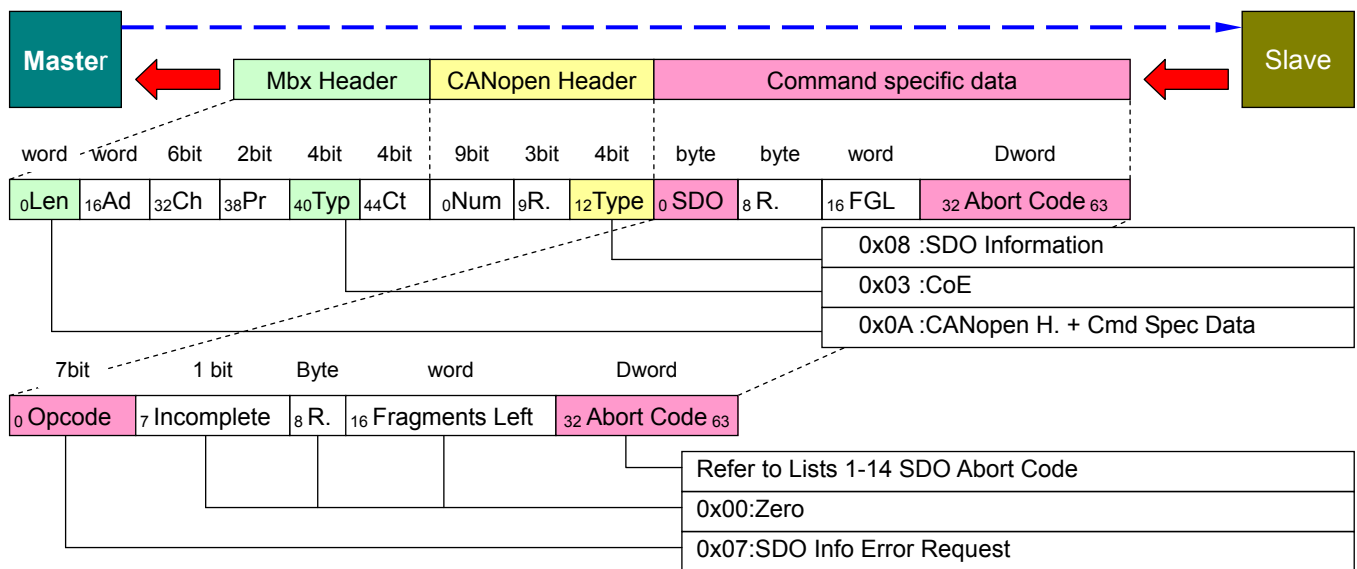


Diagram 15 : Error Request (SDO Information Error Request)

5. EtherCAT Interface

5) Process Data Object(PDO)

■ Overview

Real time data transfer of EtherCAT is performed with "Process Data Object" (PDO).

PDO transfer does not need protocol transfer processing overhead.

There are two (2) types of PDO transfers: R x PDO (Reception PDO) from master to slave and T x PDO (Transmission PDO) from slave to master.

PDO mapping of the R-Advanced EtherCAT CoE amplifier can assign necessary PDO numbers and PDO objects to applicable entries of the Object Dictionary using SDO service at the device setting stage.

■ PDO Setting

The user can optimize the "Message area with PDO mapping" and "Reception/Transmission form (transmission type) and Trigger conditions" by setting the PDO.

■ PDO Mapping

PDO mapping of the R-ADVANCED EtherCAT is changeable.

Specifically, the EtherCAT CoE Network Manager can change the PDO transfer data freely during operation.

Use "Reception PDO mapping parameters (0x1600 - 0x1603, 0x1700 - 0x1703)" to change R x PDO mapping and "Transmission PDO mapping parameters (0x1A00 - 0x1A03, 0x1B00 - 0x1B03)" to change T x DO mapping.

Index, Sub-index and Data length have to be set to each PDO to be transferred.

The data length must match the data length inside the Object Dictionary.

A mapping example of T x PDO is shown below

"0x1B0y" Transmit PDO Mapping (Example)

Sub-Index	Data (32bit)			Name
0x00	5			Number of Entry
0x01	0x6064	0x00	0x20	Position actual value
0x02	0x6077	0x00	0x10	Torque actual value
0x03	0x6061	0x00	0x08	Operation Mode Display
0x04	0x0000	0x00	0x08	Reserved
0x05	0x6041	0x00	0x10	Status Word

Index (2byte)	Sub-Index (1Byte)	Object Length (1byte)
------------------	----------------------	--------------------------



Byte	0	1	2	3	4	5	6	7	8	9
PDO "0x1B0y"	0x6064:00				0x6077:00		0x6061:00	Reserved	0x6041:00	

PDO Mapping (example)

Use the following procedures for mapping:

1. Clear the object number (Sub-index 0) zero (0) once.
2. Write the settings from the object to be assigned beginning with the head (Sub-index 1).
3. Write the assigned object number to the mapping object number (Sub-index 0).

5. EtherCAT Interface

The relation between PDO and SM is defined as Sync Manager PDO Assign in Sync Manager Channel (SM) for processing data objects.

The Sub-index: 0x00 in the SM-PDO Assign table will be assigned a PDO number.

Index: 0x1C12 (SM Channel 2) becomes the Output PDO setting and Index: 0x1C13 (SM Channel 3) becomes the Input PDO Object Dictionary in the RS2-Advanced EtherCAT CoE amplifier.

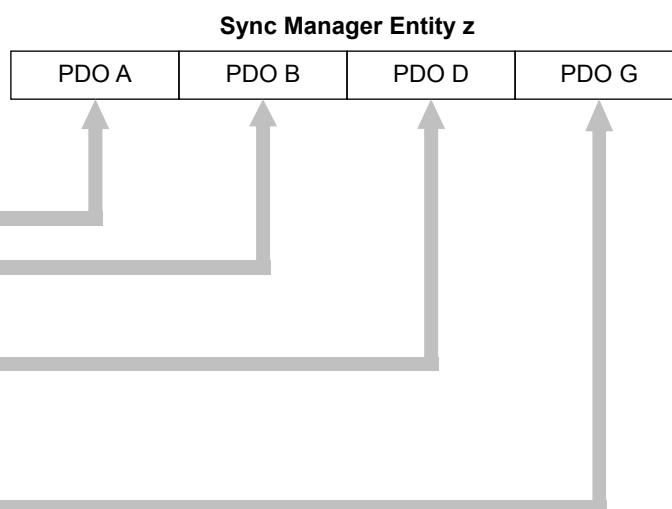
Object Dictionary

Sync Manager Assign Object

Index	Sub-index	Object contents
0x1C1z	0x01	0x1B00
0x1C1z	0x02	0x1B01
0x1C1z	0x03	0x1B03
0x1C1z	0x04	0x1B06

Mapping Object

0x1B00	PDO A
0x1B01	PDO B
0x1B02	PDO C
0x1B03	PDO D
0x1B04	PDO E
0x1B05	PDO F
0x1B06	PDO G



Sync Manager PDO Assignment (example)

■ Default PDO Mapping

Only the settings of Sub-Index : x01 for R x PDO:0x1600 and T x PDO:0x1A00 are established CoE specifications.

The other Sub-Indices and Indices are available for free mapping.

Default PDO Mapping is shown in the following table.

Default PDO Mapping

Index, Sub-Index	Object Index	Object Name	Explanation
0x1600.0x01:R x PDO (Master => Slave)	0x6040	Control Word	Controls State Machine
0x1A00.0x01:T x PDO (Slave => Master)	0x6041	Control Word	Displays Status

Besides Sub Index1 - 4 settings for, RxPDO Transmission Type:0x1400 – and TxPDO Transmission Type:0x1800 – are required in CANopen. However, those will not be used in EtherCAT (Reserved).

5.7 Distributed Clocks (DC)

EtherCAT is supported by the Distributed clock (DC) unit of the slave controller for synchronization between slaves and master.

The DC functions provided with R-Advanced EtherCAT amplifier are described as follows:

- Clock synchronization between slave-master
- Accurate time recording for input events
- Accurate synchronous processing by interruptions according to the DC settings
- Synchronous digital input sampling

1) Clock Synchronization

DC synchronization is performed as having the same EtherCAT System Time as all EtherCAT devices in the master as well as the slaves.

Since the EtherCAT devices can synchronize one another, local applications will, consequently, be synchronized. Concerning the system synchronization, all slaves will be synchronized to one reference clock.

Generally, the first slave within one (1) segment of the master holds the "System Time" and this "System Time" is used as a reference clock to synchronize the other slaves' DC local clocks "System Time" with the master.

2) System Time

- Reference clock
One EtherCAT device is used as a reference clock.
Generally, the reference clock is the first slave with DC function to synchronize between the master and all slaves.
The reference clock supplies the System Time.
- Local Clock
Each of the slaves works with a local clock independently from the reference clock in the beginning.
The difference between the local clock and the reference clock can be corrected as can clock drift.
Offset will be accomplished by adding a local clock velocity measurement and the adjusted clock drift to the local clock value.
Each DC slave maintains reference clock copies calculated from the local clock and local offset.
- Propagation Delay
The propagation delay between reference clock and slave clock must be acquired when System Time is transferred to slaves.
- Offset
There are two reasons for offset between the local clock and the reference clock.
This offset is corrected by each slave respectively according to the propagation delay from the reference clock hold to the local clock device with the initial difference of local time caused by the power input time difference.
The slave that holds the reference clock will find the System Time from local time by adding the local offset.
This offset signifies the difference between local time (beginning with power input) and the master time.
- Drift
Reference clock and DC slave clock are not provided by the same clock source normally, so their clock sources are affected by deviations between clocks. In line with this, the sources of the clocks run faster than the other clocks in no small measure, local clocks drift separately.

3) Clock Synchronization Process

The clock synchronization process consists of three (3) steps.

1) Propagation Delay Measurement

The master begins propagation delay measurement in each direction toward all slaves.

Each slave measures the received time of the measurement frame.

Then, the master calculates the propagation delay between the slaves by reading the time stamps.

2) Offset Correction to the Reference Clock (System Time)

Compares the local time of each of the slave's clocks to System Time.

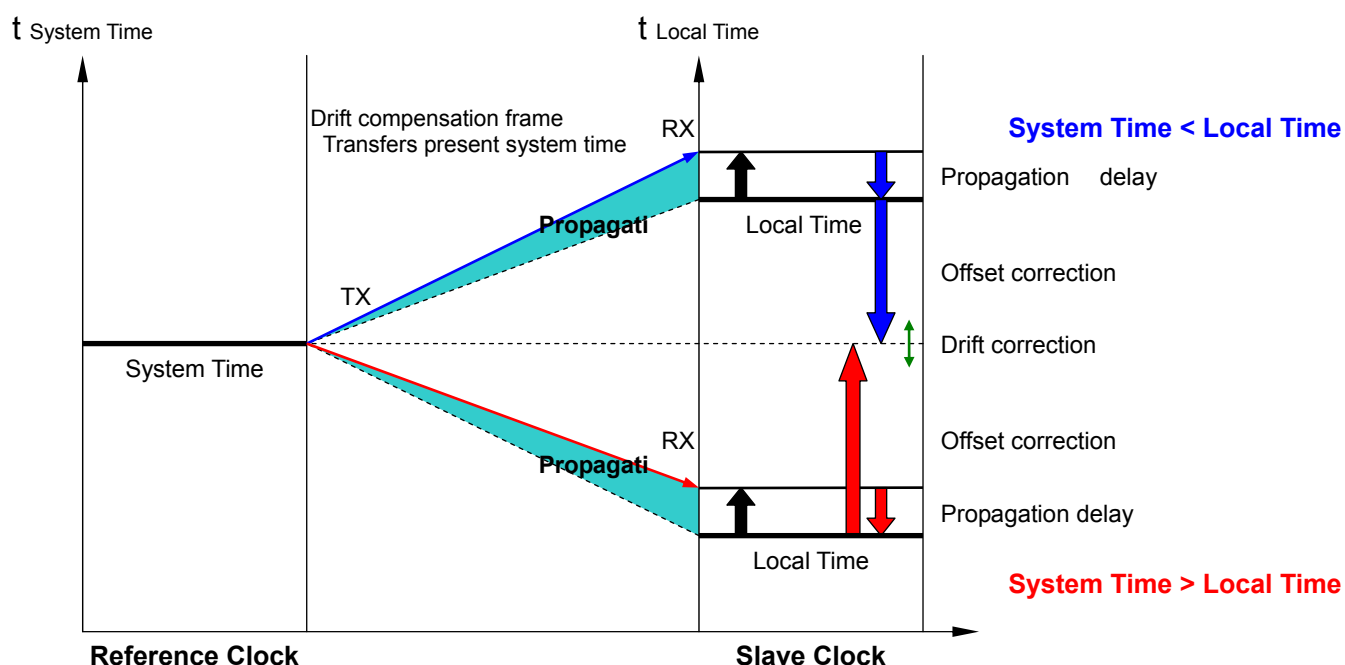
For the time difference, correct each respectively by Writing the value to each slave.

All slaves acquire the same absolute system.

3) Drift Correction to the Reference Clock

The drift between the reference clock and the local clock must be corrected regularly with a difference time measurement and local clock readjustment.

Correction calculations in both cases, when the system is smaller or larger than the slaves' local time, is shown below.



Corrections for Propagation Delay, Offset and Drift

Please refer to Chapter 7: Distributed Clock (DC) for details of Clock Synchronization:

1) Propagation Delay Measurement 2) Reference Clock Offset Correction and 3) Reference Clock Drift Correction.

4) Clock Synchronization Initialization Procedure (example)

Initialization procedure of clock synchronization including propagation delay measurement, offset correction and drift correction is as follows:

- 1) The master discovers the network configuration by reading the DL status register of the slaves.
- 2) The master transmits a minimum of 1byte of data with broadcast Write to Read the receive time of port 0 register. All slaves match local time with all ports and the ECAT processing unit.
- 3) The master waits until the broadcast Write frame returns.
- 4) The master, depending on the network configuration, reads receive time ports 0 / 1 and ECAT processing unit receive time register (0x0918:0x091F) in all slaves.
- 5) The master calculates respective propagation delays and writes the values to the system time delay register in the slaves.
- 6) The master sets the reference clock (the first slave) in the system time offset register so the reference clock will be equivalent to the master time. By subtracting the receive time of the ECAT processing unit of the reference clock (local time) from the master time, it becomes the offset value for the reference clock.
- 7) The master calculates the system time offset of all DC slaves and writes it in the system time offset register. By subtracting the ECAT processing unit receive time of each DC slave from the receive time ECAT processing unit of the reference clock; it becomes the offset value for each slave (from the 2nd axis onward).
- 8) For static drift correction, the master transmits the command "ARMW" or "FRMW" to all DC slaves at the beginning and any number of times separately (example:15,000 frames)
- 9) For dynamic drift correction, the master transmits the command "ARMW" or "FRMW" to all DC slaves periodically.

The command proportion for drift correction depends on an acceptable maximum deviation.

5) SYNC0 / 1 Signal Output Initialization Procedure (example)

Synchronous signal output is initialized according to the following procedure:

- 1) Enables DC SYNC Out Unit bit in PDI control register (0x0140.10=1)
- 2) Set SYNC0/1 output in SYNC/Latch PDI Configuration register so the output driver setting conforms to the circuit configuration inside the slave □For 0x0151,EEPROM value is set at the time of initialization.
- 3) Set SYNC signal pulse width in Pulse Length register (must be SYNC0 Cycle Time> 0)
Note) 0x0982: 0x0983 set from EEPROM at initialization.
- 4) Assign the synchronizing unit in the ECAT or the device description PDI to 0x0980.
- 5) Set SYNC 0 signal cycle time to(0x09A0:0x09A3)and SYNC1 signal cycle time to (0x09A4:0x09A7).
- 6) Set a later time than the time cycle permits in the start cycle time operation to (0x0990:0x0997).
(example: Add system Read time + start time and permission Write time)
- 7) Permits the active cycle operation bit (0x0981.0=1) as a synchronous signal to SYNC0 / SYNC1 active bit (0x0981[2:1]=0x3).

Synchronizing unit stands by until the first SYNC 0 pulse is output.

Cycle motion start time register and the next SYNC 1 pulse register can be read to acquire the next output event time.

5.8 Communication Timing

EtherCAT synchronous handling works independently from the EtherCAT device inside the master and slaves. The following three (3) communication methods are standard for synchronous modes:

1) Free-run Mode

The slave application does not synchronize with the EtherCAT synchronous signal (non-synchronous mode).

2) SM Event Synchronous Mode

The slave application synchronizes with an SM2 event when cycle output is transmitted. Also, the application synchronizes with an SM3 event (Note) only when cycle input is transmitted.

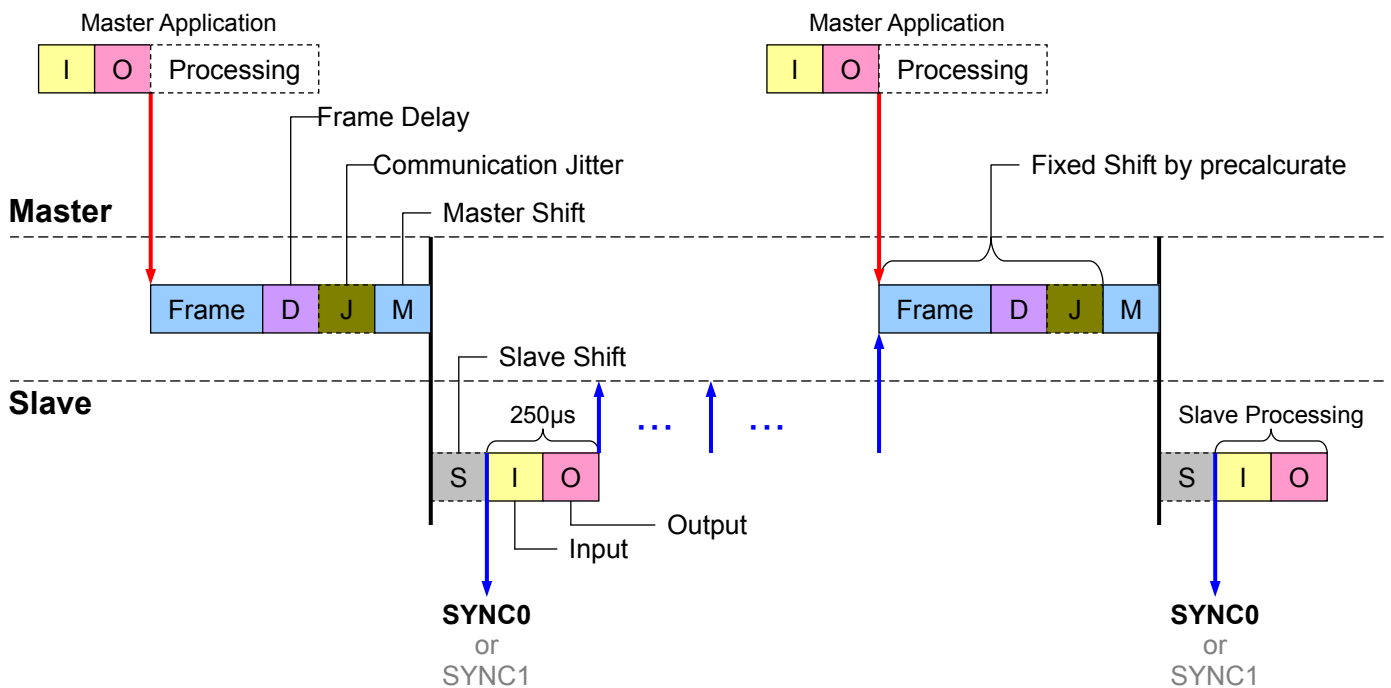
Note) Synchronizing with an SM3 event is not supported in this amplifier.

3) SYNC Event Synchronous Mode

The slave application synchronizes with a SYNC 0 or SYNC 1 event.

The differences between the synchronous type modes can be identified by the Sub-index combination in the CoE Object Dictionary 0x1C32 and 0x1033.

An example of communication timing with DC is shown below.



Communication with DC Timing

- Frame
Communication frame and frame transfer time (80ns / Byte+5µs)
- Frame Delay (Communication Delay)
Delay time of the EtherCAT slaves for data transfer (approx. 5ns/m cable delay, approx. 1µs 100BASE-TX)
- Jitter (Communication Jitter)
Frame transmission start jitter (Cycle Time Jitter) is generally influenced by the master's efficiency.
- Cycle Time Jitter
Cycle time jitter, an application specification, depends on the slave and master system hardware. In this example, 10% of the cycle time is reserved for jitter
- Master Shift (Communication Master)
Adjusting shift time inside the master also adjusts the necessary processing time in the mater.
- Slave Shift
Delay time at the start of processing in the EtherCAT slaves (= 0 in PB EtherCAT driver).
- Input or Output of the Slave
Input is for R x PDO import and processing. Output is for T x PDO output.

5.9 EtherCAT State Machine (ESM)

ESM contains states defined by EtherCAT.

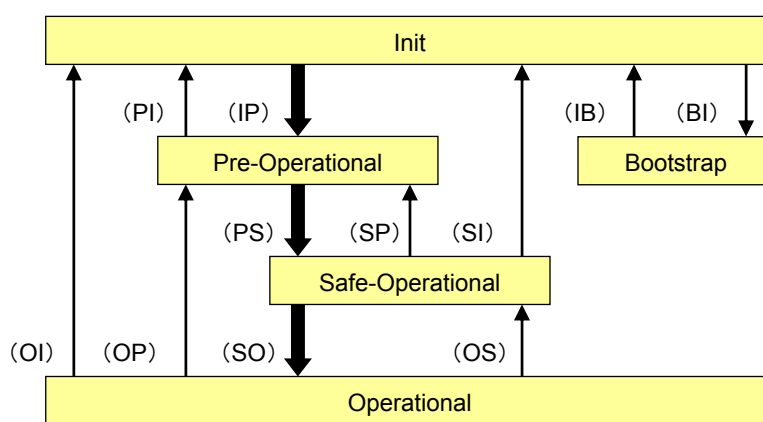
- Init
- Pre—Operational
- Safe—Operational
- Operational
- Bootstrap

1) ESM

ESM change is requested from the master.

The master requests the change by writing the ESM with the request to be changed in the AL control register of the slave(s). The slave confirms the result of the state change as either successful or failed and then responds to the master with the local AL status.

If the requested state change fails, the slave responds with an error flag.



ESM Diagram

State Transition and Local Management Service

Transition Symbol	Direction =>	Local Management Service
IP	INIT TO PREOP	Start Mailbox Communication
PI	PREOP TO INIT	Stop Mailbox Communication
PS	PREOP TO SAFEOP	Start Input Update
SP	SAFEOP TO PREOP	Stop Input Update
SO	SAFEOP TO OP	Start Output Update
OS	OP TO SAFEOP	Stop Output Update
OP	OP TO PREOP	Stop Input Update, Stop Output Update
SI	SAFEOP TO INIT	Stop Input Update, Stop Mailbox Communication
OI	OP TO INIT	Stop Input Update, Stop Output Update, Stop Mailbox Communication
IB	INIT TO BOOT	Start Firmware Update (FoE), Start Bootstrap Mode
BI	BOOT TO INIT	Start Firmware Update (FoE), Restart Device

* Model No.PB is not supporting bootstrap Function.

State

- **Init State**
“Init” state defines basic communication relations between the master and slaves in the application layer. Direct communication between the master and slaves is not possible in the application layer. The master uses the “Init” state to initialize the setting for the configuration of the slaves. When the slaves support the mailbox service, the corresponding SM settings will also be executed in “Init” state.
- **Pre - Operational State**
The mailbox communication can be performed in the “Pre - Operational” state when the slaves support the optional mailbox. Both master and slaves can use the mailbox to initialize application specifications and to change parameters. Process data communication cannot be executed in this state.
- **Safe - Operational State**
In “Safe - Operational” state, slave applications transfer the actual input data, but not the output data that may not be available for processing. The output must be set in Safe state.
- **Operational State**
In “Operational” state slave applications transfer the actual input data and the master application transfers the actual output data.
- **Bootstrap State**
In the “Bootstrap” state, slave applications can receive new firmware downloaded to the FoE (File access Over EtherCAT) protocol.

* Model No.PB is not supporting bootstrap Function

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6.1 Device Addressing

1) Address Space Overview

The device can be addressed via Device Position Address (Auto Increment address), by Node Address (Configured Station Address/Configured Station Alias), or by a Broadcast.

■ **Position Address / Auto Increment Address:**

The datagram holds the position address of the addressed slave as a negative value. Each slave increments the address. The slave which reads the address equal zero is addressed and will execute the appropriate command at receives.

Position Addressing should only be used during start up of the EtherCAT system to scan the fieldbus and later only occasionally to detect newly attached slaves.

■ **Node Address / Configured Station Address and Configured Station Alias:**

The configured Station Address is assigned by the master during start up and cannot be changed by the EtherCAT slave. The Configured Station Alias address is stored in the ESI EEPROM and can be changed by the EtherCAT slave. The Configured Station Alias has to be enabled by the master. The appropriate command action will be executed if Node Address matches with either Configured Station Address or Configured Station Alias.

Each ESC device of the Model No PB EtherCAT slave driver has a 14 bit local address space. The address range 0x0000:0x0FFF is dedicated to EtherCAT registers and address range 0x1000:0x2FFF is used as process memory, which is addressed via a 16 bit Offset address field belonging to the EtherCAT datagram.

The process memory space is used communication applications such as PDO interface and SDO (mailbox) interface.

2) Shadow Buffer for Register Write Operations

The ESCs have shadow buffers for write operations to registers (0x0000 to 0x0F7F). During a frame, write data is stored in the shadow buffers. If the frame is received correctly, the values of the shadow buffers are transferred into the effective registers. Otherwise, the values of the shadow buffers are not taken over. As a consequence of this behavior, registers take their new value shortly after the FCS of an EtherCAT frame is received. SyncManagers also change the buffers after the frame was received correctly.

User and Process Memory do not have shadow buffers. Accesses to these areas are taking effect directly. If a SyncManager is configured to User Memory or Process Memory, write data will be placed in the memory, but the buffer will not change in case of an error.

3) EtherCAT Slave Controller Function Blocks

■ **EtherCAT Interface (Ethernet/EBUS)**

The EtherCAT interfaces or ports connect the ESC to other EtherCAT slaves and the master. The MAC layer is integral part of the ESC. The physical layer may be Ethernet or EBUS. The physical layer for EBUS is fully integrated into the ASICs. For Ethernet ports, external Ethernet PHYs connect to the MII/RMII ports of the ESC. Transmission speed for EtherCAT is fixed to 100 Mbit/s with Full Duplex communication. Link state and communication status are reported to the Monitoring device.

Model No PB EtherCAT driver supports 2 ports and the logical ports are numbered 0 and 1.

■ **EtherCAT Processing unit**

The EtherCAT Processing Unit (EPU) receives, analyses and processes the EtherCAT data stream. It is logically located between port 0 and port 1. The EtherCAT Processing Units contains the main function blocks of EtherCAT slaves besides Auto-Forwarding, Loop-back function, and PDI.

6. Data Link Layer

6.2 Address Space

Model No PB EtherCAT driver has an address space of 12kByte. The lower block of 4kByte (0x0000 - 0x1000) is dedicated for configuration registers common to all EtherCAT products.

Model No PB EtherCAT driver has 8kByte of process data RAM space beginning at 0x1000 to 0x2FFF

The address space list is shown below.

Table 1: ESC address space

Address	Length (Byte)	Description	Address	Length (Byte)	Description
ESC Information			Watchdogs		
0x0000	1	Type	0x0400:0x0401	2	Watchdog Divider
0x0001	1	Revision	0x0410:0x0411	2	Watchdog Time PDI
0x0002:0x0003	2	Build	0x0420:0x0421	2	Watchdog Time Process Data
0x0004	1	FMMUs supported	0x0440:0x0441	2	Watchdog Status Process Data
0x0005	1	SyncManagers supported	0x0442	1	Watchdog Counter Process Data
0x0006	1	RAM Size	0x0443	1	Watchdog Counter PDI
0x0007	1	Port Descriptor	ESI EEPROM Interface (ESI)		
0x0008:0x0009	2	ESC Features supported	0x0500	1	EEPROM Configuration
Station Address			0x0501	1	EEPROM PDI Access State
0x0010:0x0011	2	Configured Station Address	0x0502:0x0503	2	EEPROM Control/Status
0x0012:0x0013	2	Configured Station Alias	0x0504:0x0507	4	EEPROM Address
Write Protection			0x0508:0x050F	4/8	EEPROM Data
0x0020	1	Write Register Enable	MII Management Interface (ESI)		
0x0021	1	Write Register Protection	0x0510:0x0511	2	MII Management Control/Status
0x0030	1	ESC Write Enable	0x0512	1	PHY Address
0x0031	1	ESC Write Protection	0x0513	1	PHY Register Address
Data Link Layer			0x0514:0x0515	2	PHY Data
0x0040	1	ESC Reset ECAT	FMMU (Fieldbus Memory Management Unit)		
0x0100:0x0103	4	ESC DL Control	0x0600:0x06FF	8x16	FMMU[7:0]
0x0108:0x0109	2	Physical Read/Write Offset	+0x0:0x3	4	Logical Start Address
0x0110:0x0111	2	ESC DL Status	+0x4:0x5	2	Length
Application Layer			+0x6	1	Logical Start bit
0x0120:0x0121	2	AL Control	+0x7	1	Logical Stop bit
0x0130:0x0131	2	AL Status	+0x8:0x9	2	Physical Start Address
0x0134:0x0135	2	AL Status Code	+0xA	1	Physical Start bit
PDI			+0xB	1	Type
0x0140:0x0141	2	PDI Control	+0xC	1	Activate
0x0150	1	SYNC/LATCH PDI Configuration	+0xD:0xF	3	Reserved
0x0151:0x0153	3	Extended PDI Configuration	SyncManager (SM)		
Interrupts			0x0800:0x087F	8x8	SyncManager [7:0]
0x0200:0x0201	2	ECAT Event Mask	+0x0:0x1	2	Physical Start Address
0x0204:0x0207	4	AL Event Mask	+0x2:0x3	2	Length
0x0210:0x0211	2	ECAT Event Request	+0x4	1	Control Register
0x0220:0x0223	4	AL Event Request	+0x5	1	Status Register
Error Counters			+0x6	1	Activate
0x0300:0x0307	4x2	Rx Error Counter [3:0]	+0x7	1	PDI Control
0x0308:0x030B	4x1	Forwarded Rx Error counter [3:0]			
0x030C	1	ECAT Processing Unit Error Counter			
0x030D	1	PDI Error Counter			
0x0310:0x0313	4x1	Lost Link Counter [3:0]			

* Address areas not listed here are reserved. They are not writable. A read access to reserved addresses will typically return 0.

6. Data Link Layer

Table 2: ESC address space

Address	Length (Byte)	Description	Address	Length (Byte)	Description
Distributed Clocks (DC)			DC – Latch In Unit		
0x0900:0x09FF	-	Distributed Clocks (DC)	0x09A8	1	Latch0 Control
0x0900:0x0903	4	Receive Time Port 0	0x09A9	1	Latch1 Control
0x0904:0x0907	4	Receive Time Port 1	0x09AE	1	Latch0 Status
0x0908:0x090B	4	Receive Time Port 2	0x09AF	1	Latch1 Status
0x090C:0x090F	4	Receive Time Port 3	0x09B0:0x09B7	4/8	Latch0 Time Positive Edge
DC – Time Loop Control Unit			0x09B8:0x09BF	4/8	Latch0 Time Negative Edge
0x0910:0x0917	4/8	System Time	0x09C0:0x09C7	4/8	Latch1 Time Positive Edge
0x0918:0x091F	8	Receive Time ECAT Processing Unit	0x09C8:0x09CF	4/8	Latch1 Time Negative Edge
0x0920:0x0927	4/8	System Time Offset	DC – SyncManager Event Times		
0x0928:0x092B	4	System Time Delay	0x09F0:0x09F3	4	EtherCAT Buffer Change Event Time
0x092C:0x092F	4	System Time Difference	0x09F8:0x09FB	4	PDI Buffer Start Event Time
0x0930:0x0931	2	Speed Counter Start	0x09FC:0x09FF	4	PDI Buffer Change Event Time
0x0932:0x0933	2	Speed Counter Diff	ESC specific		
0x0934	1	System Time Difference Filter Depth	0x0E00:0x0EFF	256	ESC specific registers (e.g., Power-On Values / Product and Vendor ID)
0x0935	1	Speed Counter Filter Depth	Digital Input/Output		
DC – Cyclic Unit Control			0x0F00:0x0F03	4	Digital I/O Output Data
0x0980	1	Cyclic Unit Control	0x0F10:0x0F11	2	General Purpose Outputs
DC – SYNC Out Unit			0x0F18:0x0F19	2	General Purpose Inputs
0x0981	1	Activation	User RAM		
0x0982:0x0983	2	Pulse Length of Sync Signals	0x0F80:0x0FA1	33	Extended ESC features
0x098E	1	SYNC0 Status	0x0FC0:0x0FFF	64	User RAM
0x098F	1	SYNC1 Status	Process Data RAM		
0x0990:0x0997	4/8	Start Time Cyclic Operation/ Next SYNC0 Pulse	0x1000:0x2FFF	8192	Process Data RAM
0x0998:0x099F	4/8	Next SYNC1 Pulse			
0x09A0:0x09A3	4	SYNC0 Cycle Time			
0x09A4:0x09A7	4	SYNC1 Cycle Time			

For Registers longer than one byte, the LSB has the lowest and MSB the highest address.

Register description

1) ESC Information

Type

Address	bit	Description	Master	Slave	Length	Rest Value
0x0000	7:0	Type of EtherCAT controller	R/-	R/-	1Byte	0x11

Revision

Address	bit	Description	Master	Slave	Length	Rest Value
0x0001	7:0	Revision of EtherCAT controller	R/-	R/-	1Byte	0x00

Build

Address	bit	Description	Master	Slave	Length	Rest Value
0x0002 - 0x0003	15:0	Actual build of EtherCAT controller	R/-	R/-	2Byte	0x0000

FMMUs supported

Address	bit	Description	Master	Slave	Length	Rest Value
0x0004	7:0	Number of supported FMMU channels (or entities) of the EtherCAT Slave Controller	R/-	R/-	1Byte	0x08

SyncManagers supported

Address	bit	Description	Master	Slave	Length	Rest Value
0x0005	7:0	Number of supported SyncManager channels (or entities) of the EtherCAT Slave Controller	R/-	R/-	1Byte	0x08

RAM Size

Address	bit	Description	Master	Slave	Length	Rest Value
0x0006	7:0	Process Data RAM size supported by the EtherCAT Slave Controller in KByte	R/-	R/-	1Byte	0x08

Port Descriptor

Address	bit	Description	Master	Slave	Length	Rest Value
0x0007	1:0	Port 0	R/-	R/-	1Byte	0x0F
	3:2	Port 1				
	7:4	Reserved				

ESC Features supported

Address	bit	Description	Master	Slave	Length	Rest Value
0x0008 - 0x0009	0	FMMU Operation	R/-	R/-	2Byte	0x00FC
	1	Reserved				
	2	Distributed Clocks				
	3	Distributed Clocks (width)				
	4	Low Jitter BUS				
	5	Enhanced Link Detection EBUS				
	6	Enhanced Link Detection MII				
	7	Separate Handling of FCS Errors				
	15:8	Reserved				

6. Data Link Layer

2) Station Address

Configured Station Address

Address	bit	Description	Master	Slave	Length	Rest Value
0x0010 - 0x0011	15:0	Address used for node addressing (FPxx commands) Sets node address.	R/W	R/-	2 Byte	0x0000

Configured Station Alias

Address	bit	Description	Master	Slave	Length	Rest Value
0x0012 - 0x0013	15:0	Alias Address used for node addressing (FPxx commands) The use of this alias is activated by Register DL Control Bit 24 (0x0100.24/0x0103.0) Note) EEPROM load from 0x0004	R/-	R/W	2 Byte	0x0000 Note)

3) Write Protection

ESC contained in this amplifier handles all ESC protection (or write protection register).
Registers used for write protection are described

Registers for Write Protection

Register Address	Name	Description
0x0020	Write Register Enable	Temporarily release register write protection
0x0021	Write Register Protection	Activate register write protection
0x0030	ESC Write Enable	Temporarily release ESC write protection
0x0031	ESC Write Protection	Activate ESC write protection

■ Register Write Protection

With register write protection, only the register area (0x0000 to 0x0FFF) is write protected (except for registers 0x0020 and 0x0030).
If register write protection is enabled (register 0x0021.0=1), the Register Write Enable bit (0x0020.0) has to be set in the same frame before any register write operations. This is also true for disabling the register write protection. Otherwise, write operation to registers are discarded.

■ ESC Write Protection

ESC write protection disables write operations to any memory location (except for registers 0x0020 and 0x0030).
If ESC write protection is enabled (register 0x0031.0=1), the ESC Write Enable bit (0x0030.0) has to be set in the same frame before any write operations.
This is also true for disabling the ESC write protection as well as the register write protection. Otherwise, write operations are discarded.

NOTE: If both register write protection and ESC write protection are enabled (not recommended), both enable bits have to be set before the write operations are allowed.

6. Data Link Layer

Write Register Enable

Address	bit	Description	Master	Slave	Length	Rest Value
0x0020	0	If write register protection is enabled, this register has to be written in the same Ethernet frame (value does not care) before other writes to this station are allowed. Write protection is still active after this frame (if Write Register Protection register is not changed).	-/W	-/-	1 Byte	0x00
	7:1	Reserved, write 0	-/-			

Write Register Protection

Address	bit	Description	Master	Slave	Length	Rest Value
0x0021	0	Write register protection 0: Protection disabled 1: Protection enabled	R/W	R/-	1 Byte	0x00
	7:1	Reserved, write 0	R/-			

ESC Write Enable

Address	bit	Description	Master	Slave	Length	Rest Value
0x0030	0	If ESC write protection is enabled, this register has to be written in the same Ethernet frame (value does not care) before other writes to this station are allowed. ESC write protection is still active after this frame (if ESC Write Protection register is not changed).	-/w	-/-	1 Byte	0x00
	7:1	Reserved, write 0	-/-			

ESC Write Protection

Address	bit	Description	Master	Slave	Length	Rest Value
0x0031	0	Write protect 0: Protection disabled 1: Protection enabled	R/W	R/-	1 Byte	0x00
	7:1	Reserved, write 0	R/-			

4) ESC Data Link Layer

■ ESC Reset

ESC loaded Model No PB EtherCAT driver is capable of issuing a hardware reset from the EtherCAT master. A special sequence of three independent and consecutive frames/commands has to be sent to the slave (Reset register ECAT 0x0040 or PDI 0x0041). Afterwards, the slave is reset.

It is likely that some transmitting sequence frames will not return to the master because the links will go down with the reset after the normal reception of data.

ESC Reset

Address	bit	Description	Master	Slave	Length	Rest Value
0x0040	7:0	A reset is asserted after writing 0x52 ('R'), 0x45 ('E') and 0x53 ('S') in this register with 3 consecutive frames.	R/W	R/-	1 Byte	0x00
	1:0	Progress of the reset procedure: 01: after writing 0x52 10: after writing 0x45 (if 0x52 was written before) 00: else				

6. Data Link Layer

ESC DL Control

Address	bit	Description	Master	Slave	Length	Rest Value	
0x0100 - 0x0103	0	Forwarding rule: 0:EtherCAT frames are processed, Non-EtherCAT frames are forwarded without processing 1:EtherCAT frames are processed, Source MAC Address is changed (SOURCE_MAC [1] is set to 1 - locally administered address), Non-EtherCAT frames are destroyed	R/W	R/-	4 Byte	0x01	
	1	Temporary use of settings in Register 0x101: 0:permanent use 1:use for about 1 second, then revert to previous settings					
	7:2	Reserved, write 0					
	9:8	Loop Port 0: 00:Auto => closed at "link down", opened with "link up" 01:Auto close => closed at "link down", opened with writing 01 after "link up" 10:Always open, regardless of link state 11:Always closed, regardless of link state	R/W	R/-		0x00	
		11:10					Loop Port 1: 00:Auto => closed at "link down", opened with "link up" 01:Auto close => closed at "link down", opened with writing 01 after "link up" 10:Always open, regardless of link state 11:Always closed, regardless of link state
	15:12	Reserved, write 0	R/-				
	18:16	RX FIFO Size: (ESC delays start of forwarding until FIFO is at least half full). RX FIFO Size/RX delay reduction 0: EBUS:-50ns , MII:-40ns 1: EBUS:-40ns , MII:-40ns 2: EBUS:-30ns , MII:-40ns 3: EBUS:-20ns , MII:-40ns 4: EBUS:-10ns , MII:No change 5: EBUS:No change , MII:No change 6: EBUS:No change , MII:No change 7: EBUS:default , MII:default The possibility of RX FIFO Size reduction depends on the clock source accuracy of the ESC and of every connected EtherCAT/Ethernet devices (master, slave, etc.). RX FIFO Size of 7 is sufficient for 100ppm accuracy, FIFO Size 0 is possible with 25ppm accuracy (frame size of 1518/1522 Byte).	R/W	R/-			0x07
		19					
		23:20				Reserved, write 0	
	24	Station alias: 0:Ignore Station Alias 1:Alias can be used for all configured address command types (FPRD, FPWR, ...)	R/W	R/-		0x00	
	31:25	Reserved, write 0	R/-				

Physical Read/Write Offset

Address	bit	Description	Master	Slave	Length	Rest Value
0x0108 - 0x0109	15:0	Offset of R/W Commands (FPRW, APRW) between Read address and Write address. RD_ADR=ADR and WR_ADR=ADR+R/W-Offset	R/W	R/-	2 Byte	0x0000

6. Data Link Layer

ESC DL Status

Address	bit	Description	Master	Slave	Length	Rest Value
0x0110 - 0x0111	0	PDI operational/EEPROM loaded correctly: 0:EEPROM not loaded, PDI not operational (no access to Process Data RAM) 1:EEPROM loaded correctly, PDI operational (access to Process Data RAM)	R/-	R/-	2 Byte	-
	1	PDI Watchdog Status: 0:Watchdog expired 1:Watchdog reloaded				
	2	Enhanced Link detection: Note) EEPROM ADR0x0000.9 0:Deactivated for all ports 1:Activated for at least one port NOTE: EEPROM value is only taken over at first EEPROM load after power-on or reset				
	3	Reserved				
	4	Physical link on Port 0: 0: No link 1:Link detected				
	5	Physical link on Port 1: 0: No link 1: Link detected				
	7:6	Reserved				
	8	Loop Port 0: 0: Open 1: Closed	R/-	R/-		-
	9	Communication on Port 0: 0: No stable communication 1: Communication established				
	10	Loop Port 1: 0: Open 1: Closed				
	11	Communication on Port 1: 0: No stable communication 1: Communication established				
	12	Reserved (Loop Port 2:) 1: Closed (Fixed)				
	13	Reserved (Communication on Port 2:) 0: No stable communication (Fixed)				
	14	Reserved (Loop Port 3:) 1: Closed (Fixed)				
	15	Reserved (Communication on Port 3:) 0: No stable communication (Fixed)				

5) Application layer

■ EtherCAT State Machine (ESM) Registers

The state machine is controlled and monitored via registers within the ESC. The master requests state changes by writing to the AL Control register. The slave indicates its state in the AL Status register and puts error codes into the AL Status Code register.

Registers for the EtherCAT State Machine (ESM)

Register Address	Name	Description
0x0120:0x0121	AL Control	Requested state by the master
0x0130:0x0131	AL Status	AL Status of the slave application
0x0134:0x0135	AL Status Code	Error codes from the slave application
0x0140.8	PDI Control	Device emulation configuration

* PDI control register is set via powered up EEPROM (12C).

6. Data Link Layer

■ AL Control and AL Status Register

Writing the AL Control register (0x0120:0x0121) initiates a state transition of the device state machine. The AL Status register (0x0130:0x0131) reflects the current state of the slave.

■ Device Emulation

Simple devices (without microcontroller) have the device emulation enabled (0x0140.8=1). The AL Control register is directly copied into the AL Status register by the ESC. The master should not set the Error Indication Acknowledge bit for such slaves at all, because setting this bit would result in setting the Error Indication bit – although no error occurred. The device emulation is :0x0140.8=0 in the Model No PB EtherCAT driver .

AL Control

AL Control							
Address	bit	Description		Master	Slave	Length	Rest Value
0x0120 - 0x0121	3:0	Initiate State Transition of the Device State Machine:	1: Request Init State 2: Request Pre-Operational State 3: Request Bootstrap State 4: Request Safe-Operational State 8: Request Operational State	R/(W)	R/-	2 Byte	0x0001
	4	Error Ind Ack:	0: No Ack of Error Ind in AL status register 1: Ack of Error Ind in AL status register				
	15:5	Reserved, write 0					

- * AL Control register behaves like a mailbox if Device Emulation is off (0x0140.8=0): The PDI has to read the AL Control register after ECAT has written it. Otherwise ECAT can not write again to the AL Control register.
- * If Device Emulation is on (0x0140.8=1), the AL Control register can always be written, its content is copied to the AL Status register.

AL Status

Address	bit	Description		Master	Slave	Length	Rest Value
0x0130 - 0x0131	3:0	Actual State of the Device State Machine:	1:Init State 2:Pre-Operational State 3:Request Bootstrap State 4:Safe-Operational State 8:Operational State	R/-	R/(W)	2 Byte	0x0001
	4	Error Ind:	0:Device is in State as requested or cleared by bit 4, an error indicator Ack=1 of AL controller. 1:Device has not entered requested State or changed State as result of a local action				
	15:5	Reserved. write 0					

- * AL Status register is only writable if Device Emulation is off (0x0140.8=0), otherwise AL Status register will reflect AL Control register values.

■ Error Indication and AL Status Code Register

The slave indicates errors during a state transition by setting the Error Indication flag (0x0130.4=1) and writing an error description into the AL Status Code register (0x0134:0x0135). The master acknowledges the Error Indication flag of the slave by setting the Error Ind Ack flag (0x0120.4). AL status codes are listed below.

6. Data Link Layer

AL Status Code

Address	bit	Description	Master	Slave	Length	Rest Value
0x0134 - 0x0135	15:0	AL Status Code: The slave indicates errors during a state transition by setting the Error Indication flag (0x0130.4=1) and writing an error description into the AL Status Code register (0x0134:0x0135). The master acknowledges the Error Indication flag of the slave by setting the Error Ind Ack flag (0x0120.4).	R/-	R/W	2 Byte	0x0000
	Code	Overview	Current ESM		Resulting ESM	
	0x0000	No error	Any ESM		Current ESM	
	0x0001	Unspecified error	Any ESM		Any ESM	
	0x0002	NO MEMORY	Any ESM		Current ESM	
	0x0011	Invalid requested EMS change (O->B, S->B, P->B)	I->S, I->O, P->O		Current ESM + E	
	0x0012	Unknown requested state	Any ESM		Current ESM + E	
	0x0013	Bootstrap not supported	I->B		I + E	
	0x0014	No valid firmware	I->P		I + E	
	0x0015	Invalid mailbox configuration	I->B		I + E	
	0x0016	Invalid mailbox configuration	I->P		I + E	
	0x0017	Invalid sync manager configuration	P->S, S->O		Current ESM + E	
	0x0018	No valid inputs available	O, S, P->S		P + E	
	0x0019	No valid outputs	O, S->O		S + E	
	0x001A	Synchronization error	O, S->O		S + E	
	0x001B	Sync manager watchdog	O		S + E	
	0x001C	Invalid Sync Manager Types	O, S P->S		S + E P + E	
	0x001D	Invalid Output Configuration	O, S P->S		S + E P + E	
	0x001E	Invalid Input Configuration	O, S, P->S		P + E	
	0x001F	Invalid Watchdog Configuration	O, S, P->S		P + E	
	0x0020	Slave needs cold start	Any ESM		Current ESM + E	
	0x0021	Slave needs INIT	B, P, S, O		Current ESM + E	
	0x0022	Slave needs PREOP	S, O		S + E, O + E	
	0x0023	Slave needs SAFEOP	O		O + E	
	0x0024	Invalid Input Mapping	P->S		P + E	
	0x0025	Invalid Output Mapping	P->S		P + E	
	0x0026	Unmatched setting	P->S		P + E	
	0x0027	Free-run mode unsupported	P->S		P + E	
	0x0028	SYNC mode unsupported	P->S		P + E	
	0x0029	Free-run mode, 3 Buffer mode not set	P->S		P + E	
	0x002A	BACK GROUND WATCH DOG	P->S		P + E	
	0x002B	NO VALID INPUTS SAND OUTPUTS	P->S		P + E	
	0x002C	FATAL SYNC ERROR	P->S		P + E	
	0x002D	NO SYNC ERROR	O		S + E	
	0x0030	Invalid DC SYNCH Configuration	O, S		S + E	
	0x0031	Invalid DC Latch Configuration	O, S		S + E	
	0x0032	PLL Error	O		S + E	
	0x0033	Invalid DC IO Error	O, S		S + E	
	0x0034	Invalid DC Timeout Error	O, S		S + E	
	0x0035	DC Invalid SYNC CYCLE TIME	P->S		P + E	
	0x0036	DC SYNC0 CYCLE TIME	P->S		P + E	
	0x0037	DC SYNC1 CYCLE TIME	P->S		P + E	
	0x0042	MBX_EOE	B, P, S, O		Current ESM + E	
	0x0043	MBX_COE	B, P, S, O		Current ESM + E	
	0x0044	MBX_FOE	B, P, S, O		Current ESM + E	
	0x0045	MBX_SOE	B, P, S, O		Current ESM + E	
	0x004F	MBX_VOE	B, P, S, O		Current ESM + E	
	0x0050	EE NO ACCSESS	B, P, S, O		Current ESM + E	
	0x0050	EE ERROR	B, P, S, O		Current ESM + E	

* "+E" in the resulting state column indicates setting of the Error Indication flag.

6. Data Link Layer

6) Process data interface(PDI)

PDI Control

Address	bit	Description	Master	Slave	Length	Rest Value
0x0140 -	7:0	Process data interface: 8:16 Bit asynchronous microcontroller interface	R/-	R/-	2 Byte	0x08 Note)
0x0141	8	Device emulation (control of AL status): 0:AL status register has to be set by slave 1:AL status register will be set to value written to AL control register				0x0C Note)
	9	Enhanced Link detection all ports: 0:disabled 1:enabled "0" when using MII port.				
	10	Distributed Clocks SYNC Out Unit: 0:disabled (power saving) 1:enabled				
	11	Distributed Clocks Latch In Unit: 0:disabled (power saving) 1:enabled				
	15:12	Reserved				

Note) EEPROM ADR 0x0000

8/16Bit asynchronous microcontroller configuration

Address	bit	Description	Master	Slave	Length	Rest Value
0x0150	1:0	BUSY output driver/polarity: 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)	R/-	R/-	1 Byte	0x00 Note)
	3:2	IRQ output driver/polarity: 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)				
	4	BHE polarity: 0:Active low 1:Active high				
	6:5	Reserved, set EEPROM value 0				
	7	RD Polarity: 0:Active low 1:Active high				

Note) EEPROM ADR 0x0001

Sync/Latch PDI Configuration

Address	bit	Description	Master	Slave	Length	Rest Value
0x0151	1:0	SYNC0 output driver/polarity: 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)	R/-	R/-	1 Byte	0xCC Note)
	2	SYNC0/LATCH0 configuration: 0:LATCH0 Input 1:SYNC0 Output				
	3	SYNC0 mapped to AL Event Request register 0x0220.2: 0:Disabled 1:Enabled				
	5:4	SYNC1 output driver/polarity: 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)				
	6	SYNC1/LATCH1 configuration: 0:LATCH1 input 1:SYNC1 output				
	7	SYNC1 mapped to AL Event Request register 0x0220.3: 0:Disabled 1:Enabled				

Note) EEPROM ADR 0x0001

Register Asynchronous microcontroller extended Configuration

Address	bit	Description	Master	Slave	Length	Rest Value
0x0152 -	0	Read BUSY delay: 0:Normal read BUSY output 1:Delayed read BUSY output	R/-	R/-	2 Bytes	0x0000 Note)
0x0153	15:1	Reserved, set EEPROM value 0				

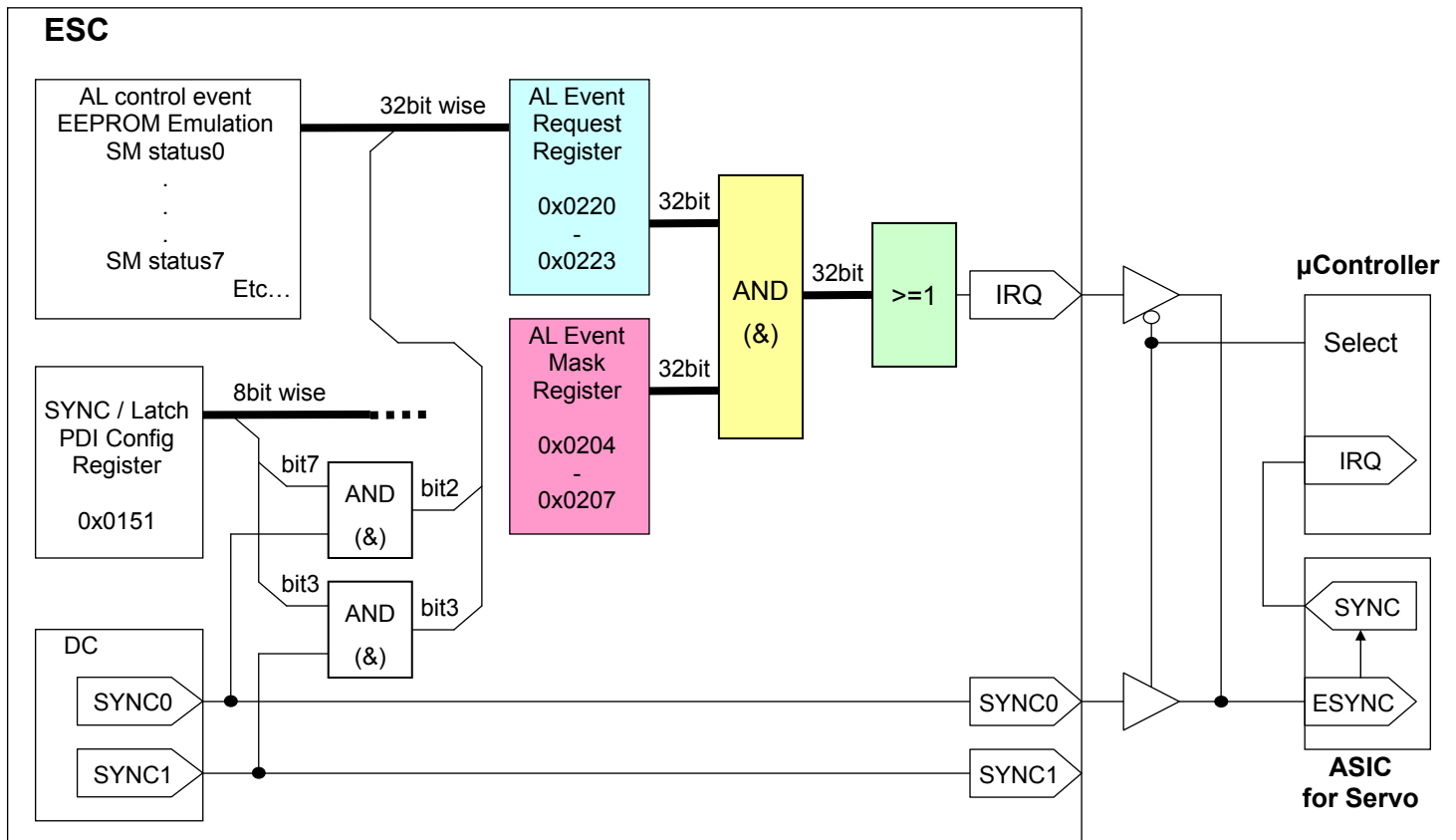
Note) Reset Value is "0". After that, depends on configuration EEPROM ADR 0x0003.

7) Interrupts

ESCs support two types of interrupts: AL Event Requests dedicated for a microcontroller, and ECAT event requests dedicated for the EtherCAT master. Additionally, the Distributed Clocks Sync Signals can be used as interrupts for a microcontroller as well.

■ AL Event Request (PDI Interrupt)

AL Event Requests can be signaled to a microcontroller using the PDI Interrupt Request signal (IRQ/SPI_IRQ, etc.). For IRQ generation, the AL Event Request register (0x0220:0x0223) is combined with the AL Event Mask register (0x0204:0x0207) using a logical AND operation, then all resulting bits are combined (logical OR) into one interrupt signal. The output driver characteristics of the IRQ signal are configurable using the SYNC/LATCH PDI configuration register (0x0151). The AL Event Mask register allows for selecting the interrupts which are relevant for the microcontroller and handled by the application.



PDI Interrupt Masking and interrupt signals

The DC Sync Signals can be used for interrupt generation in two ways:

- The DC SYNC signals are mapped into the AL Event Request Register (configured with SYNC/LATCH PDI Configuration register 0x0151.3/7). In this case, all interrupts from the ESC to the μController are combined into one IRQ signal, and the Distributed Clocks LATCH0/1 inputs can still be used. The IRQ signal has a jitter of ~40 ns.
- The DC Sync Signals are directly connected to microcontroller interrupt inputs. The μController can react on DC Sync Signal interrupts faster (without reading AL Request register), but it needs more interrupt inputs. The jitter of the Sync Signals is ~12 ns. The DC Latch functions are only available for one Latch input or not at all (if both DC SYNC outputs are used).

6. Data Link Layer

Registers used for AL event requests are described:

Registers for AL Event Requests

Register Address	Name	Description
0x0150	PDI Configuration	IRQ driver characteristics, depending on PDI
0x0151	SYNC/LATCH PDI Configuration	Mapping DC Sync Signals to Interrupts
0x0204:0x0207	AL Event Mask	Mask register
0x0220:0x0223	AL Event Request	Pending Interrupts
0x0804+N*8	Sync Manager Control	Mapping Sync Manager Interrupts

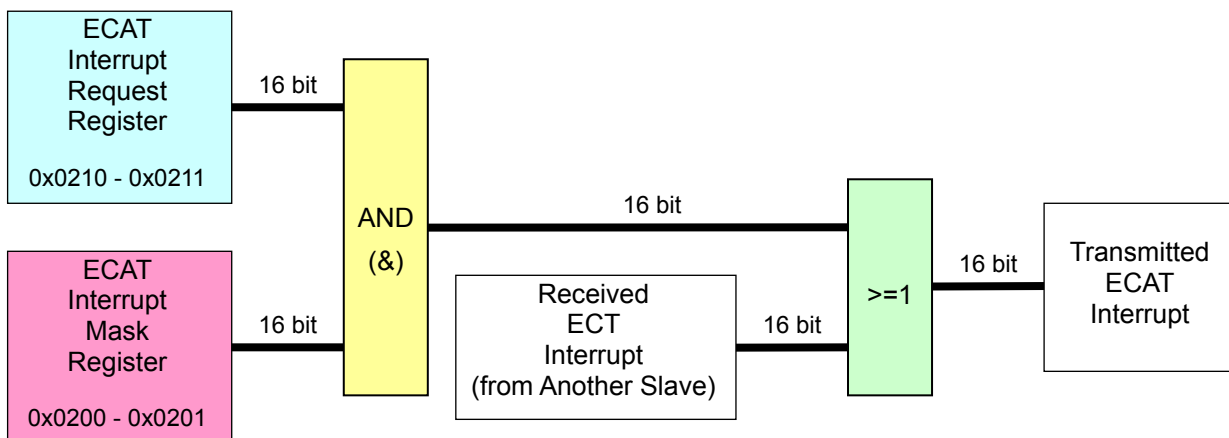
* Some registers are set by EEPROM at initialization.

■ ECAT Event Request (ECAT Interrupt)

ECAT event requests are used to inform the EtherCAT master of slave events. ECAT events make use of the IRQ field inside EtherCAT datagrams. The ECAT Event Request register (0x0210:0x0211) is combined with the ECAT Event Mask register (0x0200:0x0201) using a logical AND operation.

The resulting interrupt bits are combined with the incoming ECAT IRQ field using a logical OR operation, and written into the outgoing ECAT IRQ field. The ECAT Event Mask register allows for selecting the interrupts which are relevant for the EtherCAT master and handled by the master application.

NOTE: The master can not distinguish which slave (or even more than one) was the origin of an interrupt.



ECAT Interrupt Masking

Registers used for ECAT Interrupts are described:

Registers for ECAT Interrupts

Register Address	Name	Description
0x0200: 0x0201	ECAT Interrupt Mask	Mask register
0x0210: 0x0211	ECAT Interrupt Request	Pending Interrupts
0x0804 + N*8	SyncManager Control	Mapping SyncManager Interrupts

6. Data Link Layer

ECAT Event Mask

Address	bit	Description	Master	Slave	Length	Rest Value
0x0200 - 0x0201	15:0	ECAT Event masking of the ECAT Event Request Events for mapping into ECAT event field of EtherCAT frames: 0: Corresponding ECAT Event Request register bit is not mapped 1: Corresponding ECAT Event Request register bit is mapped	R/W	R/-	2 Bytes	0x0000

AL Event Mask

Address	bit	Description	Master	Slave	Length	Rest Value
0x0204 - 0x0207	31:0	AL Event masking of the AL Event Request register Events for mapping to PDI IRQ signal: 0: Corresponding AL Event Request register bit is not mapped 1: Corresponding AL Event Request register bit is mapped	R/-	R/W	4 Bytes	0x000000FF - 0x0000FF0F

ECAT Event Request

Address	bit	Description	Master	Slave	Length	Rest Value
0x0210 - 0x0211	0	DC Latch event (Bit is cleared by reading DC Latch event times for ECAT controlled Latch Units, so that Latch 0/1 Status 0x09AE:0x09AF indicates no event): 0: No change on DC Latch Inputs 1: At least one change on DC Latch Inputs	R/-	R/-	2 Bytes	0x0000
	1	Reserved				
	2	DL Status event (Bit is cleared by reading out DL Status): 0: No change in DL Status 1: DL Status change				
	3	AL Status event (Bit is cleared by reading out AL Status): 0: No change in AL Status 1: AL Status change				
	4	Mirrors values of each SyncManager Status 0: No Sync Channel 0 event 1: Sync Channel 0 event pending				
	...	...				
	11	Mirrors values of each SyncManager Status 0: No Sync Channel 7 event 1: Sync Channel 7 event pending				
	15:12	Reserved				

AL Event Request

Address	bit	Description	Master	Slave	Length	Rest Value
0x0220 - 0x0223	0	AL Control event: (Bit is cleared by reading AL Control register.) 0: No AL Control Register change 1: AL Control Register has been written	R/-	R/-	4 Bytes	0x00000000
	1	DC Latch event: (Bit is cleared by reading DC Latch event times.) 0: No change on DC Latch Inputs 1: At least one change on DC Latch Inputs				
	2	SYNC0 status when 0x0151.3=1 (Bit clear at SYNC0 status red)				
	3	SYNC1 status when 0x0151.7=1 (Bit clear at SYNC1 status red)				
	4	SyncManager activation register (Offset: 0x0806 + y × 8) 0: SM0 - 7 No change 1: Some of SM0 - 7 has changed (SM) (Bit clear by read of SM activation register)				
	7:5	Reserved				
	8	SM status mirror 0: No SyncManager 0 interrupt 1: SyncManager 0 interrupt pending				
	...	...				
	15	SM status mirror 0: No SyncManager 7 interrupt 1: SyncManager 7 interrupt pending				
	31:16	Reserved				

6. Data Link Layer

8) Error Counter

RX Error Counter

Errors are only counted if the corresponding port is enabled.

Address	bit	Description	Master	Slave	Length	Rest Value
0x0300 - 0x0307	7:0	Invalid frame counter of Port 0 (counting is stopped when 0xFF is reached). Note)	R/W (clr)	R/-	8 Bytes	0x00
	15:8	RX Error counter of Port 0 (counting is stopped when 0xFF is reached). Note) This is coupled directly to RX ERR of MII interface/EBUS interface.				0x00
	23:16	Invalid frame counter of Port 1 (counting is stopped when 0xFF is reached). Note)				0x00
	31:24	RX Error counter of Port 1 (counting is stopped when 0xFF is reached). Note) This is coupled directly to RX ERR of MII interface/EBUS interface.				0x00
	63:32	Reserved				0x00000000

* Cleared if one of the RX Error counters 0x0300-0x030B is written.

The invalid frame counters are incremented if there is an error in the frame format (Preamble, SFD – Start of Frame Delimiter, FCS – Checksum, invalid length). If the FCS is invalid and an additional nibble is appended, the FCS error is not counted. This is why EtherCAT forwards frames with errors with an invalid FCS and an additional nibble.

RX Errors may appear either inside or outside frames. RX Errors inside frames will lead to invalid frames.

Forwarded RX Error Counter

Address	bit	Description	Master	Slave	Length	Rest Value
0x0308 - 0x030B	7:0	Forwarded error counter of Port 0 (counting is stopped when 0xFF is reached). Note)	R/W (clr)	R/-	4 Bytes	0x00
	15:8	Forwarded error counter of Port 1 (counting is stopped when 0xFF is reached). Note)				0x00
	23:16	Reserved				0x0000

Note) Cleared if one of the RX Error counters 0x0300-0x030B is written.

ECAT Processing Unit Error Counter

Address	bit	Description	Master	Slave	Length	Rest Value
0x030C	7:0	ECAT Processing Unit error counter (counting is stopped when 0xFF is reached). Note) Counts errors of frames passing the Processing Unit (e.g., FCS is wrong or datagram structure is wrong).	R/W (clr)	R/-	1 Byte	0x00

* Cleared if register is written.

PDI Error Counter

Address	bit	Description	Master	Slave	Length	Rest Value
0x030D	7:0	PDI Error counter (counting is stopped when 0xFF is reached). Note) Counts if a PDI access has an interface error.	R/W (clr)	R/-	1 Byte	0x00

* Cleared if register is written.

Lost Link Counter

Address	bit	Description	Master	Slave	Length	Rest Value
0x0310 - 0x0313	7:0	Lost Link counter of Port 0 (counting is stopped when 0xff is reached). Note)	R/W (clr)	R/-	4 Bytes	0x00
	15:8	Lost Link counter of Port 1 (counting is stopped when 0xff is reached). Note)				0x00
	31:16	Reserved				0x0000

* Cleared if one of the Lost Link counter registers is written.

6. Data Link Layer

9) Watchdog

Watchdog Divider

Address	bit	Description	Master	Slave	Length	Rest Value
0x0400 - 0x0401	15:0	Watchdog divider: Number of 25 MHz tics (minus 2) that represents the basic watchdog increment. (Default value is $100\mu\text{s} = 2,500 - 2 = 2498$)	R/W	R/-	2 Bytes	0x09C2

Watchdog Time PDI

Address	bit	Description	Master	Slave	Length	Rest Value
0x0410 - 0x0411	15:0	Watchdog Time PDI: number of basic watchdog increments (Default value with Watchdog divider $100\mu\text{s}$ means 100ms Watchdog at $0x0400=0x09C2$)	R/W	R/-	2 Bytes	0x03E8

Watchdog Time Process Data

Address	bit	Description	Master	Slave	Length	Rest Value
0x0420 - 0x0421	15:0	Watchdog Time Process Data: number of basic watchdog increments (Default value with Watchdog divider $100\mu\text{s}$ means 100ms Watchdog) There is one Watchdog for all SyncManagers.	R/W	R/-	2 Bytes	0x03E8

- * Watchdog is restarted with every write access to SyncManagers with Watchdog Trigger Enable Bit set.
- * Watchdog is disabled if Watchdog time is set to $0x0420=0$.

■ Watchdog Status PDI

The Watchdog Status for the PDI can be read in the DL Status register 0x0110.1.

Watchdog Status Process Data

Address	bit	Description	Master	Slave	Length	Rest Value
0x0440 - 0x0441	0	Watchdog Status of Process Data (triggered by SyncManagers) 0: Watchdog Process Data expired 1: Watchdog Process Data is active or disabled	R/-	R/-	2 Bytes	0x0000
	15:1	Reserved				

Watchdog Counter Process Data

Address	bit	Description	Master	Slave	Length	Rest Value
0x0442	7:0	Watchdog Counter Process Data (counting is stopped when 0xFF is reached). Counts if Process Data Watchdog expires.	R/W (clr)	R/-	1 Byte	0x00

- * Cleared if one of the Watchdog counters 0x0442:0x0443 is written.

Watchdog Counter PDI

Address	bit	Description	Master	Slave	Length	Rest Value
0x0443	7:0	Watchdog PDI counter (counting is stopped when 0xFF is reached). Counts if PDI Watchdog expires.	R/W (clr)	R/-	1 Byte	0x00

- * Cleared if one of the Watchdog counters 0x0442:0x0443 is written.

6. Data Link Layer

10) ESI EEPROM Interface (Slave Information Interface)

EtherCAT controls the ESI EEPROM interface if EEPROM configuration register 0x0500.0=0 and EEPROM PDI Access register 0x0501.0=0, otherwise PDI controls the EEPROM interface.

EEPROM Configuration

Address	bit	Description	Master	Slave	Length	Rest Value
0x0500	0	EEPROM control is offered to PDI 0: EtherCAT (Master) 1: PDI (Slave)	R/W	R/-	1 Byte	0x00
	1	Force ECAT access 0: Do not change Bit 501.0 1: Reset Bit 501.0 to 0				
	7:2	Reserved, write 0	R/-	R/-		

EEPROM PDI Access State

Address	bit	Description	Master	Slave	Length	Rest Value
0x0501	0	Access to EEPROM (Note) 0: PDI releases EEPROM access 1: PDI takes EEPROM access (PDI has EEPROM control)	R/-	R/(W)	1 Byte	0x00
	7:1	Reserved, write 0	R/-	R/-		

Note) r/(w): write access is only possible if 0x0500.0=1 and 0x0500.1=0.

EEPROM Control/Status

Address	bit	Description		Master	Slave	Length	Rest Value
0x0502 - 0x0503	0	ECAT write enable Note1)	0: Write requests are disabled 1: Write requests are enabled This bit is always 1 if PDI has EEPROM control.	R/(W)	R/-	2 Bytes	0xC0
	4:1	Reserved, write 0		R/-	R/-		
	5	EEPROM emulation	0: Normal operation (I ² C interface used) 1: PDI emulates EEPROM (I ² C not used)				
	6	Supported number of EEPROM read bytes	0: 4Byte 1: 8Byte				
	7	Selected EEPROM Algorithm	0: 1 address byte (1KBit – 16KBit EEPROMs) 1: 2 address bytes (32KBit – 4 MBit EEPROMs)				
	8	EEPROM Read Commands Note1)	Write: 0:No Action 1: Begin read access Read: 0:No read 1: Read processing	R/(W)	R/(W)	0x00	
	9	EEPROM Write Commands Note1)	Write: 0:No Action 1: Begin write access Read: 0:No write 1: Write processing				
	10	EEPROM Reload Commands Note1)	Write: 0:No Action 1: Begin reload Read: 0: No reload 1: Reloading				
	11	Checksum Error at in ESC Configuration Area	0: Checksum ok 1: Checksum error	R/-	R/-		
	12	EEPROM loading status	0: EEPROM loaded, device information ok 1: EEPROM not loaded, device information not available				
	13	Error Acknowledge/ Commands Note1)	0: No error 1: Missing EEPROM acknowledge or invalid command				
	14	Error Write Enable Note2)	0: No error 1: Write Command without Write enable				
15	Busy	0: EEPROM Interface is idle 1: EEPROM Interface is busy					

* r/(W):write access depends upon the assignment of the EEPROM interface (ECAT/PDI).

* Write access is generally blocked if EEPROM interface is busy (0x0502.15=1).

Note1) Write Enable bit 0 and Command bits [10:8] are self-clearing. Manually clearing the command register will also clear the error bits [14:13]. Command bits [10:8] are ignored if Error Acknowledge/Command is pending (bit 13).

Note2) Error bits are cleared by writing "000" (or any valid command) to Command Register Bits [10:8].

6. Data Link Layer

EEPROM Address

Address	bit	Description	Master	Slave	Length	Rest Value
0x0504	15:0	EEPROM Address, to be read or written Lower Word(=16bit)	R/(W)	R/(W)	4 Bytes	0x00000000
0x0507	31:16	Upper Word				

* r/(w): write access depends upon the assignment of the EEPROM interface (ECAT/PDI).

* Write access is generally blocked if EEPROM interface is busy (0x0502.15=1).

EEPROM Data

Address	bit	Description	Master	Slave	Length	Rest Value
0x0508	15:0	EEPROM Write data / Read data (lower bytes : 2Byte)	R/(W)	R/(W)	8 Bytes	0x0000
0x050F	63:16	EEPROM Write data / Read data (higher bytes : 6Byte)	R/-	R/-		0x000000000000

* r/(w): write access depends upon the assignment of the EEPROM interface (ECAT/PDI).

* Write access is generally blocked if EEPROM interface is busy (0x0502.15=1).

11) MII Management Interface

MI Management Control/Status

Address	bit	Description		Master	Slave	Length	Rest Value
0x0510 - 0x0511	0	Write enable (Note)	0: Write disabled 1: Write enabled	R/(W)	R/(W)	2 Bytes	0x00
	1	Management Interface can be controlled by PDI (registers 0x0516-0 x0517)	0: Only ECAT control 1: PDI control possible	R/-	R/-		
	2	MI link detection(0x0518:0 x051B)	link configuration, link detection 0: Not available 1: MI link detection active				
	7:3	PHY address offset	00000:offset "0"				
	9:8	Command register	Write: Initiate command. Read: Currently executed command Commands: 00: No command/MI idle (clear error bits) 01: Read 10: Write Others: Reserved/invalid commands (do not issue)	R/(W)	R/(W)		0x00
	12:10	Reserved, write 0		R/-	R/-		
	13	Read error	0: No read error 1: Read error occurred (PHY or register not available) Cleared by writing to this register.	R/(W)	R/(W)		
	14	Command error	0: Last Command was successful 1: Invalid command or write command without Write Enable Cleared with a valid command or by writing "00" to Command register bits [9:8].				
	15	Busy	0: MI control state machine is idle 1: MI control state machine is active				

* r/ (w): write access depends on assignment of MI (ECAT/PDI).

* Write access is generally blocked if Management interface is busy (0x0510.15=1).

Note) Write enable bit 0 and Command bits [9:8] are self-clearing. Manually clearing the command register will also clear the status information. The Write enable bit is cleared at the SOF/at the end of the PDI access. The Command bits are cleared after the command is executed.

PHY Address

Address	bit	Description	Master	Slave	Length	Rest Value
0x0512	4:0	PHY Address	R/(W)	R/(W)	1 Byte	0x00
	7:5	Reserved, write 0	R/-	R/-		

r/ (w): write access depends on assignment of MI (ECAT/PDI).

* Write access is generally blocked if Management interface is busy (0x0510.15=1).

6. Data Link Layer

PHY Register Address

Address	bit	Description	Master	Slave	Length	Rest Value
0x0513	4:0	Address of PHY Register that shall be read/written	R/(W)	R/(W)	1 Byte	0x00
	7:5	Reserved, write 0	R/-	R/-		

r/ (w): write access depends on assignment of MI (ECAT/PDI).

* Write access is generally blocked if Management interface is busy (0x0510.15=1).

PHY Data

Address	bit	Description	Master	Slave	Length	Rest Value
0x0514 - 0x0515	15:0	PHY Read/Write Data	R/(W)	R/(W)	2 Bytes	0x0000

r/ (w): write access depends on assignment of MI (ECAT/PDI).

* Access is generally blocked if Management interface is busy (0x0510.15=1).

MII Management ECAT Access State

Address	bit	Description	Master	Slave	Length	Rest Value
0x0516	0	Access to MII management 0: ECAT enables PDI takeover of MII management control 1: ECAT claims exclusive access to MII management	R/(W)	R/-	1 Byte	0x00
	7:1	Reserved, write 0	R/-	R/-		

* r/ (w): write access is only possible if 0x0517.0=0.

MII Management PDI Access State

Address	bit	Description	Master	Slave	Length	Rest Value
0x0517	0	Access to MII management 0: ECAT has access to MII management 1: PDI has access to MII management	R/-	R/(W)	1 Byte	0x00
	1	Force PDI Access State 0: Do not change Bit 517.0 1: Reset Bit 517.0 to 0	R/W	R/-		
	7:2	Reserved, write 0	R/-	R/-		

* r/ (w): write access to bit 0 is only possible if 0x0516.0=0 and 0x0517.1=0.

PHY Port 0/1 Status

Address	bit	Description	Master	Slave	Length	Rest Value
0x0518 - 0x0519	0	Physical link Port 0 status 0: No physical link 1: Physical link detected (PHY status register 1.2)	R/-	R/-	2 Bytes	0x00
	1	Port 0 Link status 0: No link 1: Link detected (100 Mbit/s, Full Duplex, Auto negotiation)				
	2	Port 0 Link status error 0: No error 1: Link error, link inhibited				
	3 (Note)	Port 0 Read error 0: No read error occurred 1: A read error has occurred	R/(W)	R/(W)		
	4	Port 0 Link partner error 0: No error detected 1: Link partner error	R/-	R/-		
	7:5	Reserved	R/-	R/-		
	8	Physical link Port 1 status 0: No physical link 1: Physical link detected (PHY status register 1.2)	R/-	R/-	2 Bytes	0x00
	9	Port 1 Link status 0: No link 1: Link detected (100 Mbit/s, Full Duplex, Auto negotiation)				
	10	Port 1 Link status error 0: No error 1: Link error, link inhibited				
	11 (Note)	Port 1 Read error 0: No read error occurred 1: A read error has occurred	R/(W)	R/(W)		
	12	Port 1 Link partner error 0: No error detected 1: Link partner error	R/-	R/-		
	15:13	Reserved	R/-	R/-		

Note) Cleared by writing any value to at least one of the PHY Status Port 0 registers.

* r/ (w): write access depends on assignment of MI (ECAT/PDI).

6. Data Link Layer

12) FMMU [7:0] (Fieldbus Memory Management Units)

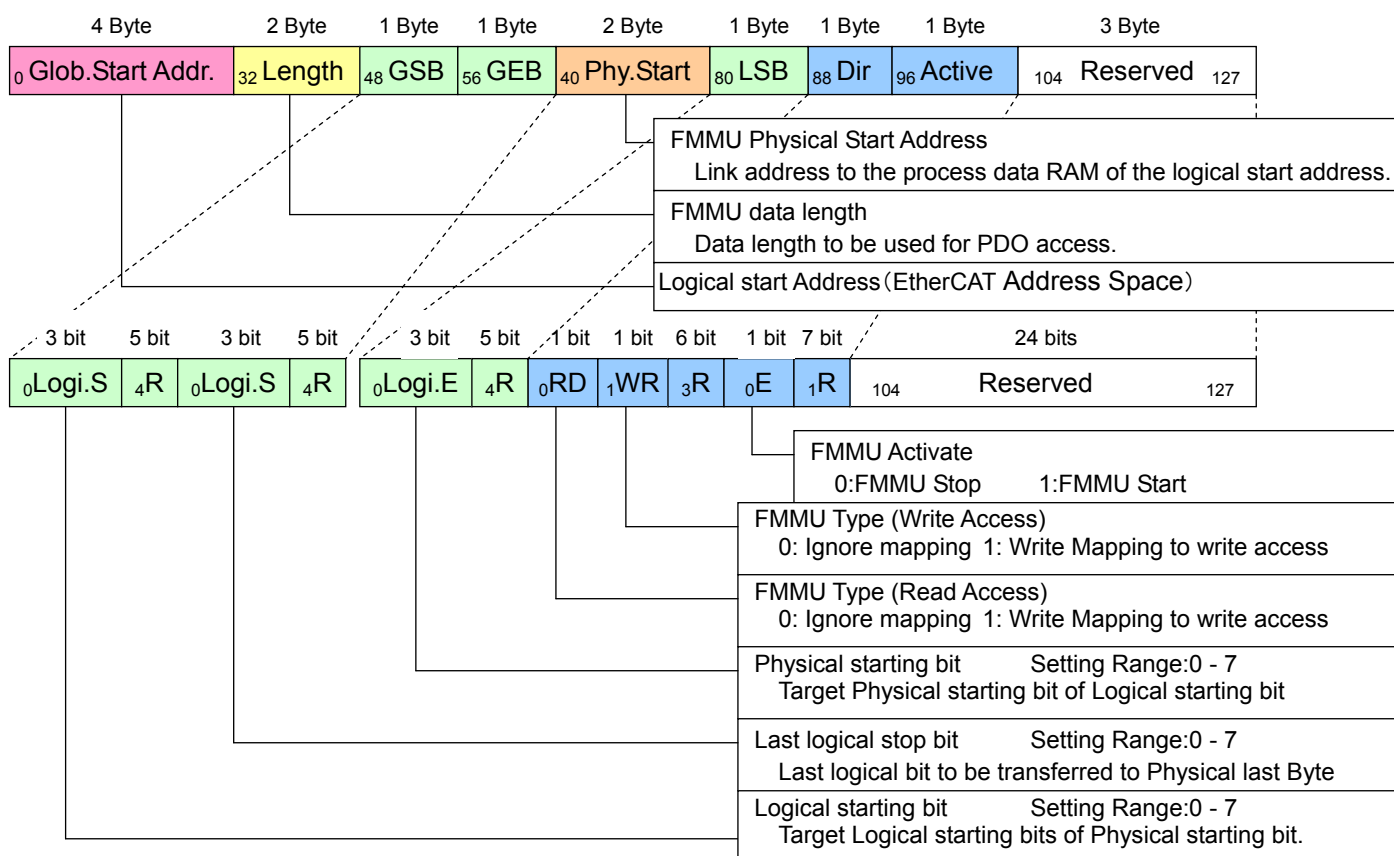
Each FMMU entry is described in 16 Bytes from 0x0600:0x060F to 0x0670:0x067F.

Model No PB EtherCAT driver has 8 FMMUs from FMMU0 - FMMU7.

y is the FMMU index (y=0 to 7).

■ FMMU configuration register

FMMU entity configuration is shown below.



FMMU Configuration Register Formation

FMMU Characteristics and Remarks

- * Each logical address byte can, at most, be mapped either by one FMMU (read) plus one FMMU (write) or by one FMMU (read/write). If two or more FMMUs (with the same direction – read or write) are configured for the same logical byte, the FMMU with the lower number (lower configuration address space) is used and the others are ignored.
- * One or more FMMUs may point to the same physical memory-all are used. Collisions cannot occur.
- * A read/write FMMU cannot be used together with SyncManagers since independent read and write SyncManagers cannot be configured to use the same (or overlapping) physical address range.
- * Bit-wise reading is supported with any address. Bits not mapped to logical addresses are not changed in the EtherCAT datagram, (e.g., this allows mapping bits from several ESCs into the same logical byte).
- * Reading an unconfigured logical address space will not change the data.

6. Data Link Layer

Logical Start address FMMU y

Address	bit	Description	Master	Slave	Length	Rest Value
0x06y0 - 0x06y3	31:0	Logical start address within the EtherCAT Address Space.	R/W	R/-	4 Bytes	0x00000000

Length FMMU y

Address	bit	Description	Master	Slave	Length	Rest Value
0x06y4 - 0x06y5	15:0	Offset from the first logical FMMU Byte to the last FMMU Byte + 1 (e.g., if two bytes are used then this parameter shall contain 2)	R/W	R/-	2 Bytes	0x0000

Start bit FMMU y in logical address space

Address	bit	Description	Master	Slave	Length	Rest Value
0x06y6	2:0	Logical starting bit that shall be mapped (bits are counted from least significant bit (=0) to most significant bit(=7)	R/W	R/-	1 Byte	0x00
	7:3	Reserved, write 0	R/-	R/-		

Stop bit FMMU y in logical address space

Address	bit	Description	Master	Slave	Length	Rest Value
0x06y7	2:0	Last logical bit that shall be mapped (bits are counted from least significant bit (=0) to most significant bit(=7)	R/W	R/-	1 Byte	0x00
	7:3	Reserved, write 0	R/-	R/-		

Physical Start address FMMU y

Address	bit	Description	Master	Slave	Length	Rest Value
0x06y8 - 0x06y9	15:0	Physical Start Address (mapped to logical Start address)	R/W	R/-	2 Byte	0x0000

Physical Start bit FMMU y

Address	bit	Description	Master	Slave	Length	Rest Value
0x06yA	2:0	Physical starting bit as target of logical start bit mapping (bits are counted from least significant bit (=0) to most significant bit(=7)	R/W	R/-	1 Byte	0x00
	7:3	Reserved, write 0				

Type FMMU y

Address	bit	Description	Master	Slave	Length	Rest Value
0x06yB	0	0:Ignore mapping for read accesses 1:Use mapping for read accesses	R/W	R/-	1 Byte	0x00
	1	0:Ignore mapping for write accesses 1:Use mapping for write accesses				
	7:2	Reserved, write 0	R/-	R/-		

Activate FMMU y

Address	bit	Description	Master	Slave	Length	Rest Value
0x06yC - 0x06yF	0	0:FMMU deactivated 1:FMMU activated. FMMU checks logical addressed blocks to be mapped according to mapping configured	R/W	R/-	4 Bytes	0x00000000
	31:1	Reserved, write 0	R/-	R/-		

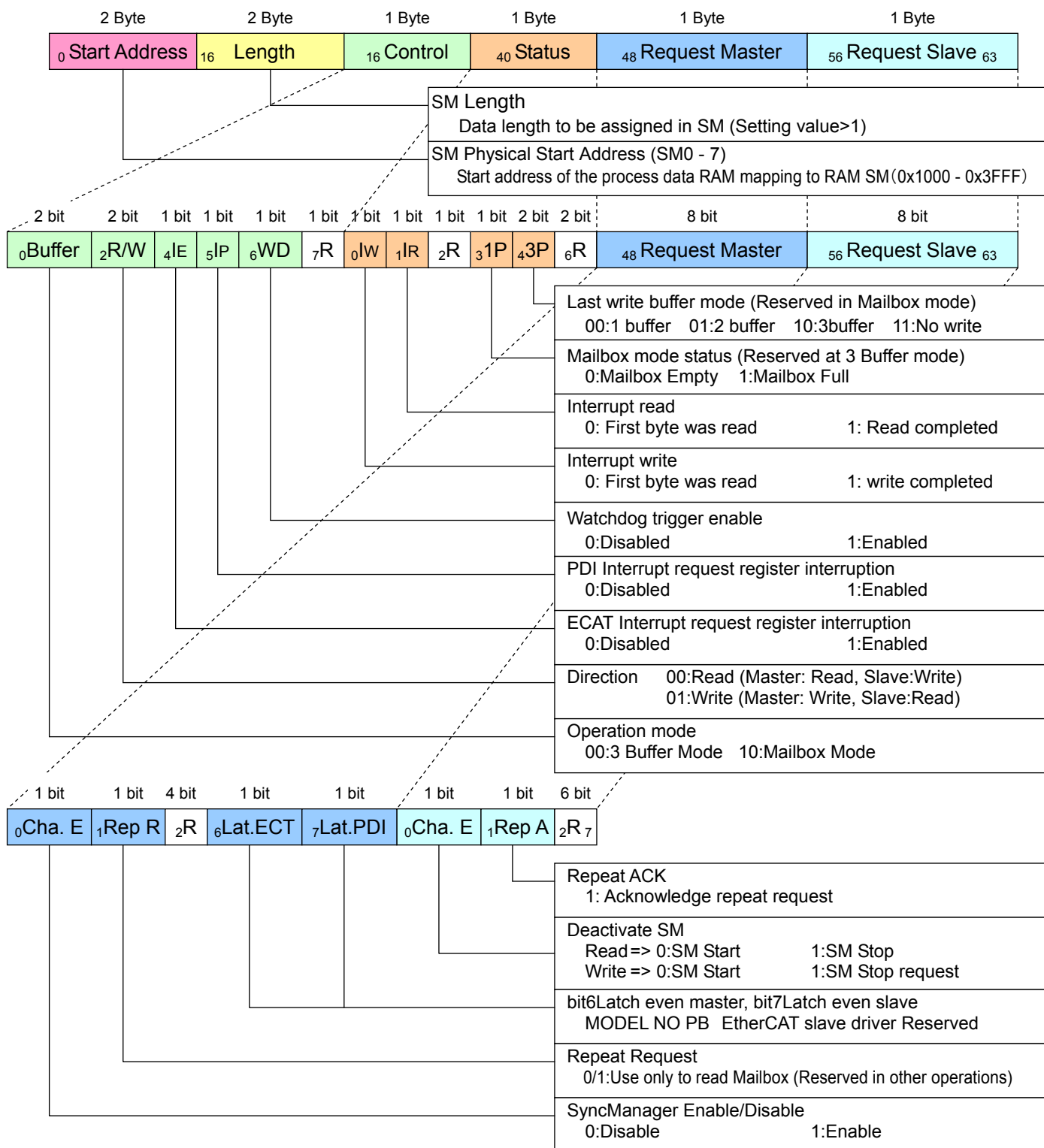
6. Data Link Layer

13) SyncManager (sm [7:0])

SyncManager registers are mapped from 0x0800:0x0807 to 0x0838:0x083F.
The Model No PB EtherCAT driver has eight SM from SM0 to SM7.
y specifies SyncManager (y=0 to 7).

■ Channel Configuration Register Formation.

SM Configuration Register Formation is shown below.



SMConfiguration Register Formation

6. Data Link Layer

Physical Start Address SyncManager y

Address	bit	Description	Master	Slave	Length	Rest Value
0x0800+y ^{x8} - 0x0801+y ^{x8}	15:0	Specifies first byte that will be handled by SyncManager r/(w): Register can only be written if SyncManager is disabled (+0x6.0 = 0).	R/(W)	R/-	2 Bytes	0x0000

Length SyncManager y

Address	bit	Description	Master	Slave	Length	Rest Value
0x0802+y ^{x8} - 0x0803+y ^{x8}	15:0	Number of bytes assigned to SyncManager (shall be greater 1, otherwise SyncManager is not activated. If set to 1, only Watchdog Trigger is generated if configured) r/(w): Register can only be written if SyncManager is disabled (+0x6.0 = 0).	R/(W)	R/-	2 Bytes	0x0000

* Setting range is 0x0080(128Byte) - 0x0400(1024Byte) with even numbered settings.

* AL status code [0x0016: Invalid Mailbox Setting] will responded to at Pre-Operation request when value is written out of setting range.

Control Register SyncManager y

Address	bit	Description	Master	Slave	Length	Rest Value
0x0804+y ^{x8} SM0 0x0804 SM1 0x080C SM2 0x0814 SM3 0x081C	1:0	Operation Mode 00: Buffered (3 buffer mode) 01: Reserved 10: Mailbox (Single buffer mode) 11: Reserved	R/W	R/-	1 Byte	0x00
	3:2	Direction 00: Read: ECAT read access, PDI write access. 01: Write: ECAT write access, PDI read access. 10: Reserved 11: Reserved				
	4	Interrupt in ECAT Event Request Register 0: Disabled 1: Enabled				
	5	Interrupt in PDI Event Request Register 0: Disabled 1: Enabled				
	6	Watchdog Trigger Enable Note) 0: Disabled 1: Enabled				
	7	Reserved, write 0	R/-	R/-		

* r/(w): Register can only be written if SyncManager is disabled (+0x6.0 = 0).

* The SyncManager Watchdog function will be disabled by setting 0x0400:Watchdog Divider zero when Watchdog Trigger enable bit6=0:Disable is set. It can also be disabled by setting 0x0420: Watchdog Time Process Data to zero.

6. Data Link Layer

Status Register SyncManager y

Address	bit	Description		Master	Slave	Length	Rest Value
0x0805 +y ^{x8} SM0 0x0805 SM1 0x080D SM2 0x0815 SM3 0x081D	0	Interrupt Write	1: Interrupt after buffer was completely and successfully written (0x0804+y ^{x8}) 0: Interrupt cleared after first byte of buffer was read	R/-	R/-	1 Byte	0x00
	1	Interrupt Read:	1: Interrupt after buffer was completely and successful read (0x0804+y ^{x8}) 0: Interrupt cleared after first byte of buffer was written				
	2	Reserved					
	3	Mailbox mode: mailbox status	0: Mailbox empty 1: Mailbox full Note) 3 Buffered mode: reserved				
	5:4	Buffered mode: buffer status (last written buffer)	00: 1buffer01: 2buffer 10: 3buffer 11: (no buffer written) Note) Mailbox mode: reserved				
	7:6	Reserved					

Activate SyncManager y

Activate SyncManager y							
Address	bit	Description		Master	Slave	Length	Rest Value
0x0806 +y ^{x8} SM0 0x0806 SM1 0x080E SM2 0x0816 SM3 0x081E	0	SyncManager Enable/Disable	0: Disable: Access to Memory without SyncManager control 1: Enable: SyncManager is active and controls Memory area set in configuration	R/W	R/-	1 Byte	0x00
	1	Repeat Request	0/1: A toggle of Repeat Request means that a mailbox retry is needed (primarily used in conjunction with ECAT Read Mailbox)				
	5:2	Reserved, write 0		R/-	R/-		
	6	Latch Event ECAT	0: No 1: Generate Latch event if EtherCAT master issues a buffer exchange	R/W	R/-		
	7	Latch Event PDI	0: No 1: Generate Latch events if PDI issues a buffer exchange or if PDI accesses buffer start address				

PDI Control SyncManager y

Address	bit	Description		Master	Slave	Length	Rest Value
0x0807 +y ^{x8} SM0 0x0807 SM1 0x080F SM2 0x0817 SM3 0x081F	0	Deactivate SyncManager	Read: 0: Normal operation, SyncManager activated. 1: SyncManager deactivated and reset SyncManager locks access to Memory area. Write: 0: Activate SyncManager 1: Request SyncManager deactivation Writing 1 is delayed until the end of a frame which is currently processed.	R/-	R/W	1 Byte	0x00
	1	Repeat Ack	If this is set to the same value as set by Repeat Request, the PDI acknowledges the execution of a previous set Repeat request.				
	7:2	Reserved, write 0					
				R/-	R/-		

14) Distributed Clocks (DC)

Propagation delay measurement, Offset compensation and Drift compensation to Reference Clock are required to perform clock synchronization. Each method is described below.

■ Propagation Delay Measurement

Since each slave introduces a small processing/forwarding delay in each direction (within the device and also in the physical layer), as well as the cable between the ESCs has a delay, the propagation delay between Reference Clock and the respective slave clock has to be considered for the synchronization of the slave clocks.

1. For measuring the propagation delay, the master sends a broadcast write to register DC Receive Time Port 0 (at least first byte).
2. Each slave device stores the time of its local clock when the first bit of the Ethernet preamble of the frame was received, separately for each port (Receive Time Port 0-1 registers).
3. The master reads all time stamps and calculates the delay times with respect to the topology. The delay time between Reference Clock and the individual slave is written to slave's System Time Delay register (0x0928:0x092B).

The receive time registers are used to sample the receive time of a specific frame (a broadcast write to Receive Time Port 0 register).

The clocks must not be synchronized for the delay measurement, only local clock values are used.

Since the local clocks of the slaves are not synchronized, there is no relation between the Receive Times of different slaves. So the propagation delay calculation has to be based on receive time differences between the ports of a slave.

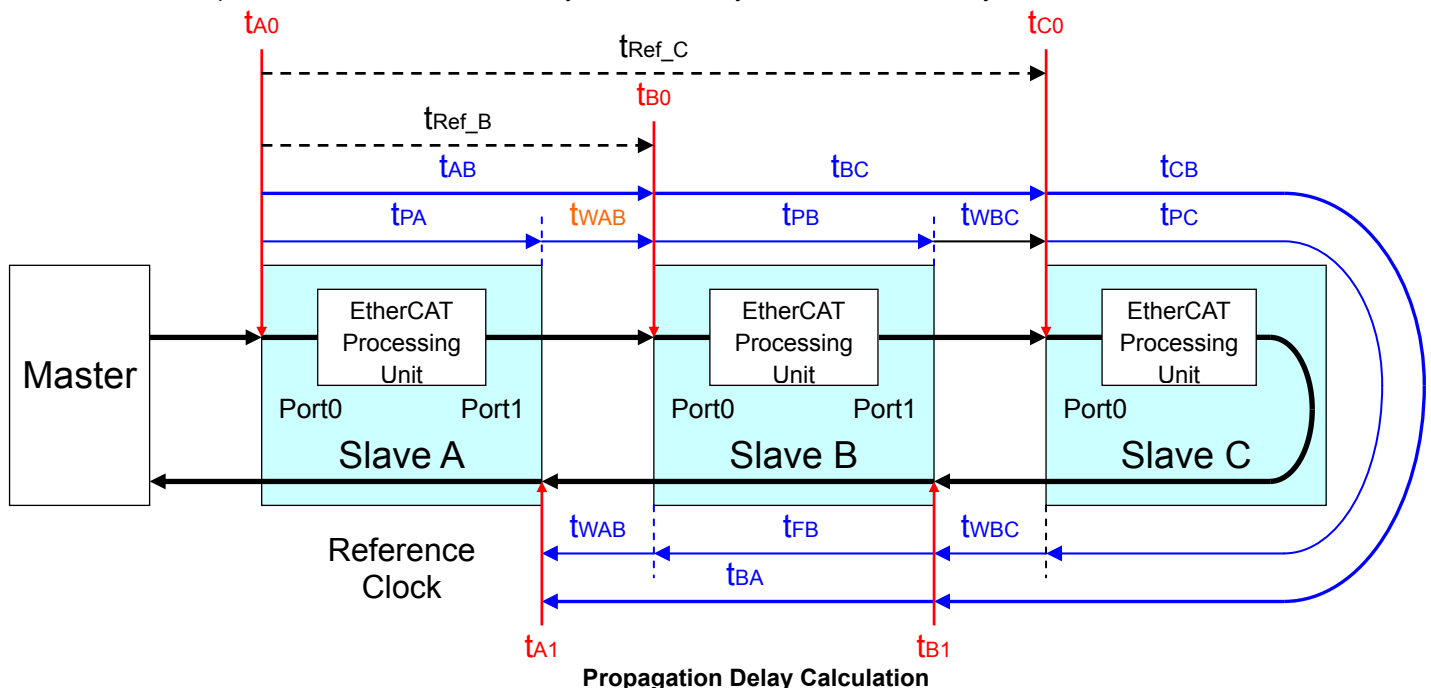
Registers for Propagation Delay Measurement

Register Address	Name	Description
0x0900:0x903	Receive Time Port 0	Local time when receiving frame on Port 0
0x0904:0x907	Receive Time Port 1	Local time when receiving frame on Port 1
0x0908:0x90B	-	Reserved
0x090C:0x90F	-	Reserved
0x0918:0x91F	Receive Time ECAT Processing Unit	Local time when receiving frame at the ECAT Processing Unit

■ Propagation Delay Measurement Example

The propagation delay between the local device and the Reference Clock device is calculated for the network example shown in Figure below. The example assumes that slave A is the Reference Clock.

The loops of slave C are closed internally. The wire delays are assumed to be symmetrical.



6. Data Link Layer

Parameters for Propagation Delay Calculation

Parameter	Description
tPA, tPB, tPC	Processing delay of slave (EtherCAT Processing Delay)
tFB	Forwarding delay of slave (EtherCAT FoR/Warding Delay)
tAB, tBC, tCB, tBA	Propagation delay from slave to slave
tWAB, tWBC, tWCB, tWBA	Wire propagation delay between slaves (assumed to be symmetrical in both directions)
tA0, tB0, tC0, tA1, tB1	Receive Time Port 0/1 values of slave (time when first preamble bit is detected)
tP	Processing delay (through EtherCAT Processing Unit) if all slaves are identical
tF	Forwarding delay (alongside EtherCAT Processing Unit) if all slaves are identical
tDiff	Difference between Processing delay and forwarding delay $tDiff = tP - tF$ if all slaves are identical. Note)TDiff of the Model No PB EtherCAT driver is 40ns at MII(Ethernet). When one or more Port is EBUS (LVDS), it is 20ns.
tRef_B, tRef_C	Propagation delay from Reference Clock (slave A) to slave

■ Propagation delay between Slave B and C

The propagation delays between slave B and C (tBC and tCB) are calculated as follows:

$$tBC = tPB + tWBC, \quad tCB = tPC + tWBC$$

assuming the processing delays are equal in slave bands B·C ($tP = tPB = tPC$)

$$tBC = tCB = tP + tWBC$$

The Receive Times (port 0 and 1) of slave B have the following relation:

$$tB1 = tB0 + tBC + tCD + tDC + tCB$$

So the propagation delay between slave B and C is

$$TBC = tCB = (tB1 - tB0) / 2$$

■ Propagation delay between Slave A and B

The propagation delays between slave A and B (tAB+tBA) are calculated as follows:

$$tAB = tPA + tWAB, \quad tBA = tFB + tWAB$$

Assuming that the processing delays of all slaves are identical ($tP = tPA = tPB = tPC$), and the difference between forwarding and processing delay of (FoR/Warding Delay) these slaves is $tDiff = tPB - tFB$:

$$TAB = tP + tWAB, \quad tBA = tAB - tDiff$$

The Receive Times of slave A (port 0 and 1) have the following relation:

$$tA1 = tA0 + tAB + tBC + tCB + tBA$$

So the propagation delay between slave A and B is

$$2 \times tAB - tDiff = (tA1 - tA0) - (tB1 - tB0) \\ tAB = ((tA1 - tA0) - (tB1 - tB0) + tDiff) / 2$$

And for the other direction:

$$tBA = ((tA1 - tA0) - (tB1 - tB0) - tDiff) / 2$$

■ Summary of Propagation Delay Calculation between Slaves

$$tAB = ((tA1 - tA0) - (tB1 - tB0) + tDiff) / 2 \\ tBA = ((tA1 - tA0) - (tB1 - tB0) - tDiff) / 2 \\ tBC = (tB1 - tB0) / 2 \\ tCB = (tB1 - tB0) / 2$$

■ Propagation Delays between Reference Clock and Slave Clocks

The System Time Delay register of each slave clock takes the propagation delay from the Reference Clock to the slave. This delay is calculated like this:

$$tRef_B = tAB \\ tRef_C = tAB + tBC$$

■ Offset Compensation

The local time of each device is a free running clock which typically will not have the same time as the Reference Clock. To achieve the same absolute System Time in all devices, the offset between the Reference Clock and every slave device's clock is calculated by the master. The offset time is written to register System Time Offset to adjust the local time for every individual device. Small offset errors are eliminated by the drift compensation after some time, but this time might become extremely high for large offset errors.

Each slave calculates its local copy of the System time using its local time and the local offset value:

$$t_{\text{Local copy of System Time}} = t_{\text{Local time}} + t_{\text{Offset}}$$

This time is used in synchronous signal output (SyncSignal) inside the slave amplifier.

The reference clock system time works as a master clock using and compensating for the calculated difference and reference clock system time offset.

Registers for offset compensation are shown below.

Registers for Offset Compensation

Register Address	Name	Description
0x0910:0x0917	System Time	Local copy of System Time (read from PDI)
0x0920:0x0927	System Time Offset	Difference between local time and System Time

■ Drift Compensation

After the delay time between the Reference Clock and the slave clocks has been measured, and the offset between both clocks has been compensated, the natural drift of every local clock (emerging from quartz variations between Reference Clock's quarts and local quarts) is compensated by the time control loop which is integrated within each ESC.

For drift compensation, the master distributes the System Time from the Reference Clock to all slave clocks periodically. The ARMW or FRMW commands can be used for this purpose. The time control loop of each slave takes the lower 32 bit of the System Time received from the Reference Clock and compares it to its local copy of the System Time. For this difference, the propagation delay has to be taken into account:

$$\Delta t = (t_{\text{Local time}} + t_{\text{Offset}} - t_{\text{Propagation delay}}) - t_{\text{Received System Time}}$$

If Δt is positive, the local time is running faster than the System time, and has to be slowed down. If Δt is negative, the local time is running slower than the System time, and has to be sped up. The time control loop adjusts the speed of the local clock.

For a fast compensation of the static deviations of the clock speeds, the master should initially send many ARMW/FRMW commands (e.g. 15,000) for drift compensation in separate frames after initialization of the propagation delays and offsets. The control loops compensate the static deviations and the distributed clocks are synchronized. Afterwards, the drift compensation frames are send periodically for compensation of dynamic clock drifts.

6. Data Link Layer

Receive Time Port 0

Address	bit	Description	Master	Slave	Length	Rest Value
0x0900 - 0x0903	31:0	[Write access] A write access to register 0x0900 with BWR, APWR (any address) or FPWR (configured address) latches the local time of the beginning of the receive frame (start first bit of preamble) at each port [Read access] Local time of the beginning of the last receive frame containing a write access to this register. Note) The time stamps cannot be read in the same frame in which this register was written.	R/W (special function)	R/-	4 Bytes	Undefined

Receive Time Port 1

Address	bit	Description	Master	Slave	Length	Rest Value
0x0904 - 0x0907	31:0	Local time of the beginning of a frame (start first bit of preamble) received at port 1 containing a BWR/APWR or FPWR to Register 0x0900.	R/-	R/-	4 Bytes	Undefined

Receive Time Port 2/3

Address	bit	Description	Master	Slave	Length	Rest Value
0x0908 - 0x090F	64:0	Reserved	R/-	R/-	8 Bytes	Undefined

Receive Time ECAT Processing Unit

Address	bit	Description	Master	Slave	Length	Rest Value
0x0918 - 0x091F	64:0	Local time of the beginning of a frame (start first bit of preamble) received at the ECAT Processing Unit containing a BWR or FPWR (configured address) to Register 0x0900	R/-	R/-	8 Bytes	Undefined

15) DC-Time Loop Control Unit

Time loop control unit is defined by master, and the write operation from slave to time loop control register is not performed.

■ Time control loop settings and status

Time control loop consists of the following five (5) registers:

- * The System Time Difference register (0x092C:0x092F) corresponds to the mean value of the difference between local copy of the System Time and the System Time (Δt). This value converges to zero when both times are identical.
- * The Speed Counter Start register (0x0930:0x0931) represents the bandwidth of the drift compensation.
- * The value of the Speed Counter Difference register (0x0932:0x0933) represents the deviation between the clock periods of the Reference Clock and the local ESC.
- * The System Time Difference Filter Depth register (0x0934) and the Speed Counter Filter Depth register (0x0935) set filter depths for mean value calculation of the received System Times and of the calculated clock period deviations. In addition, the control loop capability improves by setting the Speed Counter Filter Depth at "0".

Registers for Drift Compensation

Register Address	Name	Description
0x0900:0x090F	Receive Time Port n	Local time when receiving frame on Port n
0x0910:0x0917	System Time	Local copy of System Time (read from PDI) (Local time if System Time Offset=0)
0x0920:0x0927	System Time Offset	Time difference between System Time and local time
0x0928:0x092B	System Time Delay	Delay between Reference Clock and the ESC
0x092C:0x092F	System Time Difference	Mean difference between local copy of System Time and received System Time values
0x0930:0x0931	Speed Counter Start	Bandwidth for adjustment of local copy of System Time
0x0932:0x0933	Speed Counter Difference	Deviation between local clock period and Reference Clock's clock period
0x0934	System Time Difference Filter Depth	Filter depth for averaging the received System Time deviation
0x0935	Speed Counter Filter Depth	Filter depth for averaging the clock period deviation

System Time

Address	bit	Description	Master	Slave	Length	Rest Value
0x0910 - 0x0917	63:0	[Read access] Local copy of the System Time Master : Latch at the first Ethernet SOF DMZ frame. Slave : Latch at the last byte read of 0x0910		R/(W) (special function)	8 Bytes	0x0
	31:0	[Write access] Written value will be compared with local copy of System Time. The compensated result will be input to the time control unit and denoted as System Time difference (0x092C). Master : written value will be compared at the end of the frame with the latched (SOF) local copy of the System time if at least the first byte (0x0910) was written. Note) Usable when 0x0140.10=1 Slave : Reserved Written value will be compared at the end of the access with Latch0 Time Positive Edge (0x09B0:0x09B3) if at least the last byte (0x0913) was written. Note) Usable when 0x0140.11=1(Reserved)				

System Time Offset

Address	bit	Description	Master	Slave	Length	Rest Value
0x0920 - 0x0927	63:0	Difference between local time and System Time. Offset is added to the local time. Note) Usable when 0140.10=1 or 0x0140.11=1	R/(W)	R/(W)	8 Bytes	0x0

6. Data Link Layer

System Time Delay

Address	bit	Description	Master	Slave	Length	Rest Value
0x0928 - 0x092B	31:0	Delay between Reference Clock and the ESC * Write access to this register depends on the setting. Usable when 0140.10=1 or 0x0140.11=1	R/(W)	R/(W)	4 Bytes	0x0

System Time Difference

Address	bit	Description	Master	Slave	Length	Rest Value
0x092C - 0x092F	30:0	Actual time difference between received local time value and local copy of system time.	R/-	R/-	4 Bytes	0x0
	31	0:Local copy of System Time greater than or equal received System Time 1:Local copy of System Time smaller than received System Time				

* Usable when 0x0140.10=1 or 0x0140.11=1

Speed Counter Start

Address	bit	Description	Master	Slave	Length	Rest Value
0x0930 - 0x0931	14:0	Bandwidth for adjustment of local copy of System Time (larger values -> smaller bandwidth and smoother adjustment) A write access resets System Time Difference (0x092C:0x092F) and Speed Counter Diff (0x0932:0x0933). Minimum value: 0x0080	R/(W)	R/(W)	2 Bytes	0x1000
	15	Reserved, write 0	R/-	R/-		

* Write access to this register depends on the setting. Usable when 0x0140.10=1 or 0x0140.11=1.

Speed Counter Diff

Address	bit	Description	Master	Slave	Length	Rest Value
0x0932 - 0x0933	15:0	Representation of the deviation between local clock period and Reference Clock's clock period	R/-	R/-	2 Bytes	0x0000

* Usable when 0x0140.10=1 or 0x0140.11=1

$$\text{Deviation} = \frac{\text{Speed Counter Diff}}{5(\text{Speed Counter Start} + \text{Speed Counter Diff} + 2)(\text{Speed Counter Start} - \text{Speed Counter Diff} + 2)}$$

System Time Difference Filter Depth

Address	bit	Description	Master	Slave	Length	Rest Value
0x0934	3:0	Filter depth for averaging the received System Time deviation	R/(W)	R/(W)	1	0x0C
	7:4	Reserved, write 0	R/-	R/-	Byte	

* Usable when 0x0140.10=1 or 0x0140.11=1. Reset control loop by writing the speed counter start (0x0930:0x0931) after this value has been changed.

Speed Counter Filter Depth

Address	bit	Description	Master	Slave	Length	Rest Value
0x0935	3:0	Filter depth for averaging the clock period deviation	R/(W)	R/(W)	1	0x0C
	7:4	Reserved, write 0	R/-	R/-	Byte	

* Usable when 0x0140.10=1 or 0x0140.11=1. Reset control loop by writing the speed counter start (0x0930:0x0931) after this value has been changed.

■ DC-Cycle Unit Control

1. Synchronize Signal

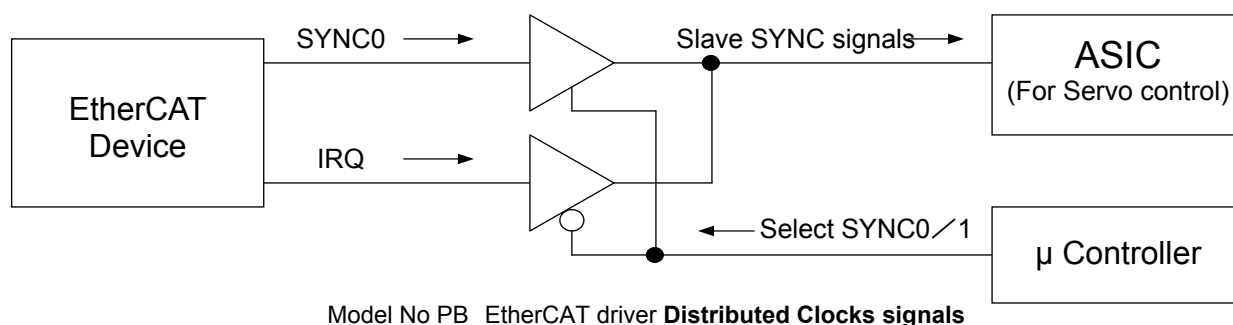
Model No PB EtherCAT driver supports Distribution Clock (DC) function and Synchronize Signal is used for the Interrupt signal generation of process start timing inside the amplifier.

Synchronizing to either signal, SYNC0 or SYNC1, is decided by the setting of the CoE Object SM

Synchronization :0x1C32 - 0x1C33 in the amplifier.

Either ECAT (Master) or PDI (Slave side microcontroller) controls SyncSignals (SYNC0 / 1) output and can be set at the Cycle unit control register (0x0980).

6. Data Link Layer



2. Configuration

The mapping of Distributed Clocks SyncSignals driver characteristics and SyncSignals to the AL Event Request register is controlled by the setting of the Sync/Latch PDI Configuration register 0x0151. The length of a SyncSignal pulse is defined in the DC Pulse Length of SYNC Signals register (0x0982:0x0983). A value of 0 selects acknowledged modes. SYNC Signals cannot be output if ESI EEPROM was loaded incorrectly at time of power up.

3. SyncSignal Generation

ESC has two synchronizing signals: SYNC0 and SYNC1 and supports four types of synchronous output: [Cyclic generation], [Single shot], [Cyclic Acknowledge], [Single shot Acknowledge]. However, use [Cyclic generation] in the Model No PB EtherCAT driver (the other synchronous outputs are unsupported). The Sync Signal mode is selected by Pulse length and SYNC0 cycle time.

SyncSignal Generation Mode Selection

Pulse Length of SYNC Signals (0x0982:0x0983)	SYNC0 Cycle Time(0x09A0:0x09A3)	
	>0	=0
>0	Cyclic Generation	Single Shot
=0	Cyclic Acknowledge	Single Shot Acknowledge

The cycle time of the SYNC0 signal is configured in the SYNC0 Cycle Time register (0x09A0:0x09A3), the start time is set in the Start Time Cyclic Operation register (0x0990:0x0997). After the Sync Unit is activated and the output of the SYNC0/1 signals is enabled (DC Activation register 0x0981), the Sync Unit waits until the start time is reached and generates the first SYNC0 pulse. Internally, the SyncSignals are generated with an update rate of 100 MHz (10 ns update cycle). The jitter of the internal SyncSignal generation in comparison to the System Time is 12 ns.

Registers for SyncSignal Generation

Register Address	Name	Description
0x0140[11:10]	PDI Control	Enable/Disable DC Units (power saving)
0x0151	Sync/Latch PDI Configuration	Configuration of SYNC/LATCH [1:0] pins
0x0980.0	Unit Cycle Control	Assignment of cyclic function to EtherCAT or PDI
0x0981	Activation	Activation of cyclic function and SYNC pins
0x0982:0x0983	Pulse Length of SYNC Signal	Length of SYNC impulse length
0x098E	SYNC0 Status	Status of SYNC0 signal
0x098F	SYNC1 Status	Status of SYNC1 signal
0x0990:0x0997	SYNC0 Start Time	Start System time of cyclic operation
0x0998:0x099F	Next SYNC1 Pulse	System Time of next Sync1 Pulse
0x09A:0x09A3	SYNC0 Cycle Time	Cycle Time of SYNC0
0x09A4:0x09A7	SYNC1Cycle Time	Cycle Time of SYNC1

* Some of these registers are set via EEPROM at the time of power ON.

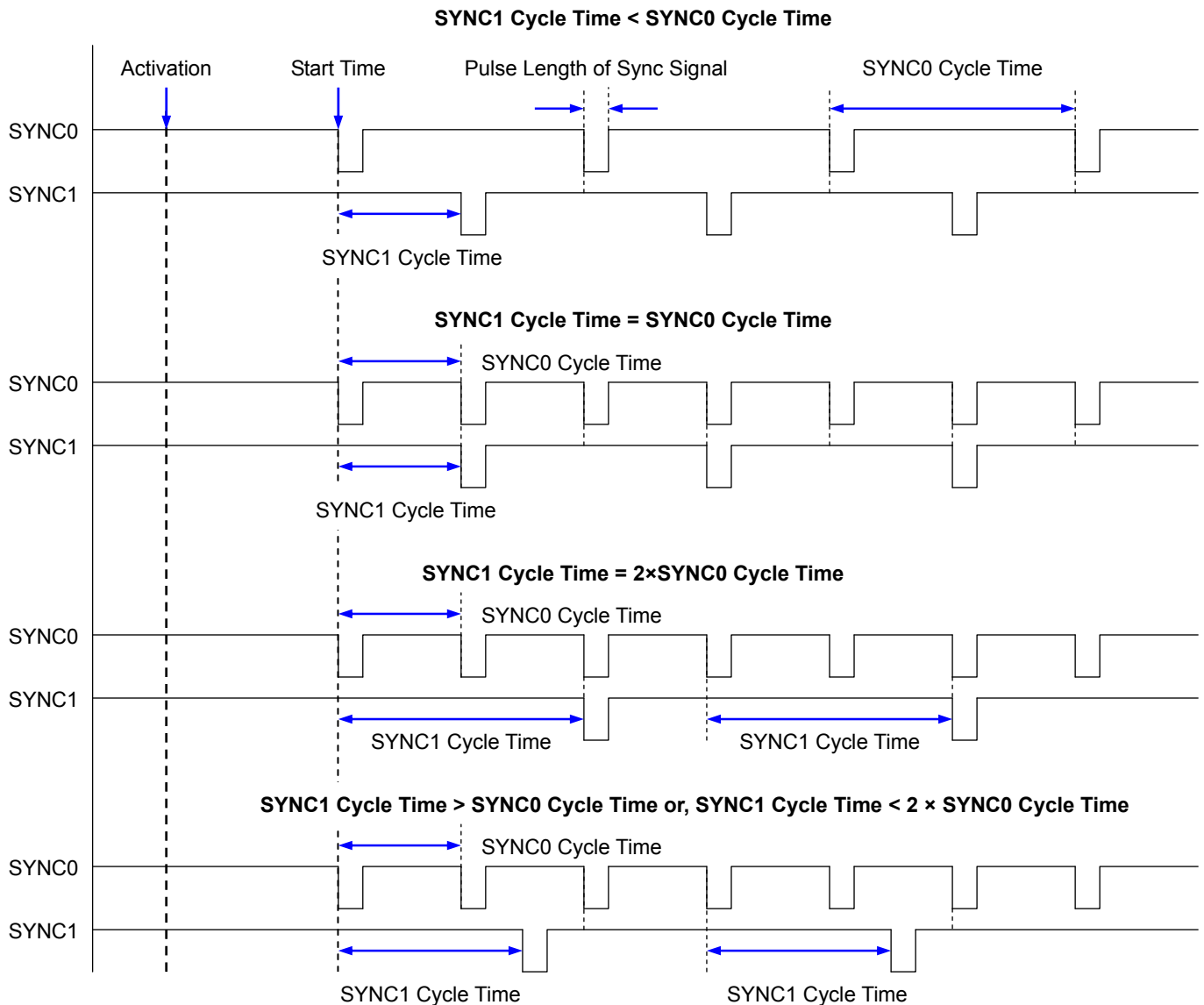
6. Data Link Layer

Cyclic Generation (Cyclic Generation)

If the SYNC1 Cycle Time is larger than the SYNC0 Cycle Time, it will be generated as follows: when the Start Time Cyclic Operation is reached, a SYNC0 pulse is generated. The SYNC1 pulse is generated after the SYNC0 pulse with a delay of SYNC1 Cycle Time. The next SYNC1 pulse is generated when the next SYNC0 pulse was generated, plus the SYNC1 Cycle Time.

SYNC1 Generation

The second SyncSignal (SYNC1) depends on SYNC0, it can be generated with a predefined delay after SYNC0 pulses. The delay is configured in the SYNC1 Cycle Time register (0x09A4:0x09A7). The following shows the output waveform by setting SYNC1 cycle time.



If the SYNC1 cycle time is greater than the SYNC0 cycle time, the SYNC1 pulse will be output with the timing shown in the lower of the two.

6. Data Link Layer

Cyclic Unit Control

Sync Unit Control							
Address	bit	Description		Master	Slave	Length	Rest Value
0x0980	0	SYNC out unit control	0: Master controlled (ECAT) 1: Slave controlled (PDI)	R/W	R/-	1 Byte	0x00
	3:1	Reserved		R/-			
	4	Latch In Unit0	Reserved (The Latch function is uncorrespondence.) (0:Master controlled 1:Slave controlled)	R/W			
	5	Latch In Unit1	Reserved (The Latch function is uncorrespondence.) (0:Master controlled 1:Slave controlled)				
	7:6	Reserved		R/-			

* Usable when 0x0140.10=1 or 0x0140.11=1

DC-SYNC Out Unit

SYNC OUT Unit Activation register

Address	bit	Description	Master	Slave	Length	Rest Value
0x0981	0	Active Cycle Operation 0:Disable 1:Enable Note) When the SYNC0 cycle time is 0, the SYNC0 pulse is output only once.	R/(W)	R/(W)	1 Byte	0x00
	1	SYNC0 Active 0:Disable 1:SYNC0 pulse is generated				
	2	SYNC1 Active 0:Disable 1:SYNC0 pulse is generated				
	7:3	Reserved	R/-	R/-		

* Write to this register depends upon setting of 0x0980.0. Usable when 0x0140.10=1.

Pulse Length of SyncSignals

Address	bit	Description	Master	Slave	Length	Rest Value
0x0982 - 0x0983	15:0	Pulse length of SyncSignals (in Units of 10ns) 0:Acknowledge mode: SyncSignal will be cleared by reading SYNC0/SYNC1 Status register Note) Load from EEPROM address0x0002	R/-	R/-	2 Bytes	0x0064 Note)

* Usable when 0x0140.10=1

SYNC0 Status

Address	bit	Description	Master	Slave	Length	Rest Value
0x098E	0	SYNC0 state for Acknowledge mode. SYNC0 in Acknowledge mode is cleared by reading this register from PDI, use only in Acknowledge mode Usable when 0x0140.10=1	R/-	R/-	1 Byte	0x00
	7:1	Reserved				

SYNC1 Status

Address	bit	Description	Master	Slave	Length	Rest Value
0x098F	0	SYNC1 state for Acknowledge mode. SYNC1 in Acknowledge mode is cleared by reading this register from PDI, use only in Acknowledge mode Usable when 0x0140.10=1	R/-	R/-	1 Byte	0x00
	7:1	Reserved				

Start Time Cyclic Operation

Address	bit	Description	Master	Slave	Length	Rest Value
0x0990 - 0x0997	63:0	Write: Start time (System time) of cyclic operation in ns Write to this register depends upon setting of 0x0980.0. Read: System time of next SYNC0 pulse in ns (Unit: 1ns), Usable when 0x0140.10=1	R/(W)	R/(W)	8 Bytes	0x0

Next SYNC1 Pulse

Address	bit	Description	Master	Slave	Length	Rest Value
0x0998 - 0x099F	63:0	Read: System time of next SYNC1 pulse in ns (Unit: 1ns), Usable when 0x0140.10=1	R/-	R/-	8 Bytes	0x0

6. Data Link Layer

SYNC0 Cycle Time

Address	bit	Description	Master	Slave	Length	Rest Value
0x09A0 - 0x09A3	31:0	Time between two consecutive SYNC0 pulses in ns. Write to this register depends upon setting of 0x0980.0. 0: Single shot mode, generate only one SYNC0 pulse. (Unit: 1ns), Usable when 0x0140.10=1	R/(W)	R/(W)	4 Bytes	0x0

SYNC1 Cycle Time

Address	bit	Description	Master	Slave	Length	Rest Value
0x09A4 - 0x09A7	31:0	Time between SYNC1 pulses and SYNC0 pulse in ns. Write to this register depends upon setting of 0x0980.0. (Unit: 1ns) Usable when 0x0140.10=1	R/(W)	R/(W)	4 Bytes	0x0

DC-Latch input unit

Latch function is not supported in Model No PB EtherCAT driver.

Sets the Latch 0 / 1 control and the status registers shown below at "0".

Latch 0 Control	: 0x09A8	Latch 1 Control	: 0x09A9
Latch 0 Status	: 0x09AE	Latch 1 Status	: 0x09AF
Latch 0 Time Positive Edge	: 0x09B0 - 0x09B7	Latch 0 Time Negative Edge	: 0x09B8 - 0x09BF
Latch 1 Time Positive Edge	: 0x09C0 - 0x09C7	Latch 1 Time Negative Edge	: 0x09C8 - 0x09CF

Latch0 Control

Address	bit	Description	Master	Slave	Length	Rest Value
0x09A8	0	Latch 0 positive edge 0: Continuous Latch active 1: Single event (only first event active)	R/W	R/-	1 Byte	0x00
	1	Latch 0 negative edge 0: Continuous Latch active 1: Single event (only first event active)				
	7:2	Reserved, write 0	R/-			

Note) Write access depends upon setting of 0x0980.4. Usable when 0x0140.11=1

Latch1 Control

Address	bit	Description	Master	Slave	Length	Rest Value
0x09A9	0	Latch 1 positive edge 0: Continuous Latch active 1: Single event (only first event active)	R/W	R/-	1 Byte	0x00
	1	Latch 1 negative edge 0: Continuous Latch active 1: Single event (only first event active)				
	7:2	Reserved	R/-			

* Write access depends upon setting of 0x0980.5. Usable when 0x0140.11=1

Latch0 Status

Address	bit	Description	Master	Slave	Length	Rest Value
0x09AE	0	Event Latch0 positive edge, "0" other than for single event Flag is cleared by reading Latch0 time positive edge	R/W	R/-	1 Byte	0x00
	1	Event Latch0 negative edge, "0" other than for single event Flag is cleared by reading Latch0 time negative edge				
	7:2	Reserved	R/-			

* Usable when 0x0140.11=1

Latch1 Status

Address	bit	Description	Master	Slave	Length	Rest Value
0x09AF	0	Event Latch1 positive edge, "0" other than for single event Flag is cleared by reading Latch1 time positive edge	R/W	R/-	1 Byte	0x00
	1	Event Latch1 negative edge, "0" other than for single event Flag is cleared by reading Latch1 time negative edge				
	7:2	Reserved	R/-			

* Usable when 0x0140.11=1

6. Data Link Layer

Latch0 Time Positive Edge

Address	bit	Description	Master	Slave	Length	Rest Value
0x09B0 - 0x09B7	63:0	Register captures System time at the positive edge of the Latch0 signal. (Usable when 0x0140.11=1)	R/-	R/-	8 Bytes	0x0

Latch0 Time Negative Edge

Address	bit	Description	Master	Slave	Length	Rest Value
0x09B8 - 0x09BF	63:0	Register captures System time at the negative edge of the Latch0 signal. (Usable when 0x0140.11=1)	R/-	R/-	8 Bytes	0x0

Latch1 Time Positive Edge

Address	bit	Description	Master	Slave	Length	Rest Value
0x09C0 - 0x09C7	63:0	Register captures System time at the positive edge of the Latch1 signal. (Usable when 0x0140.11=1)	R/-	R/-	8 Bytes	0x0

Latch1 Time Negative Edge

Address	bit	Description	Master	Slave	Length	Rest Value
0x09C8 - 0x09CF	63:0	Register captures System time at the negative edge of the Latch1 signal. (Usable when 0x0140.11=1)	R/-	R/-	8 Bytes	0x0

■ DC-SyncManager Event Times

EtherCAT Buffer Change Event Time

Address	bit	Description	Master	Slave	Length	Rest Value
0x09F0 - 0x09F3	31:0	Register captures local time of the beginning of the frame which causes at least one SyncManager to assert an ECAT event (Usable when 0x0140.10=1 or 0x0140.11=1)	R/-	R/-	4 Bytes	0x0

PDI Buffer Start Event Time

Address	bit	Description	Master	Slave	Length	Rest Value
0x09F8 - 0x09FB	31:0	Register captures local time when at least one SyncManager asserts an PDI buffer start event (Usable when 0x0140.10=1 or 0x0140.11=1)	R/-	R/-	4 Bytes	0x0

PDI Buffer Change Event Time

Address	bit	Description	Master	Slave	Length	Rest Value
0x09FC - 0x09FF	31:0	Register captures local time when at least one SyncManager asserts an PDI buffer change event (Usable when 0x0140.10=1 or 0x0140.11=1)	R/-	R/-	4 Bytes	0x0

6. Data Link Layer

16) ESC specific registers

Power-On Values

Power on Parameters							
Address	bit	Description		Master	Slave	Length	Rest Value
0x0E00 - 0x0E01	1:0	Port mode (P_MODE)	00: Logical ports 0 and 1 available 01: Logical ports 0, 1 and 2 available 10: Logical ports 0, 1 and 3 available 11: Logical ports 0, 1, 2 and 3 available	R/-	R/-	2 Bytes	0x8C
	2	Physical layer of available ports (P_CONF)	logical port 0 0: EBUS 1: MII				
	3		logical port 1 0: EBUS 1: MII				
	4		logical port 2 0: EBUS 1: MII				
	5		logical port 3 0: EBUS 1: MII				
	7:6	CPU clock output (CLK_MODE)	00: OFF 01: 25MHz 10: 20MHz 11: 10MHz	R/-	R/-		0x84
	9:8	MII TX signal shift (C25_SHI)	00: MII TX signals shifted by 0° 01: MII TX signals shifted by 90° 10: MII TX signals shifted by 180° 11: MII TX signals shifted by 270°				
	10	CLK25 Output Enable (C25_ENA)	0: Disabled – PDI [31] available as PDI port 1: Enabled – PDI [31] = 25MHz (OSC)				
	11	Transparent Mode MII (Trans_Mode_Ena)	0: Disabled 1: Enabled – ERR is input (0: TX signals are tristated, 1: ESC is driving TX signals)				
	12	Digital Control/State Move (Ctrl_Status_Move)	0: Control/Status signals are mapped to PDI [39:32] - if available 1: Control/Status signals are remapped to the highest available PDI Byte.				
	13	PHY Address Offset (PHYAD_OFF)	0: No PHY address offset 1: PHY address offset is 16				
	14	PHY Link Polarity (LINKPOL)	0: LINK_MII is active low 1: LINK_MII is active high				
	15	Reserved	Always "1"				

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■ Digital I/O Output Data

Digital I/O Output Data

Address	bit	Description	Master	Slave	Length	Rest Value
0x0F00 - 0x0F03	31:0	Output Data Note) Register size depends on PDI setting and/or device configuration.	R/W	R/-	4 Bytes	0x0

General Purpose Outputs

Address	bit	Description	Master	Slave	Length	Rest Value
0x0F10 - 0x0F11	15:0	General Purpose Output Data Note) Register size depends on PDI setting and/or device configuration	R/W	R/W	2 Bytes	0x0

General Purpose Inputs

Address	bit	Description	Master	Slave	Length	Rest Value
0x0F18 - 0x0F19	15:0	General Purpose Input Data Note) Register size depends on PDI setting and/or device configuration	R/-	R/-	2 Bytes	0x0

17) User RAM

Extended ESC Features (Reset values of User RAM)

Address	bit	Description	Master	Slave	Length	Rest Value
0x0F80 - 0x0FA0	7:0	Number of extended feature bits	R/W	R/W	33 Bytes	0xFF
	8	0x0102:0x0103 DL Control Register				-
	9	0x0134:0x0135 AL Status Code Register				-
	10	0x0200:0x0201 ECAT Event Mask				-
	11	0x0012:0x0013 Configured Station Alias				-
	12	0x0F18:0x0F1F General Purpose Inputs				-
	13	0x0F10:0x0F17 General Purpose Outputs				-
	14	0x0204:0x0207 AL Event Mask				-
	15	0x0108:0x0109 Physical Read/Write Offset				-
	16	0x0400:0x0401 Watchdog divider writeable and Watchdog PDI				-
	17	0x0442:0x0443 Watchdog counters				-
	18	0x0020:0x0031 Write Protection				-
	20:19	Reserved				-
	21	0x09F0:0x09F0 DC SyncManager Event Times				-
	22	0x030C:0x030D ECAT Processing Unit/PDI Error Counter				-
	23	0x0502.7 EEPROM Size configurable				-
	26:24	Reserved				-
	27	0x0300:0x0313 Lost Link Counter				-
	28	0x0510:0x0515 MII Management Interface				-
	29	Enhanced Link Detection MII				-
	30	Enhanced Link Detection EBUS				-
	31	Run LED (DEV_STATE LED)				-
	32	Link Activity LED				-
	37:33	Reserved				-
	38	DC Time loop control assigned to PDI				-
	39	Link detection and configuration by MI				-
	40	MI control by PDI possible				-
	41	Automatic TX shift				-
	42	EEPROM emulation by µController				-
	47:43	Reserved				-
	263:48	Reserved				0x0

6. Data Link Layer

User-RAM

Address	Byte	Description	Master	Slave	Length	Rest Value
0x0FA1 - 0x0FBF	0x1F	Application specification information	R/W	R/W	31 Bytes	Undefined

Slave Response (User-RAM)

Address	bit	Description	Master	Slave	Length	Rest Value
0x0FC0 - 0x0FFF		Use for response check of slaves. Acknowledge nonresponsive slaves with broadcast reading (BRD) of this address after corresponding axis bit is set.	R/W	R/(W)	64 Bytes	Undefined
	0	1:1 st slave				
	1	1:2 nd slave				
	2	1:3 rd slave				
	...	...				
	510	1:511 th slave				
	511	1:512 th slave				

18) Process Data RAM

Address for Process Data RAM is from 0x1000 to 0x2FFF.

Process Data RAM

Address	Byte	Description	Master	Slave	Length	Rest Value
0x1000 - 0x2FFF	0x2000	Process Data RAM Note) (r/w): Process Data RAM is only accessible if EEPROM was correctly loaded (register 0x0110.0 = 1).	(R/W)	(R/W)	8,192 Bytes	Undefined

6.3 EEPROM Mapping

1) Address Space Overview

64kbit I²C (Inter-Integrated Circuit) Interface EEPROM (Electrically Erasable Programmable Read Only Memory) is loaded in the slave controller of the Model No PB EtherCAT driver for device configuration and for various parameters.

It can be used with word addressing for device configuration up to 1kbit, for servo amplifier information from 1kbit - 32kbit and for various parameters from 32kbit - 64kbit. EEPROM layout is shown below.

Word	0	1	2	3	4	5	6	7	
0x000	PDI Control	PDI Config.	SYNC Pulse Length	Ex. PDI	Config.	Station Alias	Reserved	Reserved	Checksum
0x008	Vender ID		Product Code		Revision Number		Serial Number.		
0x010	Ex. Delay	Port 0 Delay	Port 1 Delay	Reserved	Boot RX Mailbox offset	Boot RX Mailbox Size	Boot TX Mailbox offset	Boot TX Mailbox Size	
0x018	Standard RX Mailbox offset	Standard RX Mailbox Size	Standard TX Mailbox offset	Standard TX Mailbox Size	Mailbox Protocol	Reserved			
0x020									
0x028	Reserved								
0x030									
0x038	Reserved						EEPROM Size	Version	
0x040	1 st Category Type	1 st Category Word Size	1 st Category DATA ...						
.	...								
.	2 nd Category Type	2 nd Category Word Size	2 nd Category DATA ...						
0x7F8	...								
0x800	Parameter (Future use)								
.	Reserved								
.	Reserved								
0xFF8	Reserved								

EEPROM layout

2) Address Space Definition

The data descriptions stored in the configuration address (Word:0x000 - 0x03F) and device configuration address (Word:0x040 - 0x7FF) are explained below.

6. Data Link Layer

■ Slave Information Interface Area

PDI Control

Address 0x0000	The initial value of PDI Control Register (0x0140:0x0141) bit: 9 will be copied in DL Status Register 0x110.2 (EX Link Detection) and enabled/disabled by this bit.			Length 1 word
bit	Description		Value	Register
7:0	Process data interface	8:16 Bit asynchronous microcomputer interface	0x08	0x0140
8	Device emulation (control of AL status)	0:AL status register has to be set by slave 1:AL status register will be set to value written to AL control register	0x0C	0x0141
9	Enhanced Link detection all ports	0:disabled 1:enabled "0" when MII port is used.		
10	DC SYNC Out Unit	0:disabled (power saving) 1:enabled		
11	DC Latch In Unit	0:disabled (power saving) 1:enabled		
15:12	Reserved			

PDI Configuration

Address 0x0001	PDI Configuration Register (0x0150:0x0151) Initial value			Length 1 word
bit	Description		Value	Register
1:0	BUSY output driver BUSY output polarity 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)		0x00	0x0150
3:2	IRQ output driver IRQ output polarity 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)			
4	BHE polarity 0:Active low 1:Active high			
6:5	Reserved			
7	RD Polarity 0:Active low 1:Active high			
9:8	SYNC0 output driver/polarity 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)		0xCC	0x0151
10	SYNC0/LATCH0 configuration 0:LATCH0 Input 1:SYNC0 Output			
11	SYNC0 mapped to AL Event Request register 0x0220.2 0:Disabled 1:Enabled			
13:12	SYNC1 output driver/polarity 00:Push-Pull active low 01:Open Drain (active low) 10:Push-Pull active high 11:Open Source (active high)			
14	SYNC1/LATCH1 configuration 0:LATCH1 Input 1:SYNC1 Output			
15	SYNC1 mapped to AL Event Request register 0x0220.3: 0:Disabled 1:Enabled			

Pulse Length of SyncSignals

Address 0x0002	SYNC impulse with multiples of 10ns			Length 1 word
bit	Description		Rest Value	Register
15:0	Pulse length of SyncSignals (in Units of 10ns) 0: Acknowledge mode: SyncSignal will be cleared by reading SYNC0/SYNC1 Status register Note) Usable when 0x0140.10=1		0x0064 (1μs)	0x0982 - 0x0983

Extended PDI Configuration

Address 0x0003	Extended PDI configuration area.			Length 1 word
bit	Description		Rest Value	Register
0	Read BUSY delay 0:Normal read BUSY output 1:Delayed read BUSY output		0x0000	0x0152 - 0x0153
15:1	Reserved			

6. Data Link Layer

Configured Station Alias

Address 0x0004	Alias Address used for node addressing		Length 1 word
bit	Description	Rest Value	Register
15:0	The use of this alias is activated by Register DL Control Bit 24 (0x0100.24)	0x0000	0x0012 - 0x0013

Checksum

Address 0x0007	For debug. Can be disabled by checking the checksum with a value of 0x88A4		Length 1 word
bit	Description	Rest Value	Register
15:0	low byte contains remainder of division of word 0 to word 6 as unsigned number divided by the polynomial x^8+x^2+x+1 (initial value 0xFF)	0x0000	-

Vendor ID

Address 0x0008	Vendor ID for our EtherCAT products registered in ETG. CoE Object Index:0x1018 Sub index:0x01		Length 2 word
bit	Description	Value	Register
31:0	Manufacturer's proper ID: Vendor ID for Sanyo Denki is 0x000001B9, the same as our CAN open amplifier.	0x000001B9	-

Product Code

Address 0x000A	Product code for our EtherCAT products: CoE Object Index:0x1018 Sub index:0x02		Length 2 word
bit	Description	Value	Register
31:0	Product code is "2" for EtherCAT amplifier.	0x00000002	-

Revision Number

Address 0x000C	Revision number for the servo amplifier: CoE Object Index:0x1018 Sub index:0x03		Length 2 word
bit	Description	Value	Register
31:0	Revision number to identify the revised contents in both the hardware and the software of the servo amplifier. It is the same as the alphabet character followed by the serial number on the main nameplate. These values:0x1->Main nameplate :A,0x2->B...0x1A->Y,0x1B->Z(0x9->I,0xF->O are not used)	Depends on product revision	-

Serial Number

Address 0x000E	Serial number for servo amplifier: CoE Object Index:0x1018 Sub index:0x04		Length 2 word
bit	Description	Value	Register
31:0	Serial number noting the manufacturing date of the product. Create decimal data from hexadecimal data using 10 digits as shown below and this will be the same as the serial number on the amplifier main nameplate. Month (2 digits)+Last 2 digits of the Year (2 digits)+Date (2 digits)+ Manufacturer's serial number (4 digits)	Depends on respective product	-

Execution Delay

Address 0x0010	Correction factor for line Delay in 100ps to be added if this is the last station		Length 1 word
bit	Description	Rest Value	Register
15:0	Unit: 100ps	0x0000	-

Port0 Delay

Address 0x0011	Correction factor for line Delay in 100ps to be added if Master is behind Port 0		Length 1 word
bit	Description	Rest Value	Register
15:0	Unit: 100ps / LSB, Integer	0x0000	-

Port1 Delay

Address 0x0012	Correction factor for line Delay in 100ps to be added if Master is behind Port 1		Length 1 word
bit	Description	Rest Value	Register
15:0	Unit: 100ps / LSB, Integer	0x0000	-

6. Data Link Layer

Bootstrap Receive Mailbox Offset

Address 0x0014	Mailbox offset for forwarding from master to the slave to be used in Bootstrap mode.		Length 1 word
bit	Description	Rest Value	Register
15:0	Use from register address 0x1800.	0x1800	-

Bootstrap Receive Mailbox Size

Address 0x0015	Mailbox size for forwarding from master to the slave to be used in Bootstrap mode.		Length 1 word
bit	Description	Rest Value	Register
15:0	Size of 0x0200(512byte).	0x0200	-

Bootstrap Send Mailbox Offset

Address 0x0016	Mailbox offset for forwarding from slave to the master to be used in Bootstrap mode.		Length 1 word
bit	Description	Rest Value	Register
15:0	Use from register address 0x1C00.	0x1C00	-

Bootstrap Send Mailbox Size

Address 0x0017	Mailbox size for forwarding from slave to the master to be used in Bootstrap mode.		Length 1 word
bit	Description	Rest Value	Register
15:0	Size of 0x0200(512byte).	0x0200	-

Standard Receive Mailbox Offset

Address 0x0018	Mailbox offset for forwarding from master to the slave to be used mainly in SMO.		Length 1 word
bit	Description	Rest Value	Register
15:0	Use from register address 0x1800	0x1800	-

Standard Receive Mailbox Size

Address 0x0019	Mailbox size for forwarding from master to the slave to be used mainly in SMO.		Length 1 word
bit	Description	Rest Value	Register
15:0	0x0200(512Byte) in size.	0x0200	-

Standard Send Mailbox Offset

Address 0x001A	Mailbox offset for forwarding from slave to the master to be used mainly in SM1.		Length 1 word
bit	Description	Rest Value	Register
15:0	Use from register address 0x1C00	0x1C00	-

Standard Send Mailbox Size

Address 0x001B	Mailbox size for forwarding from slave to the master to be used mainly in SM1.		Length 1 word
bit	Description	Rest Value	Register
15:0	0x0200(512Byte) in size.	0x0200	-

Mailbox Protocol

Address 0x001C	Mailbox Protocols Supported		Length 1 word
bit	Description	Rest Value	Register
0	AoE: ADS over EtherCAT (available at www.beckhoff.com)	0x0004	-
1	EoE: Ethernet over EtherCAT (tunnelling of Data Link services)		
2	CoE: CANopen over EtherCAT (access to SDO)		
3	FoE: File Service over EtherCAT		
4	SoE: Servo Profile over EtherCAT		
5	VoE: Vender specific protocol		
15:6	Reserved		

6. Data Link Layer

Port0 Tx Delay

Address 0x0020	Correction factor for line delay of Port 0 transmission time.	Length 1 word
bit	Description	Rest Value Register
15:0	Unit: 100ps / LSB, Unsigned16	0x0000 -

Port1 Tx Delay

Address 0x0021	Correction factor for line delay of Port 1 transmission time	Length 1 word
bit	Description	Rest Value Register
15:0	Unit: 100ps / LSB, Unsigned16	0x0000 -

Port0 Rx Delay

Address 0x0024	Correction factor for line delay of Port 0 receiving time	Length 1 word
bit	Description	Rest Value Register
15:0	Unit: 100ps/ LSB, Unsigned16	0x0000 -

Port1 Rx Delay

Address 0x0025	Correction factor for line delay of Port 1 receiving time	Length 1 word
bit	Description	Rest Value Register
15:0	Unit: 100ps / LSB, Unsigned16	0x0000 -

Port 0 transfer to the next port

Address 0x0028	Correction factor between PhL reception of Port and 0 PhL transmission to the next port	Length 1 word
bit	Description	Rest Value Register
15:0	Unit: 100ps / LSB, Unsigned16	0x0000 -

Transfer to the next port except Port 0

Address 0x0029	Correction factor between PhL reception of Port and 0 PhL transmission to the next port except Port 0	Length 1 word
bit	Description	Rest Value Register
15:0	Unit: 100ps / LSB, Integer	0x0000 -

Closed port additional transfer time

Address 0x002A	Additional correction factor between port and BAT WAN port	Length 1 word
bit	Description	Rest Value Register
15:0	Unit:100ps / LSB, Integer	0x0000 -

EEPROM Size

Address 0x003E	size of E2PROM in KBit-1	Length 1 word
bit	Description	Rest Value Register
15:0	The EEPROM capacity loaded on this amplifier is 32kbit [32kbit-1:0x1F]	0x001F -

Version

Address 0x003F	Version	Length 1 word
bit	Description	Rest Value Register
15:0	This Version is 1	0x0001 -

6. Data Link Layer

3) Slave information Interface Categories

1st Category Header

Address 0x0040	Slave information category			Length 1 word
bit	Description			Rest Value
15:0	Category Type	00(0x00) : NOP	No info	0x000A
		10(0x0A) : STRING	Character string frame for other category	
		20(0x14) : Data Types	Reserved	
		30(0x1E) : General	Summary	
		40(0x28) : FMMU	For FMMU use	
		41(0x29) : SyncManager	SyncManager setting	
		42(0x2A) : -	Reserved	
		43(0x2B) : -	Reserved	
		50(0x32) : TxPDO	TxPDO Description	
		51(0x33) : RxPDO	RxPDO Description	
		60(0x3C) : DC	Distributed Clock Description	
		(0xFFFF) : End	Vendor specification protocol	

* STRING category stores all character strings used in other categories. The other categories can be connected to the index inside the STRING category.

1st Category Word Size

Address 0x0041	1 st Word data size following the address of the 1 st category.			Length 1 word
bit	Description			Rest Value
15:0	Word size			Depends on setting

1st Category Data

Address 0x0042:	1 st Category Data			Length 1 word
bit	Description			Rest Value
15:0	1 st Category Data			Depends on setting

The table below describes the description according to the category type of each category header.

Structure Category String

Parameter	Address	Data Type	Value / Description
nStrings	0x0000	Byte	Number of Strings
Str1_len	0x0001	Byte	Length String1
Str_1	0x0002	Byte [Str1_Len]	String1 Data
Str2_len	0x0002+Str1_Len	Byte	Length String2
Str_2	0x0003+Str1_Len	Byte [Str2_Len]	String2 Data
...	...	...	-
Strn_len	0x000z	Byte	Length String n
Strn_2	0x000z+1	Byte [Strn_Len]	String n Data
PAD_Byte	0x000y	Byte	Padding (0x00) if Category length is odd

6. Data Link Layer

Category Summary Configuration

Parameter	Address	Data Type	Value / Description	
GroupIdx	0x0000	Unsigned8	(Vendor Specification) Group information: Shown with character strings	
ImgIdx	0x0001	Unsigned8	(Vendor Specification) Image name: Shown with character strings	
OderIdx	0x0002	Unsigned8	(Vendor Specification) Device request number: Shown with character strings	
NamIdx	0x0003	Unsigned8	(Vendor Specification) Device name information: Shown with character strings	
Physical layer Port0	0x0004	Unsigned2	0:Ebus	
Physical layer Port1		Unsigned2	1:100BASE-TX	
Physical layer Port2		Unsigned2	2:100BASE-FX	
Physical layer Port3		Unsigned2		
CoE Details	0x0005	Unsigned8	bit0: Enable SDO bit1: Enable PDO Information bit2: Enable PDO Assign	bit3: Enable PDO Configuration bit4: Enable Start upload bit5: Enable SDO Access complete
FoE Details	0x0006	Unsigned8	bit0: Enable FoE	
EoE Details	0x0007	Unsigned8	bit0: Enable EoE	
SoE Details	0x0008	Unsigned8	Reserved	
DS402Channels	0x0009	Unsigned8	Reserved	
SysmanClass	0x000A	Unsigned8	Reserved	
Flags	0x000B	Unsigned8	bit0: Enable Safe-OP bit1: Enable without LR/W	
CurrentOnEbus	0x000C	Unsigned16	Ebus Actual current consumption (mA), Negative value is absorption current	
PAD_Byte	0x000B	Byte [18]	Reserved	

FMMU Category Configuration

Parameter	Address	Data Type	Value / Description	
	0x0000	Byte	1:FMMU0 is for Output 3:FMMU0 is for SyncManagerStatus (Read Mailbox)	2:FMMU0 is for Input
	0x0001	Byte	1:FMMU1 Output 3:FMMU1 is for SyncManagerStatus (Read Mailbox)	2:FMMU1 is for Input
	...			
	0x0007	Byte	1:FMMU7 Output 3:FMMU7 is for SyncManagerStatus (Read Mailbox)	2:FMMU7 is for Input

SyncManager Category Configuration (each element)

Parameter	Address	Data Type	Value / Description	
Physical Start Address	0x0000	Word	Origin point of data (Refer to physical start address of SM)	
Length	0x0002	Word		
Control Register	0x0004	Byte	Operation mode definition (Refer to control register of SM)	
Status Register	0x0005	Byte	Don' care	
Activate	0x0006	Byte	Enable SyncManager	
PDI CTRL	0x0007	Byte	Don' care	

RXPDO & TXPDO Category Configuration (each element)

Parameter	Address	Data Type	Value / Description	
PDO Index	0x0000	Word	RxPDO : 0x1600 - 0x1603, 0x1700 - 0x1703 TxPDO : 0x1A00 - 0x1A00, 0x1b00 - 0x1B03	
nEntry	0x0002	Byte	Entry number	
SyncM	0x0003	Byte	SyncManager Association 0x02 : Associate to SM2, 0x03 : Associate to SM3 0xFF : No association	
Synchronization	0x0004	Byte	Standard value for DC Synch	
NamIdx	0x0005	Byte	Object name: Character String Index	
Flags	0x0006	Word	Reserved	
Entry Index	0x0008	Word	Entry Index	
SubIndex	0x000A	Byte	SubIndex	
Entry Name Idx	0x000B	Byte	Entry name: Character String Index	
Data Type	0x000C	Byte	Entry data type	
bitLen	0x000D	Byte	Entry bit length	
Flags	0x000E	Word	Reserved	
Next Entry	0x0010	8Byte	Next entry....continue to each element	

No Text on This Page.

7.Object Dictionary

7.1 Outline of object dictionary

1) Object dictionary configuration and definition of two axes

All the objects are given 16-bit address in 4-digit hexadecimal notation, and then allocated in object dictionary in groups.

CoE (CANopen over EtherCAT)-object dictionary configuration specified by CiA402 is shown below.

Index area of model NO.PB is divided by axis NO. as the Model No.PB is two-axis driver.

Definition of two-axis driver is declared by Device type of 0x1000.

Refer to the following object index configuration for the details.

- * The Index contents in this specification are defined by index NO. of axis 1, unless otherwise specified.
- * Add the offset to index NO. of axis 2 in accordance with the following table with respect to each object.
- * For the index NO. not related to both axis in Manufacturer Specific Profile Area and axis in Standardized Device Profile Area, the index corresponding to both axes above with the data setting for either area is updated.

Object index configuration

Index (Hex)	Object
0x0000 to 0x0FFF	Data Type Area (Data type area)
0x1000 to 0x1FFF	Communication Profile Area (CoE communication area) * In PDO-mapping, Index is in increments of 0x10 with respect to each axis. * Defines multiple-axis driver by Device type of 0x1000.
0x4000 to 0x41FF	Manufacturer Specific Profile Area (Manufacturer Specific Profile Area: PB-axis1)
0x4200 to 0x43FF	Manufacturer Specific Profile Area (Manufacturer Specific Profile Area: PB-axis 2)
0x6000 to 0x67FF	Standardized Device Profile Area (Profile area: axis 1) * Defines Device type (Stepper driver) of axis 1 by 0x67FF
0x6800 to 0x6FFF	Standardized Device Profile Area (Profile area: axis 2) * Defines Device type (Stepper driver) of axis 2 by 0x6FFF.
0xA000 to 0xFFFF	Reserved

2) Object types

Object code definition entries are organized as follows.

Object Dictionary Object Definitions

Object Code	Object Name	Comments
0x0000	NULL	A dictionary entry with no data fields
0x0002	DOMAIN	Large variable amount of data e.g. executable program code.
0x0005	DEFTYPE	Denotes a type definition such as Boolean, Unsigned16, float and so on.
0x0006	DEFSTRUCT	Defines a new record type e.g. the PDO mapping structure at 21st.
0x0007	VARIABLE	A single value such as Unsigned8, Boolean, float, Integer16, and visible string etc.
0x0008	ARRAY	A multiple data field object where each data field is a simple variable of the SAME basic data type e.g. array of UNSIGNED16 etc. Sub-index 0 is of UNSIGNED8 and therefore not part of the ARRAY data.
0x0009	RECORD	A multiple data field object where each data fields may be any combination of simple variables. Sub-index 0 is of UNSIGNED8 and therefore not part of the RECORD data.

3) Access types

The Attribute column defines the access rights for a particular object.

Means of access are access to attribute data objects, and also direction of access is indicated from Master to Slave.

Access Attributes for Data Objects

Attribute	Description
Rw, RW, rw,	Read and write access
Wo, WO, wo	Write only access
Ro, RO, Ro	Read only access
Const, CONST	Read only access, value is constant

7.Object Dictionary

4) Data Type Area

Data type Indicates the data type index of the object contained in Object Dictionary.

Standard data type is assigned to the index:0x0001-0x001F, and the data type of the special definition is to the index:0x0020 - 0x07FF. Object Dictionary area indicates the data type.

Object Dictionary of Data Type

Index	Object	Name	Index	Object	Name
0x0001	DEFTYPE	BOOLEAN	0x0026		Reserved
0x0002	DEFTYPE	INTEGER8	0x0027	DEFTYPE	PDOCOMPAR
0x0003	DEFTYPE	INTEGER16	0x0028	DEFTYPE	ENUM
0x0004	DEFTYPE	INTEGER32	0x0029	DEFSTRUCT	SYNC_PAR
0x0005	DEFTYPE	UNSIGNED8	0x002A	DEFTYPE	RECORD
0x0006	DEFTYPE	UNSIGNED16	0x002B	DEFTYPE	BACKUP
0x0007	DEFTYPE	UNSIGNED32	0x002C	DEFTYPE	MDP
0x0008	DEFTYPE	REAL32	0x002D-02F		Reserved
0x0009	DEFTYPE	VISIBLE_STRING	0x0030	DEFTYPE	BIT1
0x000A	DEFTYPE	OCTET_STRING	0x0031	DEFTYPE	BIT2
0x000B	DEFTYPE	UNICODE_STRING	0x0032	DEFTYPE	BIT3
0x000C	DEFTYPE	TIME_OF_DAY	0x0033	DEFTYPE	BIT4
0x000D	DEFTYPE	TIME_DIFFERENCE	0x0034	DEFTYPE	BIT5
0x000E		Reserved	0x0035	DEFTYPE	BIT6
0x000F	DEFTYPE	DOMAIN	0x0036	DEFTYPE	BIT7
0x0010	DEFTYPE	INTEGER24	0x0037	DEFTYPE	BIT8
0x0011	DEFTYPE	REAL64	0x0038-03F		Reserved
0x0012	DEFTYPE	INTEGER40	0x0040-05F	DEFSTRUCT	Manufacturer Specific Complex Data Type
0x0013	DEFTYPE	INTEGER48	0x0060-07F	DEFTYPE	Device Profile 0 Specific Standard Data Types
0x0014	DEFTYPE	INTEGER56	0x0080-09F	DEFSTRUCT	Device Profile 0 Specific Complex Data Types
0x0015	DEFTYPE	INTEGER64	0x00A0-0BF	DEFTYPE	Device Profile 1 Specific Standard Data Types
0x0016	DEFTYPE	UNSIGNED24	0x00C0-0DF	DEFSTRUCT	Device Profile 1 Specific Complex Data Types
0x0017		Reserved	0x00E0-0FF	DEFTYPE	Device Profile 2 Specific Standard Data Types
0x0018	DEFTYPE	UNSIGNED40	0x0100-11F	DEFSTRUCT	Device Profile 2 Specific Complex Data Types
0x0019	DEFTYPE	UNSIGNED48	0x0120-13F	DEFTYPE	Device Profile 3 Specific Standard Data Types
0x001A	DEFTYPE	UNSIGNED56	0x0140-15F	DEFSTRUCT	Device Profile 3 Specific Complex Data Types
0x001B	DEFTYPE	UNSIGNED64	0x0160-17F	DEFTYPE	Device Profile 4 Specific Standard Data Types
0x001C	DEFTYPE	SAFETY	0x0180-19F	DEFSTRUCT	Device Profile 4 Specific Complex Data Types
0x001D-1F		Reserved	0x01A0-1BF	DEFTYPE	Device Profile 5 Specific Standard Data Types
0x0020		Reserved	0x01C0-1DF	DEFSTRUCT	Device Profile 5 Specific Complex Data Types
0x0021	DEFSTRUCT	PDO_MAPPING	0x01E0-1FF	DEFSTRUCT	Device Profile 6 Specific Standard Data Types
0x0022		Reserved	0x0200-21F	DEFSTRUCT	Device Profile 6 Specific Complex Data Types
0x0023	DEFSTRUCT	IDENTITY	0x0320-23F	DEFTYPE	Device Profile 7 Specific Standard Data Types
0x0024		Reserved	0x0440-25F	DEFSTRUCT	Device Profile 7 Specific Complex Data Types
0x0025	DEFSTRUCT	COMMAND_PAR	0x0260-7FF		Reserved

7.Object Dictionary

Also, the Enumerated data type areas are assigned to reserved Index 0x0800 - 0x0FFF.

Each of objects is defined as one of two types of data:

Designates number of bits reserved exclusively (BIT3 or UNSIGNED 16) and integer values (UNSIGNED 32), they are shown strings.

Definition of the Enumerated data type

Sub-Index	Description	Data type	Access type	PDO mapping	Values
0x00	Number of entry	UNSIGNED8	RO	No	the number of the enumerated data type "N"
-	Padding	UNSIGNED8	-	-	0: Even number data (adding byte allocated for 8 bit)
0x01	Enum 1	OCTET STRING	RO	No	VISIBLE STRING of the enumerated data type Integer values of UNSIGNED 32
...					
0xN	Enum N	OCTET STRING	RO	No	

5) Setting unit

The minimum unit treated inside the driver for every operational mode is shown below.

In addition, keep in mind that an instruction unit differs from the minimum unit inside a driver.

In the case of an incremental sensor (instruction resolution = 10000 P/R)

Command	Operation Mode	Setting unit	minimum unit treated inside the driver	Remarks
Position monitor	ALL Operation Mode	—	5Pulse	Command Resolution (10000P/R) / Encoder Resolution (2000P/R) = 5
Velocity commands	Profile position Profile Velocity Homming Cycle Synchronization velocity	1 (Pulse/s)	166PPS = 1 (min ⁻¹)	Setting Value/166 Below a small number of point omission
	Cycle Synchronization Position	—	Follow the Commands	—
Actual Velocity value	ALL Operation Mode	—	5000PPS	Sampling cycle=1ms
acceleration and deceleration	Profile position Profile Velocity Homming Cycle Synchronization velocity	1 (pulse/s ²)	166666PPS = 1 (min ⁻¹ /ms)	Setting Value/166666 Below a small number of point omission
	Cycle Synchronization Position	—	Follow the Commands	—

In the case of an absolute sensor (instruction resolution=32768P/R)

Command	Operation Mode	Setting unit	minimum unit treated inside the driver	Remarks
Position monitor	ALL Operation Mode	—	Pulse	Command resolution = sensor resolution
Velocity commands	Profile position Profile Velocity Homming Cycle Synchronization velocity	1 (Pulse/s)	640PPS = 1.171875 (min ⁻¹)	Setting Value /640 Below a small number of point omission
	Cycle Synchronization Position	—	Follow the Commands	—
Actual Velocity value	ALL Operation Mode	—	1000PPS	Sampling cycle=1ms
acceleration and deceleration	Profile position Profile Velocity Homming Cycle Synchronization velocity	1 (pulse/s ²)	640000PPS = 1.171875 (min ⁻¹ /ms)	Setting Value /640000 Below a small number of point omission
	Cycle Synchronization Position	—	Follow the Commands	—

7.Object Dictionary

7.2 CoE Communication Area

The followings are shown in Table 3-6; CoE communication object list, Object type, Data length, Access (Dir), PDO Mapping, and parameter effective timing (updating). The shapes in the Update column stand for effective timing; #=immediately, \$=ESM (EtherCAT State Machine) change required, &=control-power-source re-input.

Communication Area (No.1)							
Index	Sub-Index	Object Type	Name	Data length	Dir	PDO Mapping	Update
0x1000	0x00	VAR	Device Type	Unsigned32	RO	No	-
0x1001	0x00	VAR	Error Resistor	Unsigned8	RO	No	-
0x1008	0x00	VAR	Device Name of Manufacture	VisibleString	RO	No	-
0x1009	0x00	VAR	Hardware Version of Manufacture	VisibleString	RO	No	-
0x100A	0x00	VAR	Software Version of Manufacture	VisibleString	RO	No	-
0x1010	-	ARRAY	Store Parameters	-	-	-	-
	0x00	-	Number of entry	Unsigned8	RO	No	-
	0x01	-	Save all parameters	Unsigned32	RW	No	#
0x1018	-	RECORD	Identity Object	-	-	-	-
	0x00	-	Number of Entry	Unsigned8	RO	No	-
	0x01	-	Vender ID	Unsigned32	RO	No	-
	0x02	-	Product Code	Unsigned32	RO	No	-
	0x03	-	Revision Number	Unsigned32	RO	No	-
	0x04	-	Serial Number	Unsigned32	RO	No	-
0x1400 - 0x1403 - 0x1500 - 0x1503	-	RECORD	RxPDO Parameter	-	-	-	-
	0x00	-	Number of Entry	Unsigned8	RO	No	-
	0x01	-	Reserved	Unsigned32	RW	No	\$
	0x05	-					
	0x06	-	RxPDO exception PDO	Octet-String	RW	No	\$
	0x07	-	RxPDO State	BOOLEAN	RO	Possible	-
	0x08	-	RxPDO Control	BOOLEAN	RW	Possible	#
	0x09	-	RxPDO Toggle	BOOLEAN	RW	Possible	#
0x1600 - 0x1603 - 0x1700 - 0x1703	-	RECORD	1 st to 4 th , 257 th to 260 th Reception PDO	PDO Mapping	-	-	-
	0x00	-	Number of Entry to RxPDO	Unsigned8	RW	No	\$
	0x01 ... n	-	Object mapped in the 1st ... Object mapped in the n-th	Unsigned32	RW	No	\$
0x1800 - 0x1803 - 0x1900 - 0x1903	-	RECORD	TxPDO Parameter	-	-	-	-
	0x00	-	Number of Entry	Unsigned8	RO	No	-
	0x01	-	Reserved	Unsigned32	RW	No	\$
	0x05	-					
	0x06	-	TxPDO exception PDO	Octet-String	RW	No	\$
	0x07	-	TxPDO State	BOOLEAN	RO	Possible	-
	0x08	-	Reserved	BOOLEAN	-	-	-
	0x09	-	TxPDO Toggle	BOOLEAN	RO	Possible	-
0x1A00 - 0x1BFF	-	RECORD	1 st to 512 th Reception PDO Mapping	PDO Mapping	-	-	-
	0x00	-	Number of Entry to TxPDO	Unsigned8	RW	No	\$
	0x01 ... n	-	Object mapped in the 1st ... Object mapped in the n-th	Unsigned32	RW	No	\$

7.Object Dictionary

Communication Area (No.2)							
Index	Sub-Index	Object Type	Name	Data Length	Access	PDO Mapping	Up-date
0x1C00	-	ARRAY	SM(Sync Manager) Communication	-	-	-	-
	0x00	-	Number of Entry	Unsigned8	RO	No	-
	0x01	-	Communication Type of SM0	Unsigned32	RO	No	\$
	- 0x07	-	... Communication Type of SM7				
0x1C10	-	ARRAY	PDO Assignment of SM 0 to SM3	-	-	-	-
0x1C13	0x00	-	Number of Objects PDO assigned	Unsigned8	RW (RO)	No	\$
0x1C32	-	RECORD	SM 0 to SM7 Synchronization	-	-	-	-
0x1C33	0x00	-	Number of Synchronous Parameter	Unsigned8	RO	No	-
	0x01	-	Synchronous Type	Unsigned32	RW (RO)	No	\$
	0x02	-	Cycle Time	Unsigned32	RW (RO)	No	-
	0x03	-	Shift Time	Unsigned32	RO	No	-
	0x04	-	Synchronous Type Support	Unsigned16	RO	No	-
	0x05	-	Minimum Cycle Time	Unsigned32	RO	No	-
	0x06	-	Calculate and Copy Time	Unsigned32	RO	No	-
	0x07	-	Reserved	-	-	-	-
	0x08	-	Get Cycle Time	Unsigned16	RW (RO)	No	-
	0x09	-	Delay Time	Unsigned32	RO	No	-
	0x0A	-	Sync0 Cycle Time	Unsigned32	RW (RO)	No	-
	0x0B	-	Cycle Time Too Small	Unsigned32	RO	No	-
	0x0C	-	SM-Event Missed	Unsigned32	RO	No	-
	0x0D	-	Shift Time Too Short	Unsigned32	RO	No	-
	0x0E	-	RxPDO Toggle Failed	Unsigned32	RO	No	-
	0x0F	-	Reserved	-	-	-	-
	- 0x1F	-					
	0x20	-	Sync Error	BOOL	RO	No	-

* The index which does not appear in the list among 0x1000 to 0x1FFF is Reserved.

7.Object Dictionary

1) Parameter Details of Object Group from 0x1000

0x1000: Device Type

0x1000: Device Type																		
Index	0x1000	Indicates type and profile function of device			Object Code		VAR											
Sub-Idx	Name			Data Type	Access	PDO	Value											
0x00	Device Type [DEVICE] Displays device type for EtherCAT servo drive.			Unsigned32	RO	No												
MSB LSB <table><tr><td colspan="2">Mode Bit</td><td>Type</td><td colspan="2">Number of Device Profile</td></tr><tr><td>31</td><td>24</td><td>23</td><td>16</td><td>15</td><td>0</td></tr></table>								Mode Bit		Type	Number of Device Profile		31	24	23	16	15	0
Mode Bit		Type	Number of Device Profile															
31	24	23	16	15	0													
				0x0192	Device Profile(DS402d)													
				0xFF	2Axis driver													
				0xFF	2Axis driver													

0x1001::Error Resistor

0x1001: Error Resistor		Index 0x1001		Indicates error state of slave. Refer to (Error Field Definition) for the details of error.		Object Code		VAR		
Sub-Idx		Name/Description				Data Type		Access	PDO	Initial Value
0x00		Error Resistor [ERRREG]				Unsigned8		RO	Possible	0x00
		<u>Bit7:Maker Definition Error</u>				<u>Bit3:Temperature Error</u>				
		<u>Bit6:Reserved</u>				<u>Bit2:Voltage Error</u>				
		<u>Bit5:Device Profile Definition Error</u>				<u>Bit1:Current Error</u>				
		<u>Bit4:Communication Error</u>				<u>Bit0:Generic error</u>				

0x1008: Device Name

Index		0x1008	Indicates product device name.		Object Code		VAR
Sub-Idx	Name/Description			Data Type	Access	PDO	Value
0x00	Device Name [DEVICE] Product Device Name (ASCII Code)			Visible String (Unsigned32)	RO	No	Character String (-)
PB4 D 003 E ☐ D ☐ Refer to section 1, Driver model number, for model number structure details.							

7.Object Dictionary

0x1009: Hardware Version

Index	0x1009	Indicates product hardware version.		Object Code		VAR
Sub-Idx	Name/Description		Data Type	Access	PDO	Value
0x00	Hardware Version[HARDVER] Hardware Version of Device		Visible String (Unsigned32)	RO	No	Character String (-)
01. 00						

0x100A: Software Version

Index	0x100A	Indicates product software version.		Object Code		VAR
Sub-Idx	Name/Description		Data Type	Access	PDO	Value
0x00	Software Version [SOFTVER] Software Version of Device		Visible String (Unsigned32)	RO	No	Character String (-)
01. 00						

7.Object Dictionary

0x1010:Store Parameters

Index	0x1010	Store current amplifier parameters to non-volatile memory	Object Code		ARRAY													
Sub-Idx	Name/Description		Data Type	Access	PDO	Initial value												
0x00	Number of Entry		Unsigned8	RO	No	0x01												
0x01	Store all parameters [PARASAVE] Store all reservable parameters in a lump		Unsigned32	RO	No	0x0000 0001												
In order to avoid storage of parameters by misstate, storage is only executed when a specific signature is written to the “sub-index 1”. The signature is “save” ■Sequence ■Write-access 1) Master writes “0x65 76 61 73” (ASCII:s:73, a:61, v:76, e:65) in “Sub-index 01.” ↓ 2) Slave stores storable parameters in EEPROM* of CPU performing servo control when received correct signs. * Slave information connected to ASIC is not the stored EEPROM. ↓ 3) Slave responds by SDO sending (download-initiating response) after normal storage completion. If failed to store, slave responds via SDO abort transfer servis (abort code: 0606 0000h). If incorrect sign was written, slave responds via SDO abort transfer servis (abort code: 0800 0020h). ■Read-access Slave provides information on parameter storing function in the following formats. <table><tr><th>Bit</th><th>Value</th><th>Description</th></tr><tr><td>31-2: Reserved</td><td>0</td><td>Reserved</td></tr><tr><td>1: Auto</td><td>0</td><td>Slave does not store parameters on an autonomous basis.</td></tr><tr><td>0: Cmd</td><td>1</td><td>Slave stores parameters when commanded via the above write -access.</td></tr></table>							Bit	Value	Description	31-2: Reserved	0	Reserved	1: Auto	0	Slave does not store parameters on an autonomous basis.	0: Cmd	1	Slave stores parameters when commanded via the above write -access.
Bit	Value	Description																
31-2: Reserved	0	Reserved																
1: Auto	0	Slave does not store parameters on an autonomous basis.																
0: Cmd	1	Slave stores parameters when commanded via the above write -access.																
The objects can be stored as shown in the following table.																		

The following is the table of objects saved in 0x1010:Store Parameters.

Profile / Communication Area					
Index	S-Idx	Name	Index	S-Idx	Name
0x1C32	0x01	Synchronization Type (SM2)	0x607D	0x01	Software minimam Position limit
0x1C32	0x02	Cycle Time (SM2)	↑	0x02	Software maximam Position limit
0x1C33	0x01	Synchronization Type (SM3)	0x607E	0x00	Polarity
0x605A	0x00	Quick stop option code	0x607F	0x00	Max profile velocity
0x605D	0x00	Halt option code	0x6081	0x00	Profile velocity
0x6060	0x00	Modes of operation	0x6083	0x00	Profile acceleration
0x6065	0x00	Following error window	0x6084	0x00	Profile deceleration
0x6067	0x00	Position window	0x6085	0x00	Quick stop deceleration
0x606D	0x00	Velocity window	0x6098	0x00	Homing method
0x607B	0x01	Home offset	0x6099	0x01	Speed during search for switch
↑	0x02	Min position range limit	↑	0x02	Speed during search for zero
0x607C	0x00	Max position range limit	0x609A	0x00	Homing acceleration
—	—	—	0x60E6	0x00	Actual position calculation method

7.Object Dictionary

Manufacturer Specific Profile Area

Index	S-Idx	Name	Index	S-Idx	Name
0x4001	0x00	S-curve profile filter	0x4013	0x00	Extended station alias
0x4002	0x00	Position loop propotional gain	0x4014	0x00	Regenerative resistance overheat detection permitted/ prohibited
0x4004	0x00	Feed-forward gain	0x4015	0x00	Status transition an alarm occurred on the other axis
0x4005	0x00	Velocity command low-pass filter	0x4016	0x00	Time to determine that operation of travel to fixed stop is completed.
0x4006	0x00	Velocity feedback Low-pass filter	0x4017	0x00	Initial Move type
0x4007	0x00	Velocity loop propotional gain	0x4018	0x00	Servo loop delay time
0x4008	0x00	Velocity loop integration gainn	0x4022	0x00	Two-axis synchronous operation permitted/ prohibited
0x4009	0x01	Current limit	0x4023	0x00	Two-axis synchronous operation gain
↑	0x02	Current limit when motor stopped in servo-on state	0x4030	0x01	Reserved
↑	0x03	Current limit when motor being driven	↑	0x02	Anomalous threshold of velocity difference
↑	0x04	Current limit in Switch-on state	↑	0x03	Anomalous threshold of postion deviation between two axes
0x400A	0x00	csp2 velocity loop propotional gain	↑	0x04	Abnormal detection threshold of overload
0x4010	0x01	Input-signal logic	↑	0x05	Abnormal detection time of overload
↑	0x02	Limit sensor input-logic in the positive direction	0x4031	0x01	Warning detecting condition
↑	0x03	Limit sensor input-logic in the negative direction	↑	0x02	Position deviation warning threshold
0x4011	0x00	Home sensor input-logic	0x4041	0x01	Power Down delay time
0x4012	0x00	Motor code	↑	0x02	Power Down time constant

0x1018: Identity Object

Index			0x1018	Indicates information of slave device.		Object Code		RECORD
Sub-Idx	Name/Description			Data Type	Access	PDO	Value	
0x00	Number of Entry			Unsigned8	RO	No	0x04	
0x01	Vender ID [VENDOR] Vender ID registered in ETG			Unsigned32	RO	No	0x000001B9	
0x02	Product Code [PRODUCT] Product Code of Production			Unsigned32	RO	No	0x00001000	
0x03	Revision No. [AMPREV] Revision Number of Product			Unsigned32	RO	No	0x00000001	
0x04	Serial No. [SERIAL] Serial Number of Product			Unsigned32	RO	No	0x00000000	

7.Object Dictionary

Synchronous Setup

The features of time and diagnostic function are described by object 0x1C32, 0x1C33, 0x1C02, 0x1400-0x15FF, and 0x1800-0x19FF in the supported synchronous mode.

The supported synchronous mode is described by the portion in OP mode of device description.

The PDO parameter includes the information on PDO and a PDO mapping object (0x1600-0x17FF and 0x1A00-0x1BFF) is related with PDO parameter object (0x1400-0x15FF, 0x1800-0x19FF), respectively.

Sub-Index 1 to 5 of the PDO parameter object is reserved in order to maintain compatibility with CANopen.

0x1400-0x1403,1500-1503:RxPDO Parameter 1 to 4,257 - 260 (rxpdo)

Index	0x1400-0x1403 0x1500-0x1503	The receiving PDO parameters 1 to 4, 257 to 260 show rxpdo setup and state of rxpdo 1 to 4, 257 to 260 corresponded.			Object Code	RECORD
Sub-Idx	Name/Description		Data Type	Access	PDO	Range (Initial Value)
0x00	Number of Entry		Unsigned8	Ro	No	0x09
0x01	Not supported : COB-ID RxPDO1(-512)		Unsigned32	RW	No	-
0x02	Not supported : Transmission Type		Unsigned8	RW	No	-
0x03	Not supported : Inhibit Time		Unsigned16	RW	No	-
0x04	Reserved		Unsigned8	RO	No	-
0x05	Not supported : Event Timer		Unsigned16	RW	No	-
0x06	Not supported : RxPDO Exclude PDO Includes the index of object mapping RxPDO which was not able to assign in this RxPDO.		Octet-String	RW	No	-
0x07	Not supported : RxPDO State When output data of this RxPDO were not arranged to hardware, slave sets it to TRUE =1.		BOOLEAN	RO	Possible	-
0x08	Not supported : RxPDO Control When output of this RxPDO does not have an effective value, master sets it to TRUE =1.		BOOLEAN	RW	Possible	-
0x09	Not supported : RxPDO Toggle Toggles every update of supporting RxPDO to be written by master.		BOOLEAN	RW	Possible	-

7.Object Dictionary

2) PDO Mapping

Can always optimize because PDO setting is able to change transfer data between the master and slave freely in the EtherCAT CoE profile.

The change of the RxPDO mapping uses reception of PDO mapping parameter (0x1600 - 0x1603, 0x1700 - 0x1703:Axis1, 0x1610~0x1613, 0x1710~0x1713:Axis2) with the PB EtherCAT driver, and the TxPDO mapping parameter uses transmission of PDO mapping parameter (0x1A00 - 0x1A03, 0x1B00 - 0x1B03:Axis1, 0x1A10~0x1A13, 0x1B10~0x1B13:Axis2).

For mapping, set Index of PDO, Sub-Index, and data length (bit length) to transmit.

Data length must agree with the one in the object dictionary.

Perform mapping in the following procedures.

1. Once clear the number of the objects (Set the sub-index to 0.) for mapping to zero.
2. Write in setup sequentially from the object (sub-index 1) assigned to the head.
3. Write in the number of objects assigned to the number of the objects to map (sub-index 0).

■ Restrictions on PDO-mapping

- BOOLEAN-type object can be mapped within 16-bit range continued from 16-bit boundary.
- Byte-type object can be mapped at the boundary of 8-bit, and allocated in both odd and even address.

Map the items below surely from the boundary of 8-bit or 16-bit.

【The case byte-type object is mapped in the next to BOOLEAN-type】

Allocate objects after padding out "Padding object (OD:0x0000 SI:0)" for the amount of bit that are reached at the boundary of 8-bit and 16-bit.

- Objects more than half-word can be mapped at the boundary of 16-bit, and allocated in even address.

Make sure to perform mapping for the following cases only after allocating them in even address.

【The case object more than half-word is mapped in the next to BOOLEAN-type】

Allocate objects after padding out for the amount of bit that are reached at the boundary of the next 16-bit.

【The case object more than half-word is mapped from odd address】

Allocate objects after padding out for the amount of 8-bit.

- 20 or less should be the number of objects which can be mapped in the 2 axis sum total.
- The number-of-bytes sum total of the data length to map should serve as even number.

0x1600 - 0x1603 and 0x1700 - 0x1703 :axis1, 0x1610~0x1613, 0x1710~0x1713:axis2 are entry of the RxPDO mapping object dictionary.

0x1600:Reception PDO Mapping 1:axis1

0x1610:Reception PDO Mapping 1:axis2

Index			0x1600		Reception PDO Mapping 1		Object Code		RECORD	
Sub-Idx		Name/Description				Data Type		Access	PDO	Sub-Idx
0x00		Number of Entry : Number of RxPDO1 Object				Unsigned8		RW	No	0x00
0x01		Entry 1 Object Mapped in the 1st - RxPDO1				Unsigned32		RW	No	0x01
0x02 - n		Entry 2 Object Mapped in the 2nd - RxPDO1 ... Entry-n Object Mapped in the n-th - RxPDO1 * “n” is up to 0x1F in maximum.				Unsigned32		RW	No	0x02 - n

0x1601~0x1603, 0x1700~0x1703:RxPDO Mapping 2 - 4,257 - 260(RxPDO x):axis1

0x1611~0x1613, 0x1710~0x1713:RxPDO Mapping 2 - 4,257 - 260(RxPDO x):axis2

Index		0x1601~0x1603 0x1700~0x1703	Reception PDO Mapping 2 - 4,257 - 260	Object Code		RECORD	
Sub-Idx	Name/Description			Data Type	Access	PDO	Range (Initial Value)
0x00	Number of Entry : “n” Number of RxPDOx Object			Unsigned8	RW	No	0x00~0x1F
0x01 ~ n	Entry 1 Object Mapped in the 1st - RxPDOx ... Entry n Object Mapped in the n-th - RxPDOx			Unsigned32	RW	No	0x00000000 ~ 0xFFFFFFFF

7.Object Dictionary

0x1800~0x1803, 0x1900~0x1903: TxPDO Parameter 1 - 4, 257 - 260(TxPDO)

Index		0x1800~0x1803 0x1900~0x1903	The transmitting PDO parameters 1 - 4 and 257 - 260 show TxPDO setup and state of RxPDO 1 – 4 and 257 - 260 corresponded.			Object Code	RECORD
Sub-Idx	Name/Description			Data Type	Access	PDO	Range (Initial Value)
0x00	Number of Entry			Unsigned8	RO	No	0x09
0x01	Not supported [COB-ID RxPDO1(~512)]			Unsigned32	RW	No	0x0000 0000
0x02	Not supported [Transmission Type]			Unsigned8	RW	No	—
0x03	Reserved			Unsigned16	RW	No	—
0x04	Reserved			Unsigned8	RO	No	—
0x05	Reserved			Unsigned16	RW	No	—
0x06	Not supported [TxPDO exception PDO] Includes the index of object mapping TxPDO which was not able to assign in this RxPDO.			Octet-String	RW	No	
0x07	Not supported [TxPDOState] When output data of this TxPDO were not arranged to hardware, slave sets it to TRUE =1.			BOOLEAN	RO	Possible	0
0x08	Reserved			BOOLEAN	RO	No	0
0x09	Not supported [TxPDO Toggle] Toggles every update of supporting TxPDO to be written by master.			BOOLEAN	RO	Possible	0

0x1A00 - 0x1A03 and 0x1B00 - 0x1B03 :axis1/0x1A10~0x1A13, 0x1B10~0x1B13:axis2 are entry of the TxPDO mapping object dictionary.

0x1A00: TxPDO Mapping 1(TxPDO 1):axis1

0x1A10: TxPDO Mapping 1(TxPDO 1):axis2

TxPDO Mapping 1(TxPDO 1)			Object Code		RECORD		
Index	0x1A00	TxPDO Mapping 1(TxPDO 1)		Access	PDO	Range (Initial Value)	
Sub-Idx	Name/Description			Data Type			
0x00	Number of Entry : Number of TxPDO1 Object			Unsigned8	RW	No	0x00~0x1F
0x01	Entry 1 Object Mapped in the 1st to TxPDO1			Unsigned32	RW	No	0x60410010
0x02 ~ n	Entry 2 Object Mapped in the 2nd to TxPDO2 ... Entry n Object Mapped in the n-th to TxPDO1 * “n” is up to 0x1F in maximum.			Unsigned32	RW	No	0x00000000 ~ 0xFFFFFFFF

0x1A01~0x1A03, 0x1B00~0x1B03: TxPDOMapping2~4, 257~260(TxPDO x):axis1

0x1A11~0x1A13, 0x1B10~0x1B13: TxPDOMapping2~4, 257~260(TxPDO x):axis2

Index		0x1A01~0x1A03 0x1B00~0x1B03	送信 PDOMapping4, 257~260	Object Code		RECORD	
Sub-Idx	Name/Description			Data Type	Access	PDO	Range (Initial Value)
0x00	Number of Entry : “n” Number of TxPDOx Object			Unsigned8	RW	No	0x00~0x1F
0x01 ~ n	Entry 1 Object Mapped in the 1st to TxPDO1 ... Entry n Object Mapped in the n-th to TxPDOx * “n” is to 0x1F in maximum.			Unsigned32	RW	No	0x00000000 ~ 0xFFFFFFFF

7.Object Dictionary

0x1C00:SM(SyncManager) Communication Type

Index	0x1C00	S Indicates Sync Manager communication type.		Object Code		ARRAY
Sub-Idx	Name	Description	Data Type	Access	PDO	Range (Initial Value)
0x00	Number of Entry	:SM number of channels to be used	Unsigned8	RO	No	0x08
0x01	Communication Type SM0	1:Mailbox Reception(from master to slave)	Unsigned8	RO	No	0x01
0x02	Communication Type SM1	2:Mailbox Transmission(from slave to master)	Unsigned8	RO	No	0x02
0x03	Communication Type SM2	3:PD Output (from master to slave)	Unsigned8	RO	No	0x03
0x04	Communication Type SM3	4:PD Input (from slave to master)	Unsigned8	RO	No	0x04
0x05 ~ 0x08	Communication Type SM4 ... Communication Type SM7	<u>0:Not used</u> <u>1:Mailbox Reception</u> <u>2:Mailbox Transmission</u> <u>3:PD Output</u> <u>4:PD Input</u>	Unsigned8	RO	No	0x00

SM (Sync Manager) PDO Assignment

0x1C10:SM Channel 0(Mailbox Receive)

Index	0x1C10	Indicates the number of the object assigned to SM0 as PDO.		Object Code		ARRAY
Sub-Idx	Description		Data Type	Access	PDO	Value
0x00	Number assigned by PDO		Unsigned8	RO	No	0x00

0x1C11:SM Channel 1(Mailbox Send)

Index	0x1C11	Indicates the number of the object assigned to SM1 as PDO.		Object Code		ARRAY
Sub-Idx	Description		Data Type	Access	PDO	Value
0x00	Number assigned by PDO		Unsigned8	RO	No	0x00

0x1C12:SM Channel 2(Process Data Output)

Index	0x1C12	Indicates the object assigned to SM2 as PDO.		Object Code		ARRAY
Sub-Idx	Description		Data Type	Access	PDO	Range
0x00	n [several] number of object assigned to RxPDO		Unsigned8	RW	No	0x00 to 0x04
0x01 - n	Index of the PDO object assigned to RxPDO		Unsigned16	RW	No	0x1600:RxPDO 1 ... 0x1603:RxPDO 4 0x1700:RxPDO257 ... 0x1703:RxPDO260

0x1C13:SM Channel 3(Process Data Input)

Index	0x1C13	Indicates the object assigned to SM3 as PDO.		Object Code		ARRAY
Sub-Idx	Description		Data Type	Access	PDO	Range
0x00	n [several] number of object assigned to TxPDO		Unsigned8	RW	No	0x00 to 0x04
0x01 - n	Index of the PDO object assigned to TxPDO		Unsigned16	RW	No	0x1A00:TxPDO 1 ... 0x1A03:TxPDO 4 0x1B00:TxPDO257 ... 0x1B03:TxPDO260

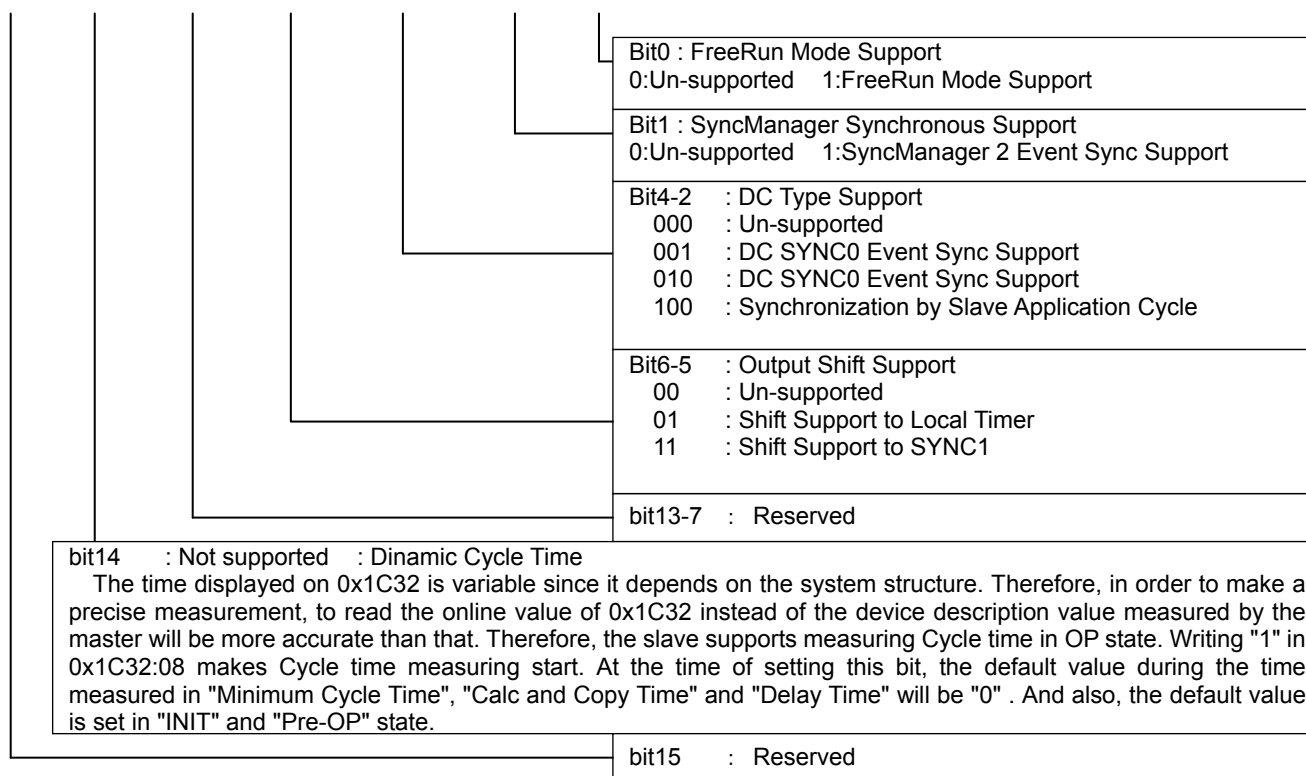
7.Object Dictionary

0x1C32: SM2 Synchronization (Output Sync Manager Parameter)

0x01:SM2 Synchronization (Output Sync Manager) Parameters

Index	0x1C32	SM2 synchronization setup	Object Code			RECORD
Sub-Idx	Name/Description		Data Type	Access	PDO	Range
0x00	Number of synchronization parameter		Unsigned8	RO	No	0x20
0x01	Synchronization Type [SM2TYP] Sets up synchronous mode.		Unsigned16	RW	No	0x0002
			Setting Range	0x0000~0x0003		
	<u>0x00:Not Synchronized (Free Run)</u>					
	<u>0x01:Synchro SM2 Event Synchronization (AL Event Synchronization of SM2)</u>					
	<u>0x02:DC Sync0 SYNC0 Event Synchronization (Synchronized with SYNC0 Hardware Signal)</u>					
	<u>0x03:DC Sync1 SYNC1 Event Synchronization (Synchronized with SYNC1 Hardware Signal)</u>					
0x02	Cycle Time : Unit(ns) [SM2SYC] Sets up communication cycle between master and slave.		Unsigned32	RW	No	0x000F4240 (1ms)
			Setting Range	0x000F4240~0x03D09000 (1~64ms)		
	<u>Free Run (Synchronization Type=0x0) : Local Timer Event Cycle of Slave</u>					
	<u>SM2 Synchro (Synchronization Type=0x01) : SM2 Event Cycle (Minimum Time)</u>					
	<u>DC SYNC0 (Synchronization Type=0x02) : SYNC0 Cycle Time (0x09A0 - 0x09A3)</u>					
	<u>DC SYNC1 (Synchronization Type=0x03) : SYNC0 Cycle Time (0x09A0 - 0x09A3)</u>					
	Possible Setting Value:T _(ns)					
	1ms :0x000F4240 2ms :0x001E8480					
	4ms :0x003D0900 8ms:0x007A1200 16ms:0x00F42400					
	32ms :0x01E84800 64ms:0x03D09000					
	☐ Error is returned when the value is set except the value that can be set as above.					
0x03	Shift Time : Unit (ns) Time between Hardware Output Effective Operation and Related Event		Unsigned32	RO	No	0x0
0x04	Synchronization Type Supported		Unsigned16	RO	No	0x4007

MSB					LSB		
Res.	Dyna	Res.	Shift	DC	Sync	Free	
15	14	13 - 7	6 5 4	3 2	1	0	



7.Object Dictionary

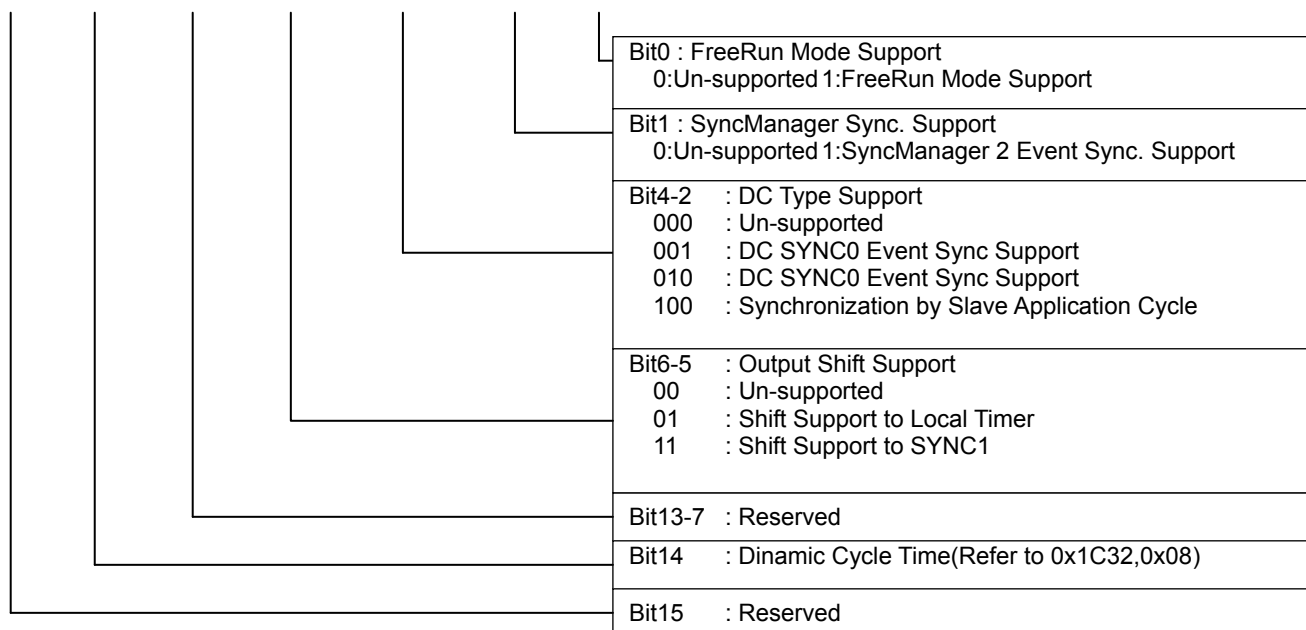
Sub-Idx	Name/Description	Data Type	Access	PDO	Range
0x05	Minimum Cycle Time : Unit(ns) The minimum cycle time is supported by slave. (Maximum time of local cycle)	Unsigned32	RO	No	0x000F4240 (1ms)
0x06	Copy and Operation Time (Calc and Copy Time) Unit (ns) Time required of micro controller in order to copy process data to local memory from SyncManager. Operation is processed, if required before data's transmitting to process.	Unsigned32	RO	No	0x0000F424 (62.5µs)
0x07	Reserved	Unsigned32	—	—	—
0x08	Get Cycle Time 0:Stops local cycle time measurement. 1:Starts local cycle time measurement. *Measurement value is reset when written into again.	Unsigned16	RW	No	—
0x09	Delay Time It is time during trigger reception of SYNC0 or SYNC1 event to be effective in order to do output drive of the value by the hardware delay time of slave, *Only the synchronous type 0x02, or DC SYNC0/1 of 0x03	Unsigned32	RO	No	0X0000F424 (62.5µs)
0x0A	Not supported [Sync0 Cycle Time] When SYNC0 fixed cycle time is required of application, it is the time between two Sync0 signals. *Synchronous Time = Only DC SYNC0 of 0x03, and local cycle control	Unsigned32	RW	No	—
0x0B	Cycle Time Too Small This error counter is incremented when cycle time is too short as local cycle cannot be completed or input data cannot prepare by the next SM event.	Unsigned16	RO	No	—
0x0C	SM Event Missed This error counter is incremented when application demands SM event and cannot receive it. As a result, data may be unable to be copied any more.	Unsigned16	RO	No	—
0x0D	Shift Time Too Short This error counter is incremented when the time interval of SYNC0 trigger and an output is too short, by the fact that shift time or SYNC1 cycle time is too short.	Unsigned16	RO	No	—
0x0E	Not supported [RxPDO Toggle Failed] This error counter is incremented when slave supports a RxPDO toggle and then new RxPDO data cannot be received from a master. (When RxPDO toggle is set to TRUE.)	Unsigned16	RO	No	—
0x0F:0x1F	Reserved	—	—	—	—
0x20	Not supported [Sync Error] TxPDO mapping is possible at the time of SM-Event Missed or Shift Time Too Short Counter support. <u>0: Not Sync. Error or unsupported Sync.Error</u> <u>1: Sync. Error</u>	BOOL	RO	Possible	

7.Object Dictionary

0x1C33:SM3 Synchronization (Input SyncManager Parameter)

0x03: SM3 Synchronization (Input Synchronization Parameter)						
Index	0x1C33	SM3 Synchronization	Object Code		RECORD	
Sub-Idx	Name/Description		Data Type	Access	PDO	Initial Value
0x00	Number of Synchronization Parameter		Unsigned8	RW	No	0x20
0x01	Synchronization Type [SM3TYP]		Unsigned16	RW	No	0x0002
	Setting Range		0x00, 0x02, 0x03, 0x22			
	<u>0x00:Not synchronized (Free Run)</u> <u>0x01:Reserved</u> <u>0x02:DC Sync0 SYNC0 Event Synchronization (Synchronized with SYNC0 Hardware Signal)</u> <u>0x03:DC Sync1 SYNC1 Event Synchronization (Synchronized with SYNC1 Hardware Signal)</u> <u>0x04 - 0x21:Reserved</u> <u>0x22:Synchro SM2 Event Synchronization (When Output is transmitted by Safe-Ope and OP)</u>					
0x02	Cycle Time : Unit (ns)	[SM3CYC]	Unsigned32	RO	No	0x0007A120 (500μs)
	<u>Free Run (Synchronous Type=0x00) : Local Timer Event Cycle of Slave</u> <u>SM2 Sync (Synchronous Type=0x01) : SM2 Event Cycle (Minimum Time)</u> <u>DC SYNC0 (Synchronous Type=0x02) : SYNC0 Cycle Time (0x09A0 - 0x09A3)</u> <u>DC SYNC1 (Synchronous Type=0x03) : SYNC0 Cycle Time (0x09A0 - 0x09A3)</u> ☐ The value shall be the same as Index:0x1C32,Sub-index2.					
0x03	Shift Time : Unit(ns)		Unsigned32	RO	No	0x0-
	Time between Input Latch Operation from Hardware and Related Operation ☐ The value shall be the same as Index:0x1C32,Sub-index2.					
0x04	Synchronous Type Support		Unsigned16	Ro	No	0x4007

MSB						LSB	
Res.	Dyna	Res.	Shift	DC	Sync	Free	
15	14	13...7	6	5	4	3	2
							1
							0



7.Object Dictionary

Sub-Idx	Name/Description	Data Type	Access	PDO	Range
0x05	Minimum Cycle Time : Unit (ns) The minimum cycle time is supported by slave. (Maximum time of local cycle) □ The value shall be the same as Index:0x1C32,Sub-index5.	Unsigned32	RO	No	0x000F4240 (1000µs)
0x06	Copy and Operation Time (Calc and Copy Time) Unit (ns) Time required from Input Latch through minimum cycle time.	Unsigned32	RO	No	0x000E4E1C (9375µs)
0x07	Reserved	-	-	-	-
0x08	Get Cycle Time 0:Stops local cycle time measurement. 1:Starts local cycle time measurement. *Measurement value is reset when written into again.	Unsigned16	RW	No	-
0x09	Delay Time It is time during trigger reception of SYNC0 or SYNC1 event to be effective in order to do output drive of the value by the hardware delay time of slave, *Only the synchronous type 0x02, or DC SYNC0/1 of 0x03	Unsigned32	RO	No	-
0x0A	Not supported : Sync0 Cycle Time When SYNC0 fixed cycle time is required of application, it is the time between two Sync0 signals. *Synchronous Time = Only DC SYNC0 of 0x03, and local cycle control	Unsigned32	RW	No	-
0x0B	Cycle Time Too Small This error counter is incremented when cycle time is too short as local cycle cannot be completed or input data cannot prepare by the next SM event.	Unsigned16	RO	No	-
0x0C	SM-Event Missed This error counter is incremented when application demands SM event and cannot receive it. As a result, data may be unable to be copied any more.	Unsigned16	RO	No	-
0x0D	Shift Time Too Short This error counter is incremented when the time interval of SYNC0 trigger and an output is too short, by the fact that shift time or SYNC1 cycle time is too short.	Unsigned16	RO	No	-
0x0E	Not supported : RxPDO Toggle Failed This error counter is incremented when slave supports a RxPDO toggle and then new RxPDO data cannot be received from a master. (When RxPDO toggle is set to TRUE.)	Unsigned16	RO	No	-
0x0F:0x1F	Reserved	-	-	-	-
0x20	Reserved (Sync Error) TxPDO mapping is possible at the time of SM-Event Missed or Shift Time Too Short Counter support. <u>0: Not Sync. Error or unsupported Sync-Error</u> <u>1: Sync. Error</u>	BOOL	RO		

7.Object Dictionary

3) Communication Timing

Since application is synchronized with master and slave, data handling of EtherCAT makes a peculiar motion. As for synchronization type, synchronization mode discernment is possible by the combination of 0x1C32 and 0x1C33 of sub index in Object Dictionary. Terms used to Communication Timing are explained below.

Copy and Prepare Outputs

Output data in trigger events, such as local timer event and SM2/3 event and SYNC0/1 event, are read from SyncManager output area. Then, slave operates process using output data, and is outputted to motor.

The overview of "Copy and Prepare Output" time is the hardware delay depending on the time and software operating time for copying process data to a local memory from SyncManager, when accurate operation move is required. They follow the value described by SyncManager Object: 0x1C32.

Index	Sub-Index	Time Definition
0x1C32	0x06	Process data copy from SyncManager and accurate operation
0x1C32	0x09	Hardware Delay Time

Get and Copy Inputs

The abstract of "Get and Copy Inputs" time is the delay for copying input process data to hardware reading of a sensor signal and SyncManager 3 area, when accurate operation move is required. They follow the value described by SyncManager Object: 0x1C33.

Input can be used in SyncManager 3 area after 0x1C32 and 0x05 "Minimum Cycle Time".

Index	Sub-Index	Time Definition
0x1C33	0x06	Data copy from accurate operation and local memory to SyncManager
0x1C33	0x09	Hardware delay time for input latch preparation

Outputs Valid

"Outputs Valid" in RS2-EtherCAT slave amplifier indicates the time, which added together the following three kinds of time.

- 1) Time until copies process data to local memory from SyncManager by trigger event
- 2) Time until servo loop operation process and the current command to ASIC for servo are written in
- 3) Hardware delay to current loop operation process within ASIC and IGBT gate output

Start Driving Outputs

"Start Driving Outputs" is the timing to write current command in ASIC for servo by micro controller.

0x1C32 and 0x09 "Hardware Delay Time" indicate between "Start Driving Outputs" and "Outputs Valid".

Start Latch

"Start Latch" is start signal to input latch process.

Between "Start Latch" and "Input Latch", defines as 0x1C33 and 0x09:"Delay Time" in consideration of hardware delay time and the software operating time mounted in slave.

Input Latch

"Input Latch" in RS2-EtherCAT slave amplifier indicates the real position acquisition timing of motor sensor.

However, when position cannot be received more correctly than sensor (serial sensor), data is not copied to SyncManager area.

User Shift Time

"User Shift Time" is value in consideration to the jitter of the master.

SYNC1 Cycle Time

"SYNC1 Cycle Time" may be used for the shift of "Start Input Latch" or "Start Driving Output". "SYNC1 Cycle Time" is defined as a register 0x984 - 0x987 as a shift time between SYNC0 and SYNC1, as long as SYNC0 is a standard signal.

Shift Time

"Shift Time" defines time between the synchronous event such as SM2 event, SYNC0, and SYNC1, and also "Outputs Valid" and "Input Latch". Possible to write if its specifications can shift "Outputs Valid" or "Input Latch".

7.Object Dictionary

The synchronous mode supported to PB driver is shown the following.

4) Free Run Mode (Free Run:Asynchronous Operation)

In free run mode, starts by the local timer interrupt of an application controller.

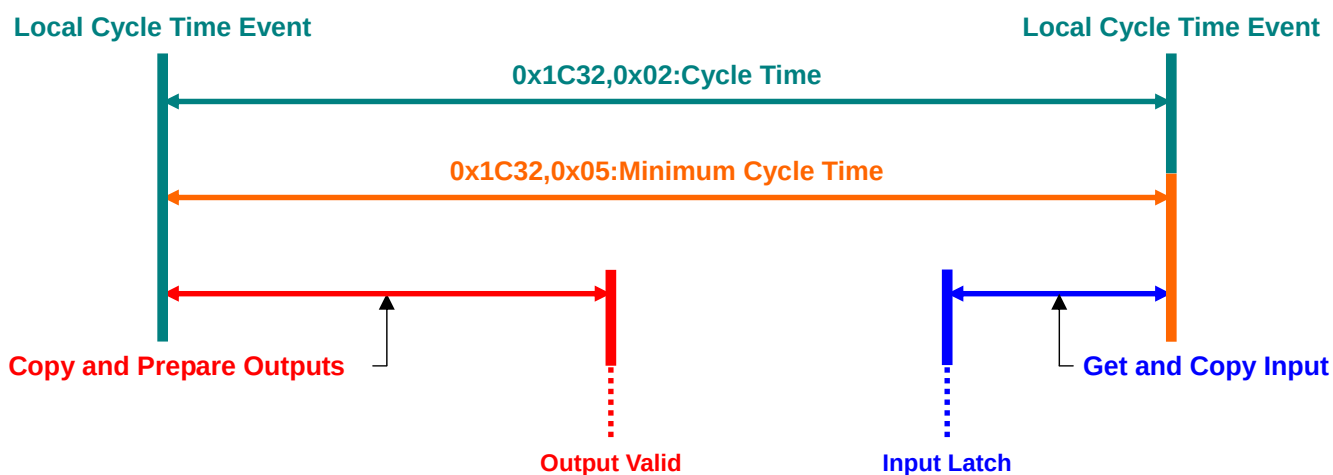
Local cycle moves independently of communication cycle or master cycle.

As an optional feature, slave supports 0x02 of 0x1C32 "Cycle Time". In this case, 0x05 of 0x1C32 "Minimum Cycle Time" is also supported with slave.

Free run mode is set as 0x1C32:0x01=0x00 and 0x1C33:0x00=0x00.

Parameter of Free Run Mode List

Index	Sub-Index	Dir	Name	Remarks
0x1C32	0x01	RW	Synchronization Type	0x00:Free Run Support
	0x02	RO	Cycle Time	Control Cycle Time of Slave
	0x04	RO	Synchronization Type Supported	Bit0=1:FreeRun Support
	0x05	RO	Minimum Cycle Time	RS2-EtherCAT(s) are the same setup to 0x1C32:0x02.
0x1C33	0x01	RW	Synchronization Type	0x00:Free Run Support
	0x02	RO	Cycle Time	Same setup to 0x1C32:0x02
	0x04	RO	Synchronization Type Supported	Same setup to 0x1C32:0x04
	0x05	RO	Minimum Cycle Time	Same setup to 0x1C32:0x05



Communication Timing of Free Run Mode

7.Object Dictionary

5) SM2 Event Synchronization Mode (Synchronous with SM2 Event)

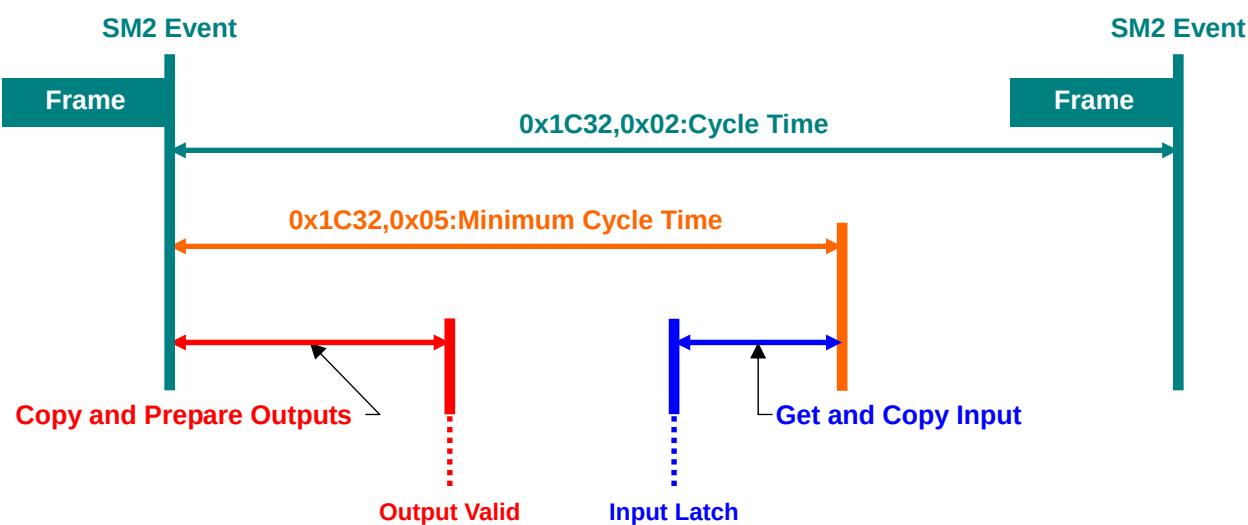
Since slave process is started to SM2 event cycle, always synchronizes with SM2 event.

Operated in local cycle time until receiving SM2 event.

With RS2-EtherCAT amplifier, since Output is always effective, SM3 event synchronization cannot be performed..

SM2 Set Parameter of Event Synchronization Mode

Index	Sub-Index	Dir	Name	Remarks
0x1C32	0x01	RW	Synchronization Type	Synchronized with 0x01:SM2 Event
	0x02	RW	Cycle Time	Communication Cycle
	0x04	RO	Synchronization Type Supported	Bit1=1:Synchronization Supported
	0x05	RO	Minimum Cycle Time	
	0x08	RW	Cycle Time Acquisition	
	0x0B	RO	Cycle Time Short	
	0x0C	RO	SM Event Missed (Event Omission)	
	0x0E	RO	RxPDO Toggle Failed	
	0x20	RO	Synchronization Error	
0x1C33	0x01	RW	Synchronization Type	Synchronized with 0x22:SM2
	0x02	RO	Cycle Time	Same set to 0x1C32:0x02
	0x04	RO	Synchronization Type Supported	Same set to 0x1C32:0x04
	0x05	RO	Minimum Cycle Time	Same set to 0x1C32:0x05
	0x08	RW	Cycle Time Acquisition	Same set to 0x1C32:0x08
	0x0B	RO	Cycle Time Short	Same set to 0x1C32:0x0B
	0x0C	RO	SM Event Missed (Event Omission)	Same set to 0x1C32:0x0C
	0x0E	RO	RxPDO Toggle Failed	Same set to 0x1C32:0x0E
	0x20	RO	Synchronization Error	Same set to 0x1C32:0x20



Communication Timing of SM2 Synchronization Mode

7.Object Dictionary

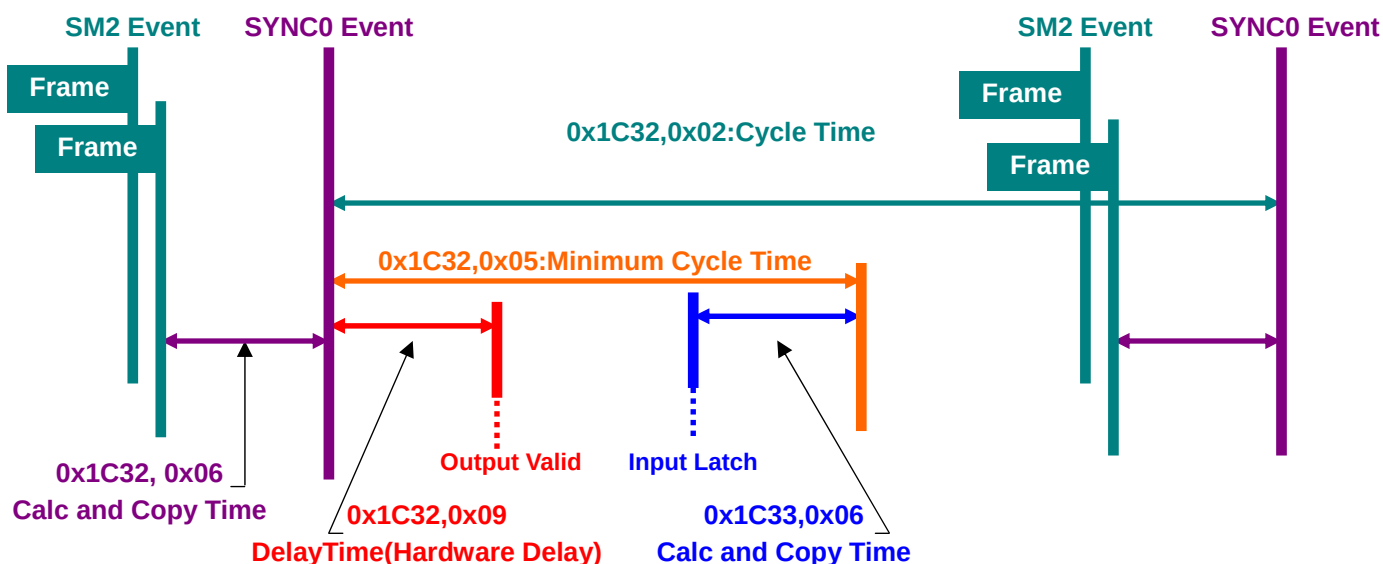
6) DC Mode (SYNC0 Event Synchronization)

Local cycle of slave is started to SYNC0 event reception.

Process data frame must complete data reception within slave before the next SYNC0 interruption generating.
"Calc and Copy Time" contains the minimum time lag between frame reception and SYNC0 event.

Parameter of DC Mode (SYNC0 Event Synchronization)

Index	Sub-Index	Dir	Name	Remarks
0x1C32	0x01	RW	Synchronization Type	Synchronized with 0x02:DC SYNC0
	0x02	RO	Cycle Time	SYNC0 Cycle Time
	0x04	RO	Synchronization Type Supported	Bit4:2=001:DC SYNC0
	0x05	RO	Minimum Cycle Time	
	0x06	RO	Calc and Copy Time	Minimum Time between Frame and SYNC0
	0x08	RW	Cycle Time Acquisition	
	0x09	RO	Delay Time	
	0x0B	RO	Cycle Time Short	
	0x0C	RO	SM Event Missed(Event Omission)	
	0x0E	RO	RxPDO Toggle Failed	
	0x20	RO	Synchronization Error	
0x1C33	0x01	RW	Synchronization Type	Synchronized with 0x02:DC SYNC0
	0x02	RO	Cycle Time	Same set to 0x1C32:0x02
	0x04	RO	Synchronization Type Support	Same set to 0x1C32:0x04
	0x05	RO	Minimum Cycle Time	Same set to 0x1C32:0x05
	0x06	RO	Calc and Copy Time	Time between Input Latch and Minimum Cycle Time
	0x08	RW	Cycle Time Acquisition	Same set to 0x1C32:0x08
	0x0B	RO	Cycle Time Short	Same set to 0x1C32:0x0B
	0x0C	RO	SM Event Missed(Event Omission)	Same set to 0x1C32:0x0C
	0x0E	RO	RxPDO Toggle Failed	Same set to 0x1C32:0x0E
	0x20	RO	Synchronization Error	Same set to 0x1C32:0x20



Communication Timing of DC Synchronization Mode (SYNC0)

7.Object Dictionary

7) DC Mode (SYNC1 Event Synchronization)

Local cycle of slave is started to SYNC0 event reception.

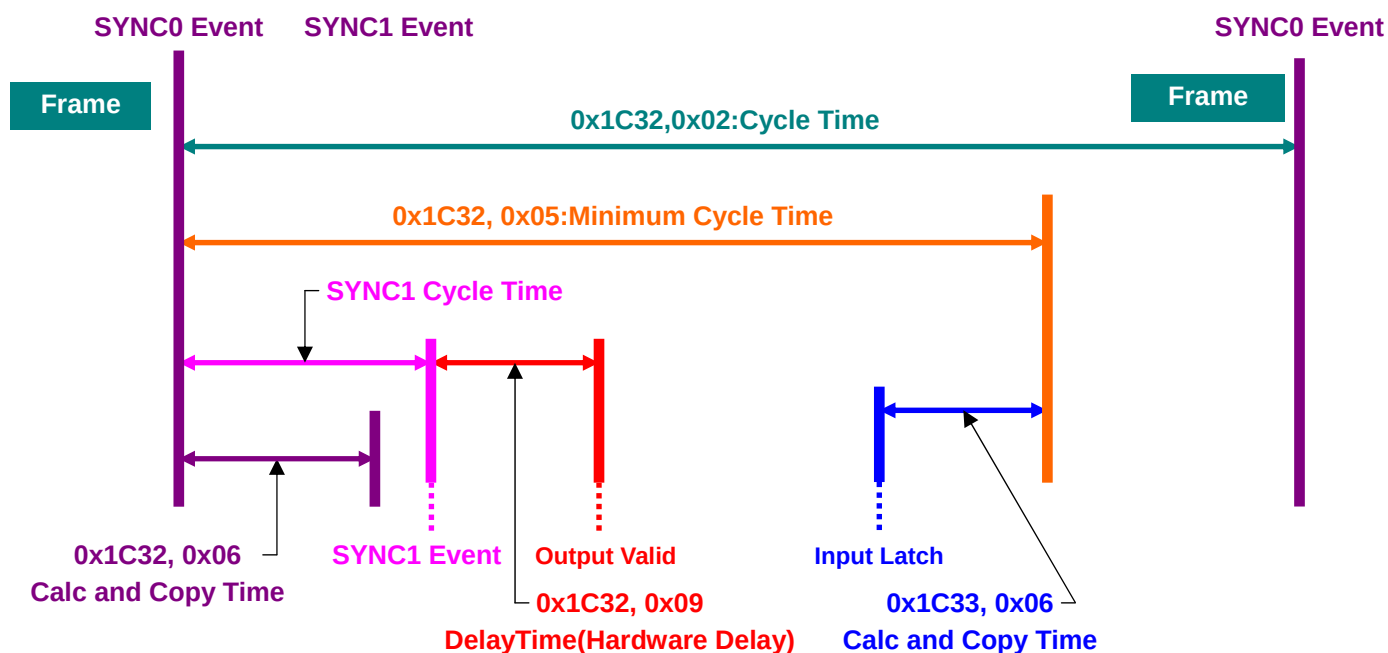
Should receive process data frame before the next SYNC0 interruption generating.

Since SYNC1 is used for "Output Valid", SYNC1 cycle time defines the time lag between SYNC0 and "Start Driving Output".

0x1C32 and 0x06 (Calc and Copy Time) indicate the allowance time for SYNC1 cycle time, and 0x1C32 and 0x09 (Delay Time) define the hardware delay for driving an output.

Parameter of DC Mode (SYNC1 Event Synchronization)

Index	Sub-Index	Dir	Name	Remarks
0x1C32	0x01	RW	Synchronization Type	Synchronized with 0x03:DC SYNC0
	0x02	RO	Cycle Time	SYNC0 Cycle Time
	0x04	RO	Synchronization Type Supported	Bit4:2=010:DC SYNC1
	0x05	RO	Minimum Cycle Time	
	0x06	RO	Calc and Copy Time	Value between SYNC0 and Minimum SYNC1 Cycle Time
	0x08	RW	Cycle Time Acquisition	
	0x09	RO	Delay Time	
	0x0B	RO	Cycle Time Short	
	0x0C	RO	SM Event Missed(Event Omission)	
	0x0E	RO	RxPDO Toggle Failed	
	0x20	RO	Synchronization Error	
0x1C33	0x01	RW	Synchronization Type	Synchronized with 0x03:DC SYNC1
	0x02	RO	Cycle Time	Same set to 0x1C32:0x02
	0x04	RO	Synchronization Type Supported	Same set to 0x1C32:0x04
	0x05	RO	Minimum Cycle Time	Same set to 0x1C32:0x05
	0x06	RO	Calc and Copy Time	Time between Input Latch and Minimum Cycle Time
	0x08	RW	Cycle Time Acquisition	Same set to 0x1C32:0x08
	0x0B	RO	Cycle Time Short	Same set to 0x1C32:0x0B
	0x0C	RO	SM Event Missed(Event Omission)	Same set to 0x1C32:0x0C
	0x0E	RO	RxPDO Toggle Failed	Same set to 0x1C32:0x0E
	0x20	RO	Synchronization Error	Same set to 0x1C32:0x20



Communication Timing of DC Synchronization Mode (SYNC0)

7.Object Dictionary

7.3 PDS FSA

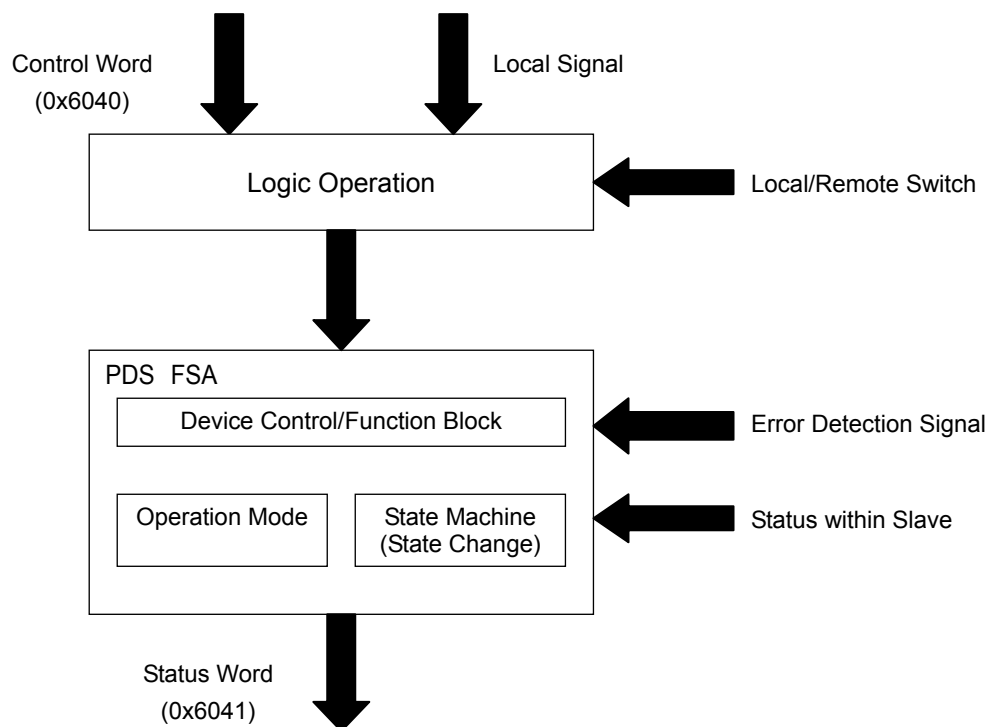
(Power Device System Finite State Automaton)

1) Abstract

PDS (Power System Device) FSA (Finite States Automaton) of the EtherCAT slave amplifier is an abstract concept which defines the state of the control device stays or passes, operation with the Black Box. It defines the slave's application operating. Slave controls State Device, Mode, and State Change with Object "Control Word (0x6040)" sent via the network.

By "Status word (0x6041)" generated with slave device, the State returns the present state. Besides, PDS and FSA are controlled also by Error Detection Signal.

The slave local and network shows you how to be driving.



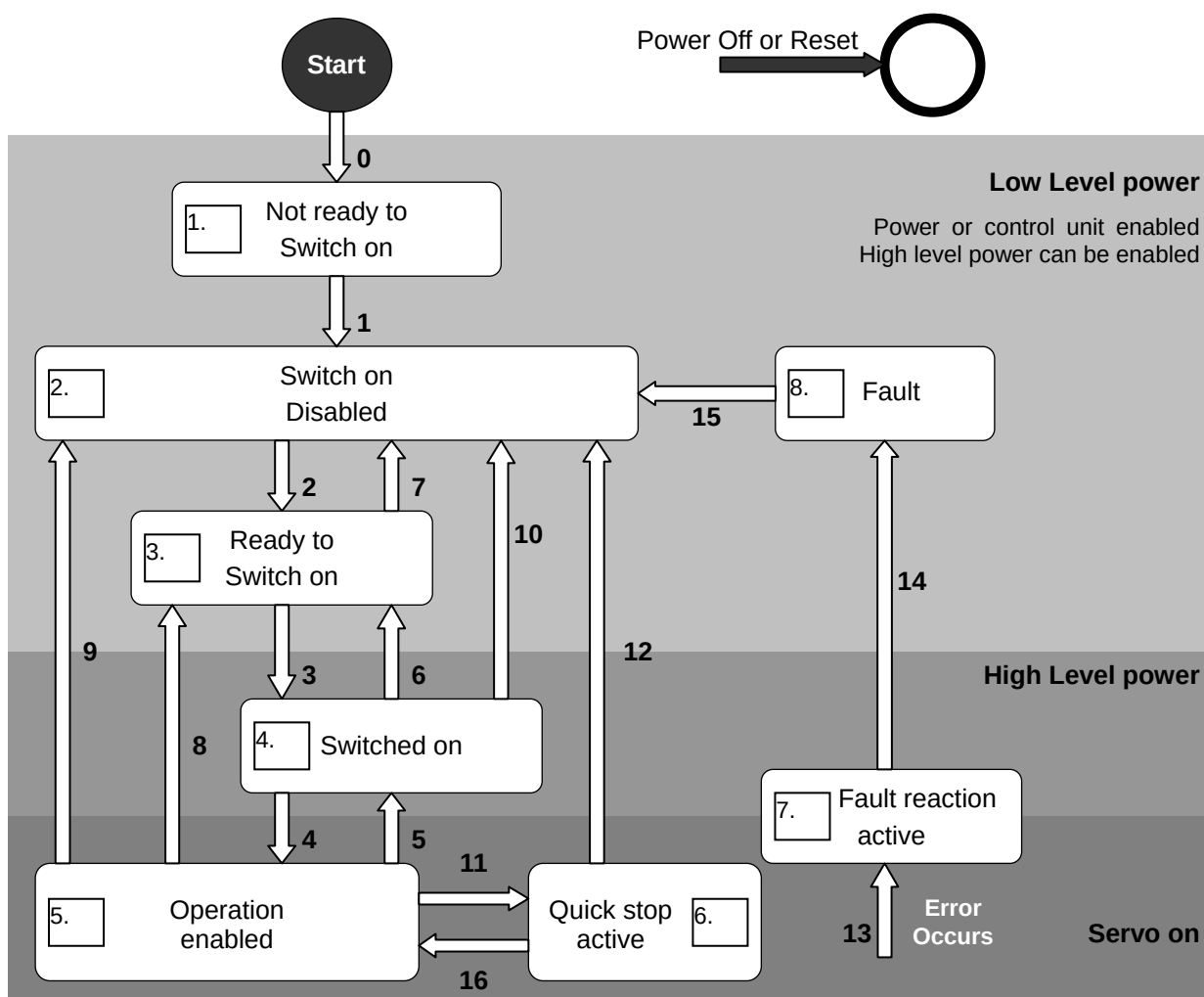
Control Word / Status Word Concept of Slave

7.Object Dictionary

2) FSA (Finite States Automaton)

FSA of PB EtherCAT driver determines the sequence of device state and drive control, and operation peculiar to each state is shown.

With this State Machine, what kind of command slave driver receives is changed.



FSA of RS2 EtherCAT Amplifier

Low Level power Area

: The control source is established and the state can switch on main circuit power supply.

High Level Power Area

: Main circuit power supply is in SwitchOn state. However, motor is in servo-off (torque(force)-off) state, and when the main circuit is not established, Shift 3 is canceled by slave.

Target and set point value are invalid.

In the case of an incremental sensor, initialization operation is performed in the state of first-time Switch On.

Servo on

: After slave completes servo-on , Motor is operated by target or set point value.

7.Object Dictionary

FSA and FSA state describes the state transitions.

FSA State Definition		
No.	State	Description
[A]	Not Ready to Switch on	The control source is provided to the slave and established. Slave is performing initialization or self-test.
[B]	Switch on Disabled	Initialization is completed, and slave is in condition to be able to set parameter. However, main circuit power supply is not in the state should be supplied.
[C]	Ready to Switch on	In input permission state about main circuit power supply. Although parameter can be set, function is in invalid state.
[D]	Switch on	Main circuit power supply is provided and in the completion state of switch-on preparation. Parameter to slave can be set. * In the case of an incremental sensor, initialization operation is performed in the state of first-time Switch On (a maximum of 5 sec). Keep in mind that it cannot change to Operation enabled in the meantime. * The initialization operation operates after fixed exsitation according to an initialization operation type setup of 0x4017.
[E]	Operation Enabled	Fault (alarm) is not generated, where drive function is effective and motor is excited.Parameter to slave can be set.
[F]	Quick Stop Active	In the state where the Quick stop (scram) function is performed. In the state where drive function is effective and motor is excited.
[G]	Fault Reaction Active	In the state where Fault (alarm) occurs with slave and the Quick stop (scram) function is performed. Also, in the state that motor is excited by the drive function effective.
[H]	Fault	In the state which the fault (alarm) generated with the slave and Fault reaction completed. Drive function is invalid, and main circuit power supply is turned on or off by application.

7.Object Dictionary

State Shift of FSA		
No.	[Before Shift]->[After]	Event / Action
0	[Start] ↓ [Not ready to Switch on]	Event : After control power supply ON or reset application, shifts automatically. Action : Slave performs initialization and self-test.
1	[Not ready to Switch on] ↓ [Switch on Disabled]	Event : Shifts automatically. Action : Communication is permitted.
2	[Switch on Disabled] ↓ [Ready to Switch on]	Event : [Shut down] command (Bit2, 1, 0=1, 1, 0) is received from master. Action : None
3	[Ready to Switch on] ↓ [Switch on]	Event : [Switch On] command (Bit3, 2, 1, 0=0, 1, 1, 1) is received from master. Action : Since in main circuit power supply permission state, provide main circuit power supply.
4	[Switch on] ↓ [Operation enabled]	Event : [Enable operation] command (Bit3, 2, 1, 0=1, 1, 1, 1) is received from master. Action : Slave is Servo-ON and all the internal preset values are cleared.
5	[Operation enabled] ↓ [Switch on]	Event : [Disabled operation] command (Bit3, 2, 1, 0=0, 1, 1, 1) is received from master. Action : Slave is Servo-ON.
6	[Switch on] ↓ [Ready to Switch on]	Event : [Shut down] command (Bit2, 1, 0=1, 1, 0) is received from master. Action : Master should intercept main circuit power supply.
7	[Ready to Switch on] ↓ [Switch on Disabled]	Event : [Quick Stop] command (Bit2, 1=0, 1) or [Disable voltage] command (Bit1=0) is received from master. Action : None
8	[Operation enabled] ↓ [Ready to Switch on]	Event : [Shut down] command (Bit2, 1, 0=1, 1, 0) is received from master. Action : Slave is Servo-Off. Master should intercept main circuit power supply.
9	[Operation enabled] ↓ [Switch on Disabled]	Event : [Disable voltage] command (Bit1=0) is received from master. Action : Slave is Servo-Off. Master should intercept main circuit power supply.
10	[Switch on] ↓ [Switch on Disabled]	Event : [Quick Stop] command (Bit2, 1=0, 1) or [Disable voltage] command (Bit1=0) is received from master. Action : Master should intercept main circuit power supply.
11	[Operation enabled] ↓ [Quick stop active]	Event : [Quick Stop] command (Bit2, 1=0, 1) is received from master. Action : Quick Stop function is performed.
12	[Quick stop active] ↓ [Switch on Disabled]	Event : Shifts automatically when Quick Stop operation is completed or when the "Disable voltage" command (Bit1=0) is received at Quick Stop option code 1-3. Action : Slave is Servo-Off. Master should intercept main circuit power supply.
13	Error occurs ↓ [Fault reaction active]	Event : Fault (Alarm) occurs at slave. Action : Set-up Fault operation function is performed.
14	[Fault reaction active] ↓ [Fault]	Event : Shifts automatically. Action : Slave is Servo-Off. Master should intercept main circuit power supply.
15	[Fault] ↓ [Switch on Disabled]	Event : [Fault reset] command (Bit7=0 -> 1) is received from master. Action : Without slave's Fault factor, Fault reset is performed. Master should clear the "Fault reset" bit (Bit7=1->0) after normal state check.
16	[Quick stop active] ↓ [Operation enabled]	Event : [Enable operation] command (Bit3, 2, 1, 0=1, 1, 1, 1) is received by Quick Stop option code5 to 7. Action : Slave function is permitted.

7.Object Dictionary

3) Control Word

Control Word (Object: 0x6040) indicates the command for controlling the FSA state of slave.

Control Word consists of "FSA Control Bit", "Operation Mode spec. Control Bit", and "Maker Option Control Bit."

All the operation mode common "FSA Control Bit" allotment and command coding are described below.

Allotment for Each Bit of Control Word

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
Manufacturer Specific (Manufacture Specification)					Reserved	Operation mode Specific	Halt
*	*	Push	ECLR	*			

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Fault Reset	Operation mode Specific (Operation Mode Specification)			Enable Operation	Quick Stop	Enable Voltage	Switch On

Bit9, 6, 5, and 4 are Operation Mode Specification. Halt functional operation of Bit8 is also Operation Mode Specification.

Motion under command is interrupted when Bit8 =1. Slave is defined by Halt option code and operated.

Since Bit10,11,14,15 is Reserved, set to "0."

Bit15 to 11 are Manufacturer Specification.

0x6040:Control Word (Intersection)

Index		0x6040	Indicates reception command of FSA (State Machine) that PDS (Power Device System) is controlled.		Object Code		Variable
Sub-Idx		Description		Data Type	Access	PDO	Initial Value
0x00		Control Word [CWORD] Bit pattern (Bit 7, 3, 2, 1, 0) of Control Word The composition is as follows.		Unsigned16	RW	Possible	0x0000
				Display Range	0x0000 - 0xFFFF		

MSB

Manufacturer Specific	Reserved	Operation mode Specific	Halt	Fault reset	Operation mode Specific	Enable operation	Quick stop	Enable voltage	Switch on
15 ... 11	10	9	8	7	6 ... 4	3	2	1	0

Control word bit pattern command

Command	Control Word bit					Transition No.
	bit7	bit3	bit2	bit1	bit0	
Shut down	0	x	1	1	0	2,6,8
Switch On	0	0	1	1	1	3
Disable voltage	0	x	x	0	x	7,9,10,12
Quick Stop	0	x	0	1	x	7,10,11
Disabled operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	0->1	x	x	x	x	15

7.Object Dictionary

Operation mode

Manufacturer Specific	Reserved	Operation mode Specific	Halt	Fault reset	Operation mode Specific	Enable operation	Quick stop	Enable voltage	Switch on
15 ... 11	10	9	8	7	6 ... 4	3	2	1	0

bit NO	Operation mode	Status	Logic	Function
4	PP	New set point	0→1: Start up	Starts up PP.
	CSP	reserve	—	—
	PV	reserve	—	—
	CSV	reserve	—	—
	hm	Homing operation start	0→1: Start up	Starts up Home-operation.
5	PP	Change set immediately	1: Additional command	Additionally commands when starting up or during operation with Logic 1.
	CSP	reserve	—	—
	PV	reserve	—	—
	CSV	reserve	—	—
	hm	reserve	—	—
6	PP	ABS/REL	0: ABS	Setting of ABS/Rel for amount of movement of 0x607A: Acknowledged when starting up.
	CSP	ABS/REL	1: ABS	Setting of ABS/Rel for amount of movement of 0x607A: Acknowledged when starting up.
	PV	reserve	—	—
	CSV	reserve	—	—
	hm	reserve	—	—
9	-	reserve	—	—

Manufacturer Specific

Reserved	Push	Eclr	Reserved	Reserved	Operation mode pacific	Halt	Fr*	Operation mode pacific	eo*	qs*	ev*	so*
15.14	13	12	11	10	9	8	7	6...4	3	2	1	0

bit12: Encoder clear enable [ECLR]
Clear absolute sensor battery malfunction or multiple rotating positions.
Clear in case state "1" lasted for 112ms.
"0": Encoder clear disable "1": Encoder clear enable

bit13: Operation of travel to fixed stop [Push]
Commands current limit during operation.
"0": Current limit disabled "1": Current limit enabled
Overload error is not detected during "Push = 1."

7.Object Dictionary

4) Status Word

Status Word (Object: 0x6041) provides the status of slave FSA.

Status Word consists of a "Slave FSA Status Bit", "Operation Mode spec. Status Bit", and "Maker Option Status Bit." "FSA State Bit of Slave" allotment of driver common portion and command coding are described below.

Allotment for Bit of Status Word

bit15	bit14	bit13	bit12	bit11	bit10	bit9	bit8
Reserved (Manufacture Specification)		Reserved (Operation Mode Specification)	Target Value Ignored	Internal Limit Active	Target reached	Remote	Reserved (Manufacture Specification)
bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Warning	Switch On Disabled	Quick Stop	Voltage Enabled	Fault	Operation Enabled	Switched On	Ready to Switch on

Each state will be displayed in the status word bit pattern that indicates the current state.

0x6041:Status Word (Intersection)

Index	0x6041	Indicates status of FSA (State Machine) that PDS (Power Device System) is controlled.				Object Code		Variable
Sub-Idx	Description			Data Type		Access	PDO	Initial Value
0x00	Status Word [STSWORD] Bit pattern (Bit 6, 5, 3, 2, 1, 0) of Status Word The composition is as follows.			Unsigned16		RO	Possible	0x0000
				Display Range		0x0000 to 0xFFFF		

MSB

LSB

Manufac- -turer Specific	Operation mode Specific	Target Value Ignored	Internal Limit Active	Target reached	Remote	Manufac- -turer Specific	Warning	Switch on disabled	Quick stop	Voltage Enabled	Fault	Operation enabled	Switch on	Ready to switch on
15, 14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

No.	FSA State	Bit of Status Word					
		bit6	bit5	bit3	bit2	bit1	bit0
[A]	Not ready to Switch on	0	x	0	0	0	0
[B]	Switch on Disabled	1	x	0	0	0	0
[C]	Ready to Switch on	0	1	0	0	0	1
[D]	Switch on	0	1	0	0	1	1
[E]	Operation enabled	0	1	0	1	1	1
[F]	Quick stop active	0	0	0	1	1	1
[G]	Fault reaction active	0	x	1	1	1	1
[H]	Fault	0	x	1	0	0	0

bit4 :Voltage Enabled Means that main circuit power supply is impressed at the time of "1."

bit5 :Quick Stop Shows that it is under operation by Quick Stop Request at the time of "0"

bit7 :Warning

It is set to "1" when warning is occurring in slave. This bit is not cleared even if warning factor is lost.

bit9 :Remote always replied 「1」

bit10:Target reached

It is set to "1" when an operation mode is changed.

It is set to "1" when Quick stop operation is finished and motor stops with Quick stop Option Code; 5 to7

Besides, when Bit10 (Target reached) of status word is "1", Indicates that the motor reached the preset value.

Then cleared to "0" when target position is changed. (Only Profile Position (pp): Reserved)

bit11:Internal Limit Active

When target position is outside of range, and at invalid, soft limit, and forward/backward side limit, it is set to "1".

Setting range is based on specification.

bit12:Target value ignored Inposition(csp),Velocity Attainment(csv)

When Target value ignored bit is in Position (csp), and Velocity (csv) mode, the update of the command becomes permission "0" with command update permission monitor within driver. Other than this (when command is prohibited), is set to "1."

* At SOFF → SON, holding brake operation open time after motor excitation is set up, and it becomes "0"after BOFDY passes.

Bit13 and 8 are based on operation mode specifications, and Bit15 and 14 are maker specifications.

7.Object Dictionary

7.4 Profile Area

0x6000 to 0x67FF	Standardized Device Profile Area (Axis1)
0x6800 to 0x6FFF	Standardized Device Profile Area (Axis2)

The table below shows the following items:

- List of object of CoE (CANopen over EtherCAT) profile area
- Support/ not support PB-EtherCAT
- Data length
- Access (Dir)
- PDO-mapping
- Parameter-enabled period (Mode setting value is referred.)
- "●": immediately enabled ▲: needs ESM-status transition ■: enabled on re-turning on control power supply"
- * Index No listed in the table below are all for axis1. To get Index No for axis2, add 0x0800 to axis1.

Profile Area (No.1)

○ :Support, □:Support (Not changeable: Fixed Value), —:Not supported

Index	S-Idx	PP	PV	CSP1	CSP2	CSV	Hm	Name	Save	Dir	PDO_M	Update
0x6007	0x00	□	□	□	□	□	□	Abort Connection Option Code	—	RW	No	—
0x603F	0x00	○	○	○	○	○	○	Error Code	No	RO	Possible	—
0x6040	0x00	○	○	○	○	○	○	Control Word	—	RW	Possible	●
0x6041	0x00	○	○	○	○	○	○	Status Word	—	RO	Possible	—
0x605A	0x00	○	○	○	○	○	○	Quick Stop Option Code	YES	RW	No	●
0x605B	0x00	□	□	□	□	□	□	Shutdown Option Code	—	RW	No	—
0x605C	0x00	□	□	□	□	□	□	Disable Operation Option Code	—	RW	No	—
0x605D	0x00	○	○	□	□	□	○	Halt Option Code	YES	RW	No	●
0x605E	0x00	□	□	□	□	□	□	Fault Reaction Option Code	—	RW	No	—
0x6060	0x00	○	○	○	○	○	○	Operation Mode	YES	RW	Possible	*1
0x6061	0x00	○	○	○	○	○	○	Operation Display	—	RO	Possible	—
0x6063	0x00	○	○	○	○	○	○	Internal Actual Position (Absolute sensor)	—	RO	Possible	—
0x6064	0x00	○	○	○	○	○	○	Real Position	—	RO	Possible	—
0x6065	0x00	○	×	○	○	×	○	Excessive Position Deviation Value	YES	RW	Possible	●
0x6067	0x00	○		○	○	×	×	Position Window (In-Position)	YES	RW	Possible	●
0x606C	0x00	○	○	○	○	○	○	Real Velocity Value (Velocity Monitor)	—	RO	Possible	—
0x606D	0x00	○	○	○	○	○	○	Velocity Window (Velocity coincidence range)	YES	RW	Possible	●
0x607A	0x00	○	×	○	○	×	×	Target Position (Position Command)	—	RW	Possible	●
0x607B	0x00	—	—	—	—	—	—	Position Range Limit	—	RO	No	—
↑	0x01	○	×	○	○	×	×	Mimi nun Position Limit	YES	RW	Possible	●
↑	0x02	○	×	○	○	×	×	Maximum Position Limit	YES	RW	Possible	●
0x607C	0x00	×	×	×	×	×	○	Coordinates Offset (Homing Offset)	YES	RW	Possible	●
0x607D	0x00	—	—	—	—	—	—	Software Position Limit	—	RO	No	—
↑	0x01	○	○	○	○	○	×	Software Mimi nun Position Limit	YES	RW	Possible	●
↑	0x02	○	○	○	○	○	×	Software Maximum Position Limit	YES	RW	Possible	●
0x607E	0x00	○	○	○	○	○	○	Polarity	YES	RW	No	■
0x607F	0x00	○	×	×	×	×	×	Max. Profile Velocity	YES	RW	Possible	●
0x6081	0x00	○	×	×	×	×	×	Profile Velocity	YES	RW	Possible	●
0x6083	0x00	○	○	×	×	×	×	Profile Acceleration (Accelerating Constant)	YES	RW	Possible	●
0x6084	0x00	○	○	×	×	×	×	Profile Deceleration (Decelerating Constant)	YES	RW	Possible	●
0x6085	0x00	○	○	○	○	○	○	Quick Stop Deceleration	YES	RW	Possible	●

*1 This is prohibition of a setup during operation.

7.Object Dictionary

Index	S-Idx	PP	PV	CSP1	CSP2	CSV	Hm	Name	Save	Dir	PDO_M	Update
0x6098	0x00	x	x	x	x	x	o	Homing Method	YES	RW	Possible	●
0x6099	0x00	—	—	—	—	—	—	Homing Speed	—	RO	No	—
↑	0x01	x	x	x	x	x	o	Speed during search for switch	YES	RW	Possible	●
↑	0x02	x	x	x	x	x	o	Speed during search for Zero	YES	RW	Possible	●
0x609A	0x00	x	x	x	x	x	o	Homing Acceleration	YES	RW	Possible	●
0x60B8	0x00	o	o	o	o	o	o	Touch probe mode	No	RW	Possible	●
0x60B9	0x00	o	o	o	o	o	o	Touch probe state	—	RO	Possible	●
0x60BA	0x00	o	o	o	o	o	o	Touch probe1 positive edge position stored	—	RO	Possible	●
0x60BB	0x00	o	o	o	o	o	o	Touch probe1 negative edge position stored	—	RO	Possible	●
0x60E3	0x00	—	—	—	—	—	—	Support Homing Method	—	RO	No	—
↑	0x01	x	x	x	x	x	o	Support Homing Method 1	—	RO	No	—
↑	0x02	x	x	x	x	x	o	Support Homing Method 2	—	RO	No	—
↑	0x03	x	x	x	x	x	o	Support Homing Method 3	—	RO	No	—
↑	0x04	x	x	x	x	x	o	Support Homing Method 4	—	RO	No	—
↑	0x05	x	x	x	x	x	o	Support Homing Method 5	—	RO	No	—
↑	0x06	x	x	x	x	x	o	Support Homing Method 6	—	RO	No	—
↑	0x07	x	x	x	x	x	o	Support Homing Method 7	—	RO	No	—
↑	0x08	x	x	x	x	x	o	Support Homing Method 8	—	RO	No	—
↑	0x09	x	x	x	x	x	o	Support Homing Method 9	—	RO	No	—
↑	0x0A	x	x	x	x	x	o	Support Homing Method 10	—	RO	No	—
↑	0x0B	x	x	x	x	x	o	Support Homing Method 11	—	RO	No	—
0x60E6	0x00	x	x	x	x	x	o	Actual position calculation method	YES	RW	No	●
0x60F4	0x00	x	x	o	o	x	x	Actual Position Deviation (Following Error Actual Value)	—	RO	Possible	—
0x60FD	0x00	o	o	o	o	o	o	Digital Input	—	RO	Possible	—
0x60FE	0x00	—	—	—	—	—	—	Digital Output	—	RO	No	—
↑	0x01	o	o	o	o	o	o	Digital Output	—	RW	Possible	●
0x60FF	0x00	x	o	x	x	o	x	Target Velocity (Velocity Command)	—	RW	Possible	●
0x6502	0x00	o	o	o	o	o	o	Support Drive Mode	—	RO	Possible	—
0x67FF	0x00	o	o	o	o	o	o	Axis1Device type	—	RO	No	—

7.Object Dictionary

1) Error Code and Error Operation

0x6007: Abort Connection Option Code

0x6007: Abort Connection Option Code							
Index	0x6007	When main circuit power supply turns off, sets up which operation is performed.			Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	2: Disable Voltage (Transits to state "Switch On Disable," and the state is in "Gate OFF.")			Integer16	RW	No	0x0002
				Setting Range	0x0002		

0x603F: Error code

Index	0x603F	Displays codes of errors occurred in the Driver.			Object Code	Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	For the list of error codes, please refer to the list of alarm codes in chapter 10.		Unsigned16	RO	Possible	—
			Setting Range	0x0000 to 0xFFFF		
✓ This error code is not saved as an alarm in alarm history. Codes defined with 0x4101 are saved as alarms.						

0x605A: Quick Stop Option Code (EMR)

0x0000: Quick Stop Option Code (EMR)								
Index	0x605A	When quick stop (EMR) command is input, it is set up by which action motor is stopped.			Object Code		Variable	
Sub-Idx	Description				Data Type	Access	PDO	Initial Value
0x00	0: Switch on Disabled after stop at No-Excitation 1: Switch on Disabled after stop at slowdown deceleration (0x6084) 2: Switch on Disabled after stop at quick stop deceleration (0x6085) 3 :Switch on Disabled after stop at velocity command=0 5: Quick Stop Active after stop at slowdown deceleration (0x6084) 6: Quick Stop Active after stop at quick stop deceleration (0x6085) 7: Quick Stop Active after stop at velocity command=0				Integer16	RW	No	0x0002
					Setting Range	0x0000 to 0x0007		
✓ Current during slow-down in the state of “Quick Stop Active” follows the current limit during drive(0x4009-0x02) , current after motor stopped follows the current limit at stop in “SON” state(0x4009-0x01) .								
✓ When operating at cycle synchronous position, and in velocity mode, setting the value at 1, 2, 5, or 6 stops with velocity-command zero.								

0x605B: Shutdown Option Code

0x605B: Shutdown Option Code							
Index	0x605B	This code is to specify motor operation when operation transits from Operation Enabled to Ready to Switch On state.			Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	0: Stop at No-Excitation			Integer16	RW	No	0x0000
				Setting Range	0x0000 to 0x0000		

0x605C: Disable Operation Option Code

0x0000: Disable Operation Option Code							
Index	0x605C	This code is to specify motor operation when operation transits from Operation Enabled to Switched On state.			Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	0: Stop at No-Excitation			Integer16	RW	No	0x0000
				Setting Range	0x0000		
✓ The excitation current follows the set value of Power Limit after motor stopped.							

7.Object Dictionary

0x605D: Halt option code

0x000D: Halt option code

Index	0x605D	This object shall indicate what action is performed when the Halt function is executed.	Object Code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	1: Operation enable after stop at slowdown deceleration (0x6084)		Integer16	RW	NO	0x0001
	2: Operation enable after stop at quick stop deceleration (0x6085)		Setting Range	0x0001 to 0x0003		
3: Operation enable after stop at velocity command=0						
✓ Operation commands are not receivable in “Halt=1” state. ✓ Operation commands are receivable in “Halt=0, motor stopped” state. ✓ Current during slow-down in the state of “Halt=1” follows the current limit during drive to operate (0x4009-0x02) , current after motor stopped follows the current limit at stop in “SON” state (0x4009-0x01) . ✓ When operating at cycle synchronous position, and in velocity mode, motor stops with velocity-command zero, regardless of this setting.						

0x605E: Fault Reaction Option Code

Index	0x605E	When alarm is generated with driver, determined how it operates.		Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	0: Fault state after stop at no-excitation		Integer16	RW	NO	0x0000
			Setting Range	0x0000 to 0x0000		

7.Object Dictionary

2) Operation Mode

EtherCAT-CoE specification has modes of operation shown in operation mode list.
 Profiles applicable to Model No.PB EtherCAT-CoE slave amplifier are listed in the following Operation Mode List.
 Besides, operation mode supported can check at "Supported Drive Mode: x6502."
 In cycle synchronous position mode, two control methods, PI control method (csp1) and command synchronous control (csp2) are selectable.

- CSP1 This is effective operation mode when operating with travel to fixed stop or maximum torque utilization. Position deviation occurs. When using it at the speed less than 6min^{-1} , use by CSP2 is recommended.
- CSP2 This is effective operation mode to ensure command synchronous. Operation of travel to fixed stop is not available.

Operation Mode List

Operation Mode	Mark	Supported
Profile Position Mode	pp	Yes
Profile Velocity Mode	pv	Yes
Homing Mode	hm	Yes
Interpolated Position Mode	ip	No
Torque (force) Mode	tq	No
Velocity Mode (ex. Inverter)	vl	No
Cycle Sync. Position Mode	Csp1/2	Yes
Cycle Sync. Velocity Mode	csv	Yes
Cycle Sync. Torque (force) Mode	cst	No

Shift of an operation mode uses the object "operation mode: 0x6060."

Also, the object "operation mode display: x6061" is used for the present operation mode check.

At each operation mode, the bit assigned to Control Word and Status Word is prepared.

Unique Mode Bit Assigned to Control Word

Operation Mode	bit8	bit6	bit5	bit4
pp Profile Position Mode	Halt	abs /rel	Change set immediately	New setpoint
csp Cycle Sync. Position Mode			Reserved	Reserved
csv Cycle Sync. Velocity Mode		Reserved	Reserved	Reserved
pv Profile Velocity Mode		Reserved	Reserved	Reserved
hm Homing Mode		Reserved	Reserved	Homing Enable

Manufacturer own Bit Assigned to Status Word

Operation Mode	bit13	bit12	bit10
pp Profile Position Mode	Following error	Set-point Acknowledge	Target reached Quick Stop Finished Operation Change Finished Halt Active
csp Cycle Sync. Position Mode	Following error	Target Position ignore	
csv Cycle Sync. Velocity Mode	Reserved	Target velocity ignore	
pv Profile Velocity Mode	Reserved	Target velocity ignore	
hm Homing Mode	Homing error	Homing attained	

7.Object Dictionary

3) Function Group "Position" Mode

■Abstract of Function Group "Position" Mode

As for function group "Position" operation mode, "Profile position Mode" and "Cyclic Synchronous Position Mode" are supported.

0x6060: Operate "Profile Position Mode" by setting "1" in operation mode, "Cyclic Synchronous Position Mode1" by setting "8", and "Cyclic Synchronous Position Mode2" by setting "-1".

Here is the main object list for the function group "Profile Position Mode"

List of Position Mode Object (Manufacturer Specific Profile Area)

Index	Sub-Index	Name	PDO Mapping	0x6060 Mode
0x4001	0x00	Position command smoothing time constant	Possible	csp1/2
0x4002	0x00	Position Loop Proportional Gain	Possible	csp1/2
0x4004	0x00	Feed Forward Gain	Possible	csp1/2
0x4006	0x00	Velocity feedback LPF	Possible	csp1/2, pp
0x4007	0x00	Velocity Loop Proportional Gain	Possible	csp1/2, pp
0x4008	0x00	Velocity Loop Integral Time Constant	Possible	csp1/2, pp
0x4009	0x00 to 0x04	Current limit	Possible	csp1/2, pp
0x400A	0x00	Velocity Loop Proportional Gain for csp2	Possible	csp2
0x4022	0x00	Two-axis synchronous operation allowed/prohibited	Possible	pp

List of Position Mode Object (Standardized Device Profile Area)

Index	Sub-Index	Name	PDO Mapping	0x6060 Mode
0x6040	0x00	Control Word	Possible	csp1/2, pp
0x6041	0x00	Status Word	Possible	csp1/2, pp
0x605A	0x00	Quick stop option code	No	csp1/2, pp
0x6063	0x00	Position actual value *(Internal)	Possible	csp, pp
0x6064	0x00	Position actual value	Possible	csp, pp
0x6065	0x00	Following error window	No	csp, pp
0x6067	0x00	Position window	No	csp, pp
0x606C	0x00	Velocity Actual Value	Possible	csp, pp
0x607A	0x00	Target Position	Possible	csp, pp
0x607B	0x00 to 0x02	Position range Limit	No	pp
0x607C	0x00	Home offset	Possible	csp, pp
0x607D	0x00 to 0x02	Software Position Limit	No	csp, pp
0x607E	0x00	Polarity	No	csp, pp
0x607F	0x00	Max Profile Velocity	No	pp
0x6081	0x00	Profile Velocity	Possible	pp
0x6083	0x00	Profile Acceleration	Possible	pp csp*)
0x6084	0x00	Profile Deceleration	Possible	pp csp*)
0x60F4	0x00	Following error actual value	Possible	csp, pp

7.Object Dictionary

4) Profile Position Mode

0x6060: When Operation Mode is set "1", "Profile Position Mode" shall be operated.

The master sends "Target Position (0x607A)", "Profile Velocity (0x6081)", "Profile Acceleration and Deceleration (0x6083, 0x6084).

The slave (Drive device) executes trajectory generation and reaches to the target position by setting Bit4=1:New setpoint of Control word 0x6040.

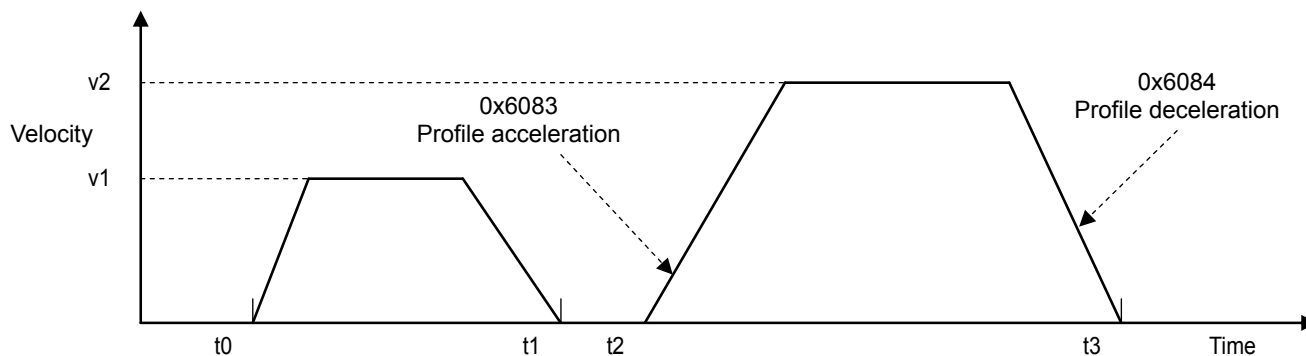
The slave (Drive device) executes all of Position Control, Velocity control, and current control.

Two different ways to apply target positions to a drive are supported by this device profile.

1 Set of set points: (when starting up with 0x6040: control word bit5: Change set immediately= 1)

After reaching the target position the drive unit immediately processes the next target position, which results in a move where the velocity of the drive normally is not reduced to zero after achieving a set point.

The drive receives the first target position at t_0 . At the time point t_1 the drive receives a second target position. The drive readapts the actual move to the new target position immediately.



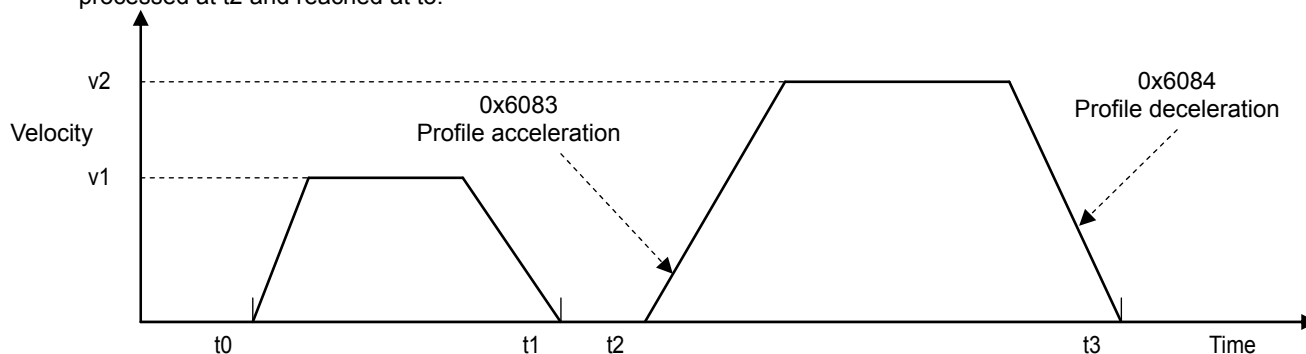
Profile Position Mode (Change set immediately)

2. Single set point (when starting up with 0x6040: control word bit5: Change set immediately=0)

After reaching the target position the drive unit signals this status to the master and then receives a new set point. After reaching a target position the velocity normally is reduced to zero before starting a move to the next set point.

*If controller inputs a new command into driver during motor operation, the motor re-starts up after the current operation is completed. (The start-up is suspended until the current operation is completed.)

This mechanism results in a velocity of zero after ramping down in order to reach a target position x_1 at t_1 . After signaling to the host, that the set point is reached like described above, the next target position x_2 is processed at t_2 and reached at t_3 .



Profile Position mode (Single set point)

Note2) When axis-synchronous operation is allowed (0x4022=1), axis2 simultaneously starts up by start-up command for axis1.

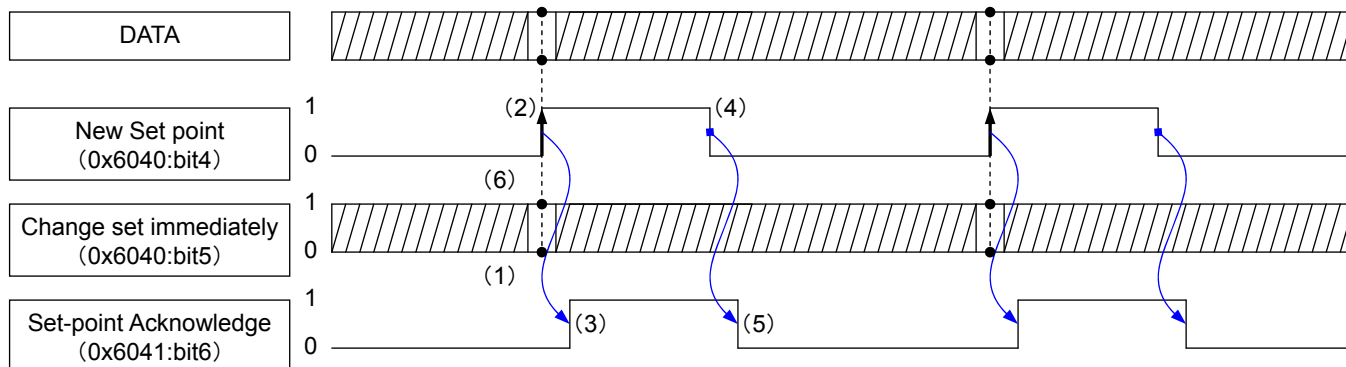
In this case, operation profile of axis2 (acceleration and deceleration, velocity, and target position) is automatically overwritten with the values of operation profile of axis1. Two-axis synchronous operation becomes effective after origin return operation completed.

* Synchronous operation is valid only in profile position mode. This operation does not work in cycle synchronous position mode.

7.Object Dictionary

The timing of the bits 'new set-point' and 'change set immediately' in the Control Word and 'set-point acknowledge' in the Status Word controls the two modes. These bits allow to set up a request response mechanism in order to prepare a set of set-points while another set still is processed in the drive unit.

This minimizes reaction times within a control program on the master.



Sequence Diagram for Profile Position Mode

0x6040:Control Word (Profile Position Mode: pp)

Index		0x6040	This object shall indicate Operation Mode Specific bit and Manufacturer specific bit of Profile Position Mode (pp).		Object Code		Variable		
Sub-Idx		Description			Data Type		Access	PDO	Initial value
0x00		Control Word [CWORD] * See the Command table for "Control word bit pattern (Bit 7, 3, 2,1, 0.)"			Unsigned16 Range		RW	Possible	0x0000 0x0000-0xFFFF

MSB

LSB

15...14	13	12	11...9	8	7	6	5	4	3	2	1	0
-	Push	Eclr	-	Halt	Fr*	Abs / Rel	Change set immediately	New Set point	eo*	qs*	ev*	so*

bit4: New setpoint [New setpoint]

0: Does not assume target position

1: Assume target position

bit5: Change set immediately [Change set immediately]

Used for changing the target position during operation.

If this bit is set to 1, and bit 4 is changed "Zero" to "One" again, the trajectory generation to the new set point shall be processed immediately. All previously loaded set points shall be discarded.

bit6: ABS/REL [ABS/REL]

0: Target position (0x607A) is an absolute value

1: Target position (0x607A) is a relative value

bit8: HALT [HALT]

1: Stop axle with halt option code (0x605D)

Bit13: Push [Push]

1: Overload stop error is not detected as mechanical end current limit becomes valid. Operation of travel to fixed stop becomes valid at the time when this is acknowledged during operation.

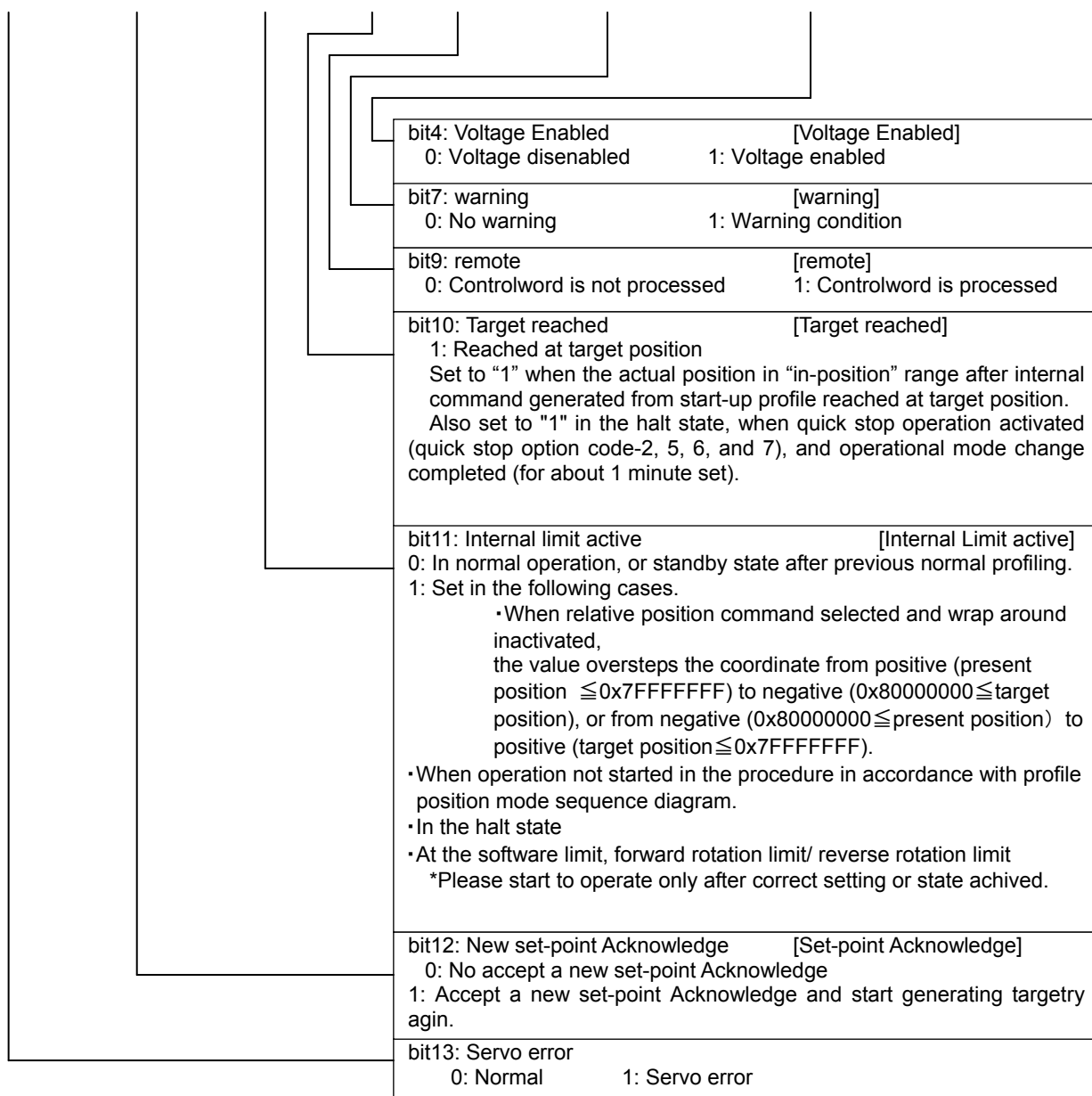
Provided that when the work has reached the target position when Push is set to "1," a failure alarm is detected.

7.Object Dictionary

0x6041:Status Word (Profile Position Mode: pp)

Index		0x6041	This object indicates Operation Mode Specific bit and Manufacturer Specific bit of the Profile Position mode (pp).		Object code		Variable	
Sub-Idx		Discription		Data Type	Access	PDO	Initial value	
0x00		Status Word [STSWORD] * See the Pattern Status table for“Status word bit pattern (Bit 6,5, 3,2,1,0.)		Unsigned16	RO	Possible	0x0000	
				Range	0x0000-0xFFFF			

MSB																LSB
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
—	—	se*	Set-point Acknowledge	Internal Limit active	Tr	Rm	Res	W	Sod*	Qs [□]	Ve	F*	Oe*	So*	Rtso*	



7.Object Dictionary

5) Cycle Synchronization Position Mode

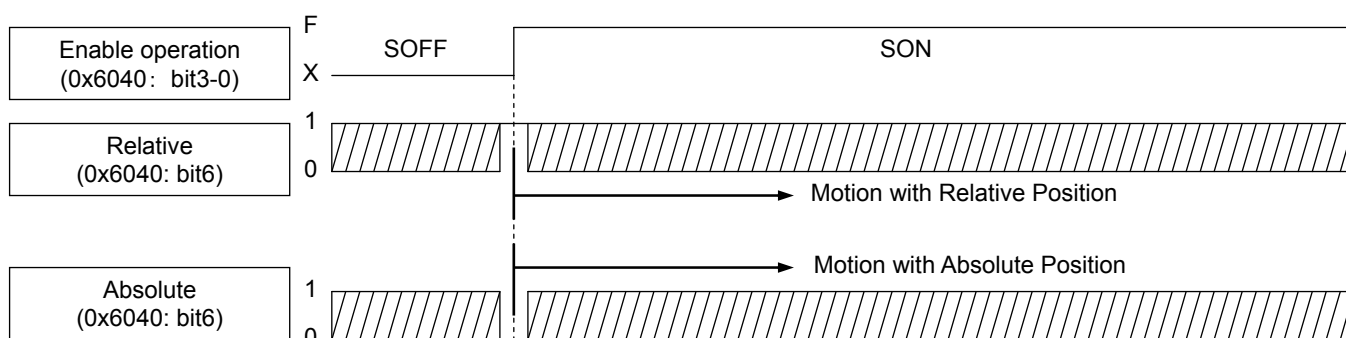
When operating in "0x6060: operation mode 8" driver operates in cycle synchronous position mode 1 (csp1).
When operating in "0x6060: operation mode -1," driver operates cycle synchronous position mode 2 (csp2).

Outline of control methods are show below. Select from the followings according to your individual needs.

Item	csp1	csp2
Outline of control method	Propotional/ integral control	Vector control with current control
Motor excitation current (Heat generation)	The amount of heat generation can be reduced as the required current is supplied in accordance with operation conditions.	The amount of heat generation tends to increase over proportion/ integration due to combination operation of rated current operation and current control.
Position deviation	Position deviation occurs. Position deviation can be reduced by feedforward parameter.	Command following performance has an advantage over proportional/ integral control.
Operation of travel to fixed stop	Enabled	Diabled

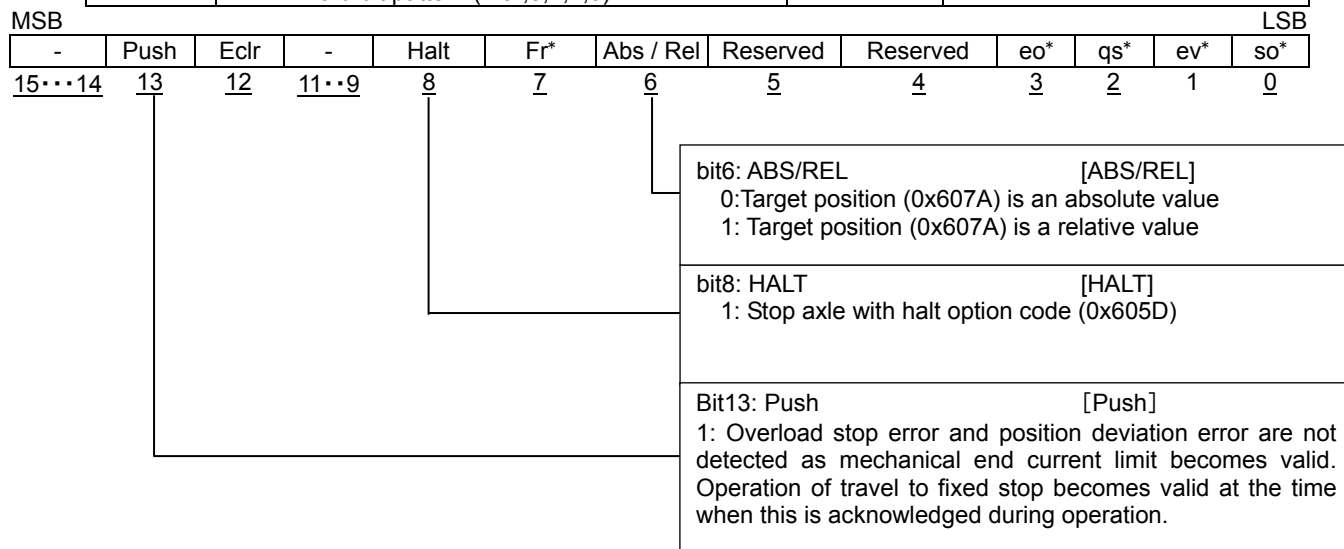
In "Cycle Synchronization Position control system", the master (Control Device) generate trajectory and transmit the Target position continuously to the slave to make control Position and Velocity.

A command type - Absolute/Relative position - is selectable by 0x6040: Bit 6. (Bit 6 = 0: Absolute position, Bit 6 = 1: Relative position). However, when the master sets Operation enabled state (Bit 0 to 3 = 0x0F), it shall be defined after the amplifier refers it.



0x6040: Control Word (Cyclic Sync. Position Mode: csp)

Index		0x6040	This object indicates Operation Mode Specific bit and Manufacturer Specific bit under the Cyclic Sync. Position mode (csp).		Object code		Variable	
Sub-Idx		Description		Data Type	Access	PDO	Initial value	
0x00		Control Word [CWORD]		Unsigned16	RW	Possible	0x0000	
		* See the Pattern command table for “Control word bit pattern (Bit7,3,2,1,0)”		Range	0x0000-0xFFFF			



7.Object Dictionary

0x6041:Status Word (Cyclic Sync. Position Mode: csp)

Index		0x6041	This object indicates Operation Mode Specific bit and Manufacturer Specific bit under Cyclic Sync. Position Mode (csp).		Object code		Variable	
Sub-Idx		Description		Data Type	Access	PDO	Initial value	
0x00		Status Word [STSWORD] *See the Pattern status table for "Status word bit" (Bit6,5, 3,2,1,0)		Unsigned16	RO	Possible	0x0000	
				Range	0x0000-0xFFFF			

MSB

—	—	Fe	Target Value Ignored	Internal Limit active	Tr	Rm	Res	W	Sod*	Qs*	Ve	F*	Oe*	So*	Rtso*
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

LSB

bit4: Voltage Enabled	[Voltage Enabled]
0: Voltage disenabled	1: Voltage enabled
error	
bit1: Within velocity Window	0= Outside velocity Window
bit9: remote	[remote]
0: controlword is not processed	1: controlword is processed
bit9: remote	[remote]
0: controlword is not processed	1: controlword is processed
bit4: Voltage Enabled	[Voltage Enabled]
0: Voltage disenabled	1: Voltage enabled
bit11: Internal Limit active	[Internal Limit active]
0: Target position ignored.	
1: Target position to be used as position control loop input.	
bit13: Following error	[Following error]
0: No following error	1: Following
bit11: Internal Limit active	[Internal Limit active]
0: Target position ignored.	
1: Target position to be used as position control loop input.	
bit12: Target value ignored	[Target value ignored]
(Command acceptance prohibition)	
0: Target position shall be used as input to position control loop.	
1: Target position ignored.	
bit13: Following error	[Following error]
0: No following error	1: Following error

7.Object Dictionary

6) Function Group "Velocity", "Homing mode"

■ Abstract of Function Group "Velocity", "Homing mode"

In Function Group "Velocity" the operation mode, "Profile Velocity mode" and "Cyclic Synchronous Velocity Mode" shall be supported.

0x6060: When the bit is set "3" in Operation Mode it is operated profile Velocity Mode, and when the bit is set "9", it is operated by Cyclic Synchronous Velocity Mode.

And also, when the bit is "6" in Homing mode, the slave performs Returning to the origin position in Velocity mode. The below indicates the main objects list in Function Group "Velocity" and "Homing" mode.

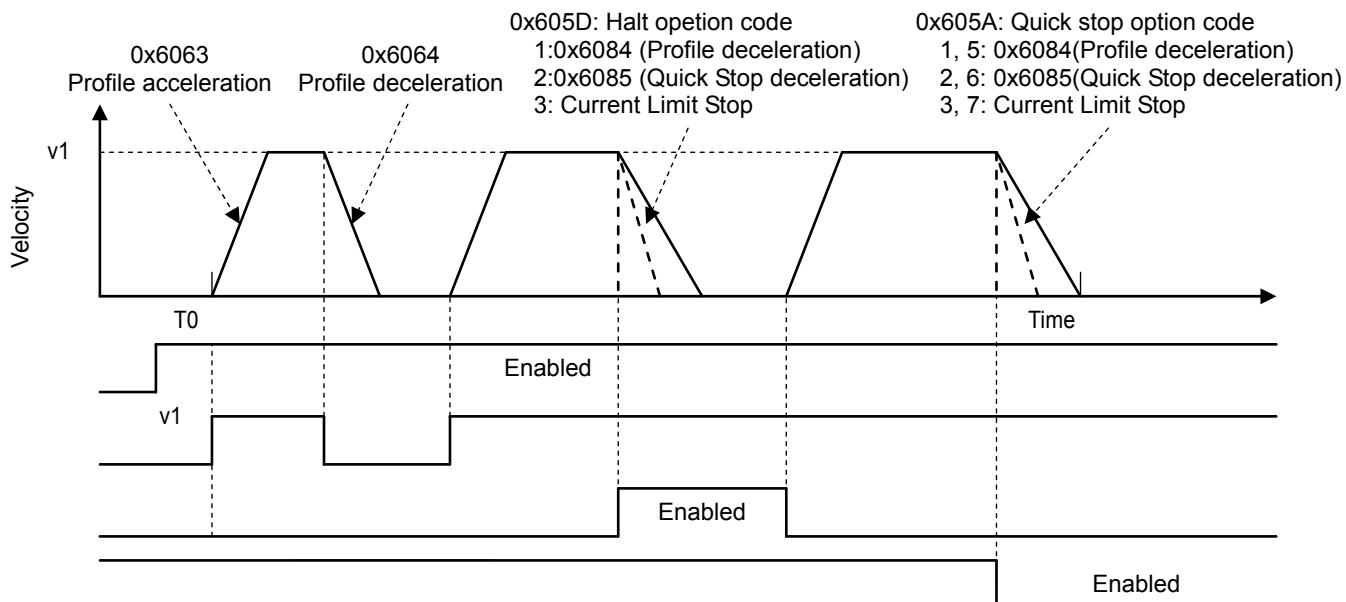
List of velocity Mode Object

Index	Sub-Index	Name	PDO Mapping	0x6060 Mode
0x4006	0x00	Velocity feedback LPF	Possible	csv, pv, hm
0x4007	0x00	Velocity Loop Proportional Gain	Possible	csv, pv, hm
0x4008	0x00	Velocity Loop Integral Time Constant	Possible	csv, pv, hm
0x4009	0x00 to 0x04	Current limit	Possible	csv, pv, hm
0x6040	0x00	Controlword	Possible	csv, pv, hm
0x6041	0x00	Statusword	Possible	csv, pv, hm
0x605A	0x00	Quick stop option code	No	csv, pv, hm
0x6063	0x00	Position actual internal value	Possible	csv, pv, hm
0x6064	0x00	Position actual value	Possible	csv, pv, hm
0x606C	0x00	Velocity actual value	Possible	csv, pv, hm
0x607C	0x00	Home offset	Possible	csv, pv, hm
0x607E	0x00	Polarity	No	csv, pv, hm
0x6083	0x00	Profile acceleration	Possible	pv(csv, hm*)
0x6084	0x00	Profile deceleration	Possible	pv(csv, hm*)
0x6098	0x00	Homing method	No	hm
0x6099	0x01 to 0x02	Homing Speed	Possible	hm
0x609A	0x00	Homing acceleration	No	hm
0x60FF	0x00	Target velocity	Possible	csv, pv, hm

7.Object Dictionary

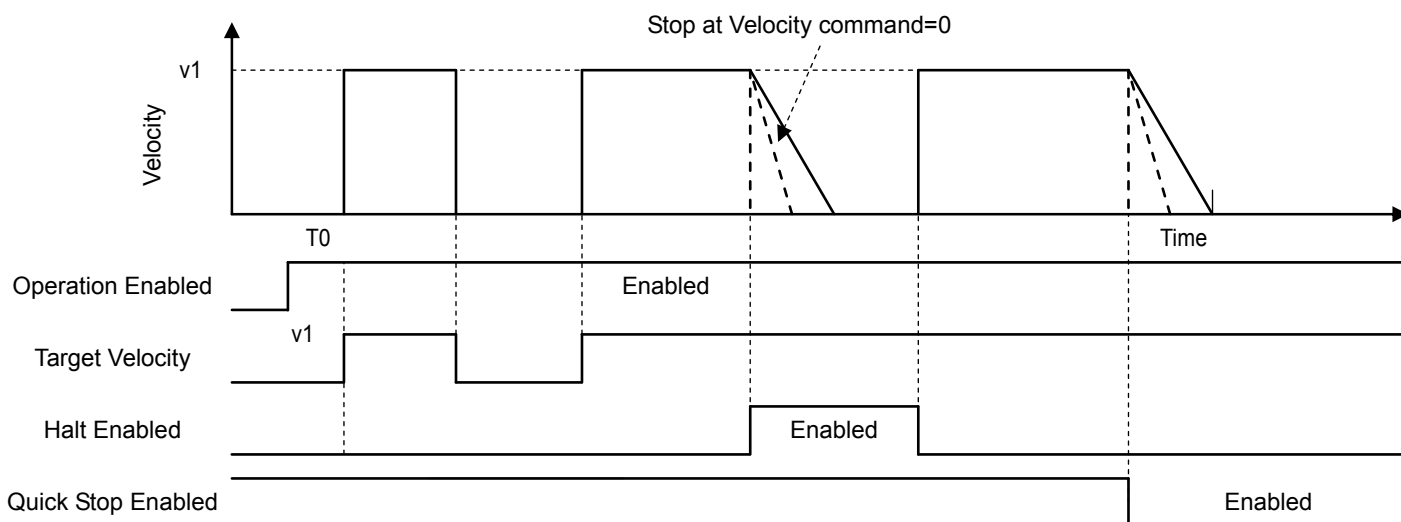
7) Profile Velocity Mode

In this Profile torque mode, the master (Control Device) generates trajectory and transmits 0x60FF: Target velocity to the slave to make control velocity by Cyclic mode or Non-Cyclic mode. Target velocity is given inclination by setting "0x6083: profile acceleration" and "0x6084: profile deceleration."



8) Cyclic Synchronous Velocity Mode

In this Cyclic Synchronous Velocity Mode, the master (Control Device) generates trajectory and transmits Target velocity (0x60FF) to the slave to make control velocity and torque (force) by Cyclic mode. When the Profile acceleration and deceleration 0x60083, 0x6084 are used, they function only for Halt and Quick stop operations.



7.Object Dictionary

0x6040: Control Word (Cyclic Sync. Velocity Mode: csv, Profile Velocity Mode: pv)

Index	0x6040	This object shall indicate the operation mode specific and manufacturer specific bit in Cyclic Sync-position mode (csv), Profile velocity mode (pv)	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Control word	[CWORD]	Unsigned16	RW	Possible	0x0000
	* See the bit patter command list for the detail on Bit 7, 3, 2, 1, 0		Range	0x0000-0xFFFF		

MSB															LSB
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	—	Push	Eclr	—	Halt	Fr*	Reserved	Reserved	Reserved	Reserved	Eo*	qs*	ev*	so*	

bit8: HALT 1: Stop axle with halt option code (0x605D)	[HALT]
Bit13: Push 1: Overload stop error is not detected as mechanical end current limit becomes valid. Operation of travel to fixed stop becomes valid at the time when this is acknowledged during operation.	[Push]

0x6041: Status Word (Cyclic Sync. Velocity Mode: csv, Profile Velocity Mode: pv)

Index		0x6041	This object indicates Operation mode specific bits and Manufacturere specific bits in Cyclic Shunc. Mode (csv) and Profile velocity (pv) mode.			Object code	Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial value
0x00	Status Word [STSWORD] * See the Status word bit patterns status lists for the details on Bit 6, 5, 3, 2, 1, 0			Unsigned16 Range	RO	Possible	0x0000
					0x0000-0xFFFF		

MSB															LSB
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
—	—	—	Target Value Ignored	Internal Limit active	Tr	Rm	Res	W	Sod*	Qs*	Ve	F*	Oe*	So*	Rtso*

t4: Voltage Enabled 0: voltage disenabled 1: voltage enabled	[Voltage Enabled]
bit7: warning 0: No warning 1: warning condition	[warning]
bit9: remote 0: Controlword is not processed 1: Controlword is processed	[remote]
bit10: Target velocity reached 1: Reached at target velocity Set to "1" when the actual velocity is within constant velocity. Coincident velocity output has two settings, "OD: 0x606D rotational rate setting"	[Target reached]
bit11: Internal Limit active 0: Nomal operation 1: Software Position limit, CW limit/CCW limit	[Internal Limit active]
bit12: Target value ignored (Command acceptance perohibition) 0: Target velocity ignored. 1: Target velocity to be used as position control loop input.	[Target value ignored]

7.Object Dictionary

9) Homing Mode

This clause describes the method by which a drive seeks the home position (also called, the datum, reference point or zero point)

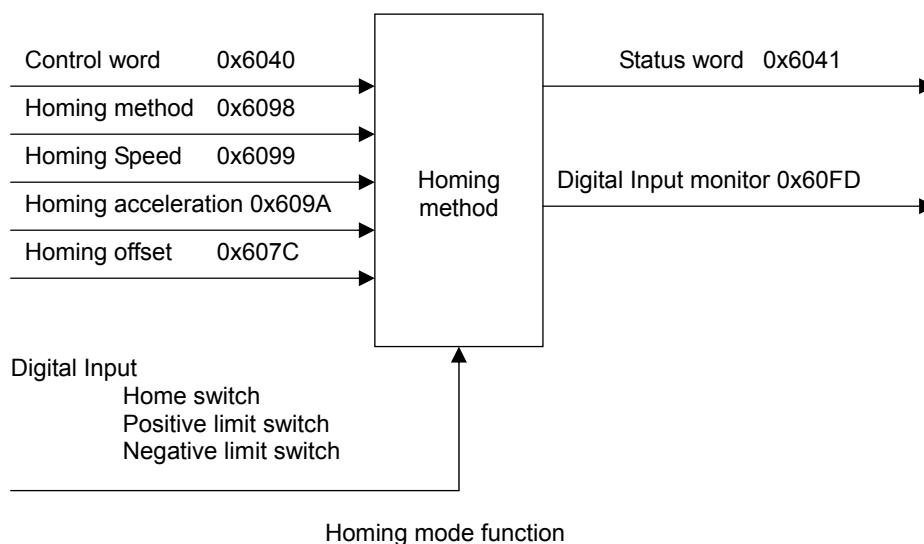
Input objects are defined as well as the output objects. The user may specify the speed, acceleration and the method of homing. There is a further object home offset, which allows the user to displace zero in the user's coordinate system from the home position.

There is no output data except for those bits in the status word, which return the status or result of the homing process and the demand to the position control loops.

There are two homing speeds; the faster speed is used to find the home switch (Sub-Index 1) and slower speed is used to find the index pulse.

Here is the Objects list in the Homing mode.

List of Homing Mode Object			
Index	Sub-Index	Name	PDO Mapping
0x607C	0x00	Home offset	Possible
0x6098	0x00	Homing method	No
0x6099	0x00	Homing speeds	Possible
0x609A	0x00	Homing acceleration	No
0x60E3	0x00	Support Homing Method	No
0x60E6	0x00	Actual position calculation method	No
0x60FD	0x00	Digital Input	Possible



7.Object Dictionary

The following table lists Homing Methods.

Homing Method			
Method	Homing Mode	Stop direction	Operation start direction (When target sensor is inactive.)
-2	Homing on negative Mechanical end	Push END	negative
-1	Homing on positive Mechanical end	Push END	positive
17	Homing on negative limit switch	Positive Edge	negative
18	Homing on positive limit switch	Negative Edge	positive
20	Homing on positive home switch	Negative Edge	positive
22	Homing on negative home switch	Positive Edge	negative
24	Homing on positive limit switch and Homing on positive home switch	Negative Edge	positive
28	Homing on negative limit switch and Homing on positive home switch	Positive Edge	negative
33	Homing on the index pulse	Positive Edge	negative
34	Homing on the index pulse	Negative Edge	positive
35	Homing on the current position	Current position	—

* In the case of the ABS encoder, the homing system is supported only 35.

- This depends on rotational direction definition: 0x607E.
- The logics of home and limit signals are settable with 0x4010.

■ Object: 0x607C Use of the object 0x607C Homing Offset

This is established by the setting for home position coordinate 0x607C: home offset value and 0x60E6: actual position calculation method.

A) Absorute Homing : 0x60E6=0

Actual position(0x6064)= Homing offset (0x607C)

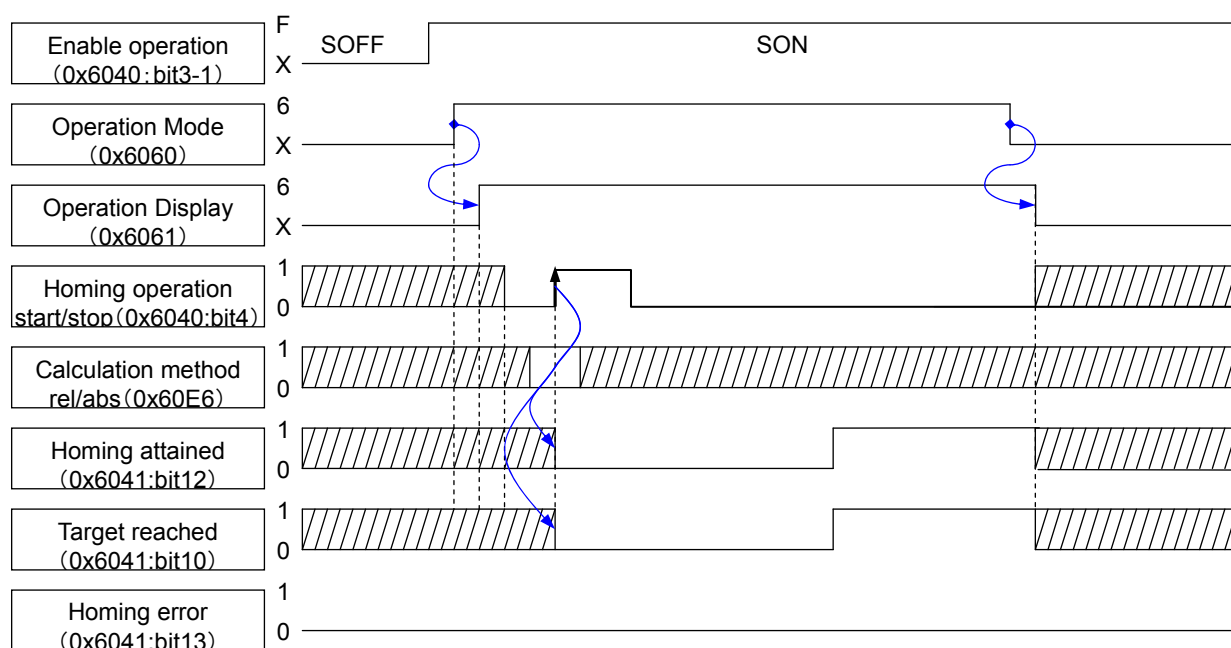
* In the case of a Incremental sensor (PB4D003E2D*), please use only this mode.

B) Relative value homing : 0x60E6=1 (Relative homing)

Actual position (0x6064)= Present position + Homing offset (0x607C)

The following sequence shows homing modes corresponding to the driver.

1) Start and completion sequence of homing mode

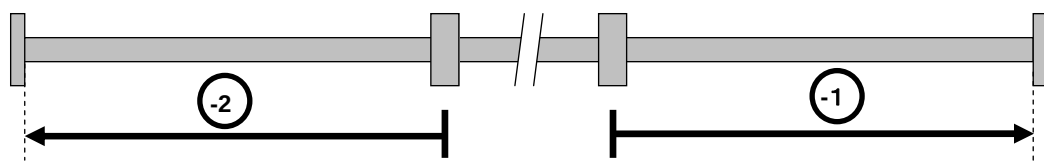


7.Object Dictionary

* Sensor Logic indicated =On Active

- Homing Method[-2]:Homing on negative Mechanical end
- Homing Method[-1]:Homing on positive Mechanical end

Origin of mechanical end becomes "Homming Attained (0x6041-bit12=1)" at the point of the time set with 0x4016 after the current limit at mechanical end set with 0x4009 attained, and then becomes "fixed-excitaion state."

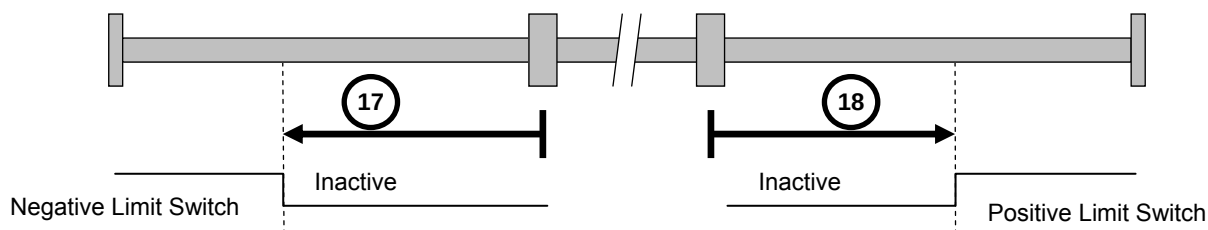


[-2]Homing on negative mechanical end

[-1] Homing on positive mechanical end

- Homing Method[17]:Homing on negative limit switch
- Homing Method[18]:Homing on positive limit switch

When designated limit switch is "Inactive," the moving direction at the time homing is started follows the direction of the sensor subject to be detected. Motor sets the internal counter as the origin at the point motor detected "Active" edge of sensor, and then stops. When limit sensor is already "Active," the rotational direction is reversed, and is re-reversed at the time sensor detects "Inactive state," and then the sensor detects origin position.

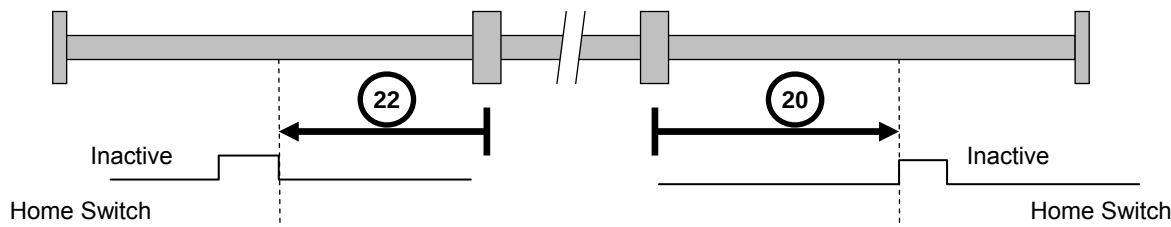


[17]negative limit switch

[18] positive limit switch

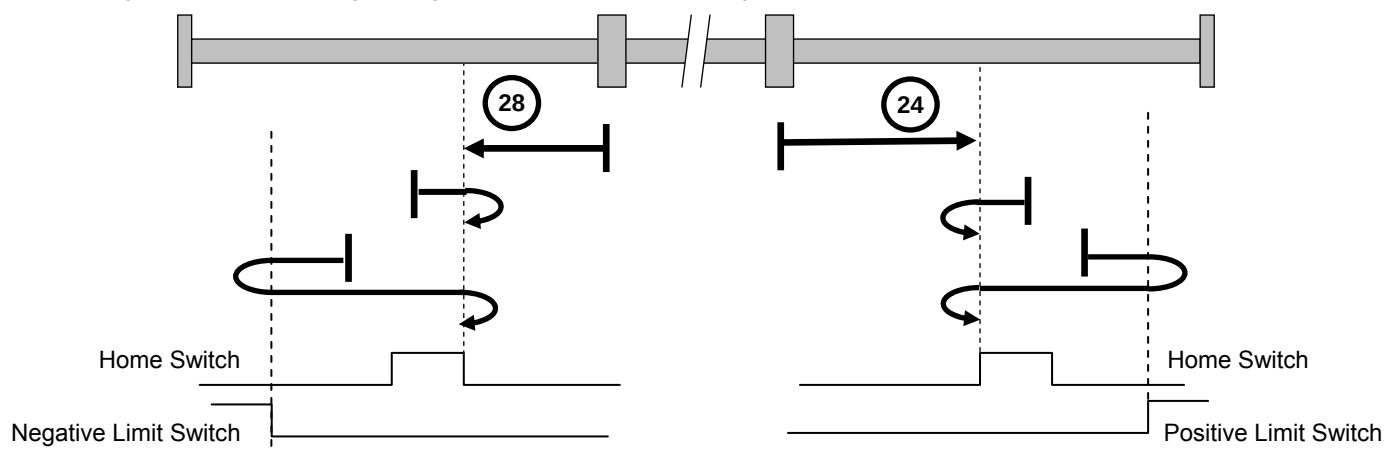
- Homing Method[20]:Homing on positive home switch
- Homing Method[22]:Homing on negative home switch

When Home switch is "Inactive," the moving direction follows the designated direction. Motor sets the internal counter as the origin at the point sendor detects "Active edge," and then stops. When home sensor is already "Active," the rotational direction is reversed, and is re-reversed at the time sensor detects "Inactive state," and then the sensor detects origin position.



7.Object Dictionary

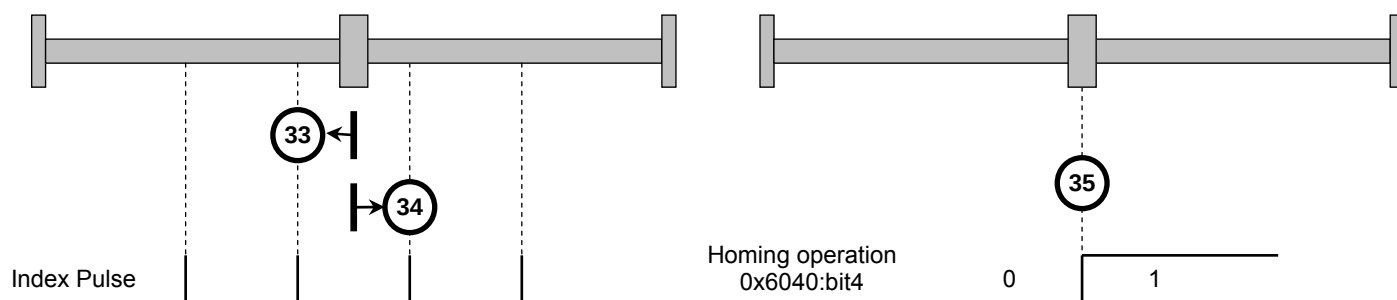
- Homing Method[24]:Homing on positive limit switch and Homing on positive home switch
- Homing Method[28]:Homing on negative limit switch and Homing on positive home switch



- Homing Method[33][34]: Homing on index Pulse
- Homing Method[35]: Homing on current position

Using these methods, the direction of homing is negative (CW) or positive (CCW) respectively. The home position shall be at the nearest index pulse that is found in the selected direction.

In homing method [35], the current position shall be taken to be the home position. This method does not require the drive device to be in operation-enabled state (Servo-ON).



- [33] Homing on negative Index Pulse in CW direction
- [34] Homing on positive Index Pulse in CCW direction

- [35] Homing on Current position

7.Object Dictionary

■ Home position retention function when using absolute system

If using absolute system, execution result of "OD: 0x6098 Homing method 35 (Homing to present position)" can be retained by performing all parameters retention in "OD: 0x1010 Store parameter," and then the origin coordinate shall be retained in "OD: 0x6064: Actual position" even when re-turning on the power next time. In this regard, however if any encoder clear or battery errors occur, correct origin coordinate shall not be presented, so re-homing is required. Absolute system homing "origin coordinate retention procedure" is shown below:

Step ① Preparation of homing

OD: 0x6098 Set homing method to "35 (0x23): Homing to present position."

OD: 0x60E6 Select actual position calculation method (0: Absolute homing
1: Relative position homing)

OD: 0x607C Setting of home offset (When using "0: Absolute homing," set the position you want to set to "detection reference position," when using "1: Relative position homing," set to zero.)

OD: 0x6060 Change operation mode to "6: Homing mode."

Step ② Homing start

OD: 0x6040 Set "Control word, Bit4=1 (0x0010): Homing start."

Step ③ Confirmation of reference position detection

OD: 0x6041 Monitor "Status word, Bit12=1: Homing completed."

When performing "0: Absolute homing," proceed to step 5, when performing "1: Relative homing," proceed to step 4.

Step ④ Setting of home offset

OD: 0x210C Calculate "OD: 0x607C Home offset" value from home index position to set.

Home offset (0x607C) = Origin coordinate after homing completed - Home index (0x210C)

Step ⑤ Homing completion

Exit "OD: 0x6040 Control word, Bit4 = 0 (0x0000): Homing," and then change the control mode back to the one using "OD: 0x6060 Operation mode."

Step ⑥ Storage of origin coordinate

Write "0x65766173" in "Sub-Idx01: All parameters storage" of "OD: 0x1010 Parameter storage."

Step ⑦ Confirmation of storage completion

Storing is completed by turning back to "Sub-Idx01=1" of "OD: 0x1010 Parameter storage."
(0: Now in storing)

- ✓ If you use absolute system, you can not use any homing methods other than Homing method: 35 (0x23).

0x6040:Control Word (Homing Mode: hm)

Index		0x6040		This object indicates the Operation Mode Specific bit and Manufacturer Specific bit in Homing Mode.		Object code		Variable		
Sub-Idx		Description				Data Type		Access	PDO	Sub-Idx
0x00		Control Word [CWORD] *For details on Bit 7,3,2,1 and 0, see the table of Control Word Bit Pattern Command.				Unsigned16 Range		RW	Possible	0x00
						0x0000-0xFFFF				

MSB								LSB				
—	—	Eclr	-	Halt	Fr [□]	Reserved	Reserved	Homing operation start	eo [□]	qs [□]	ev [□]	so [□]
15	14...13	12	11...9	8	7	6	5	4	3	2	1	0

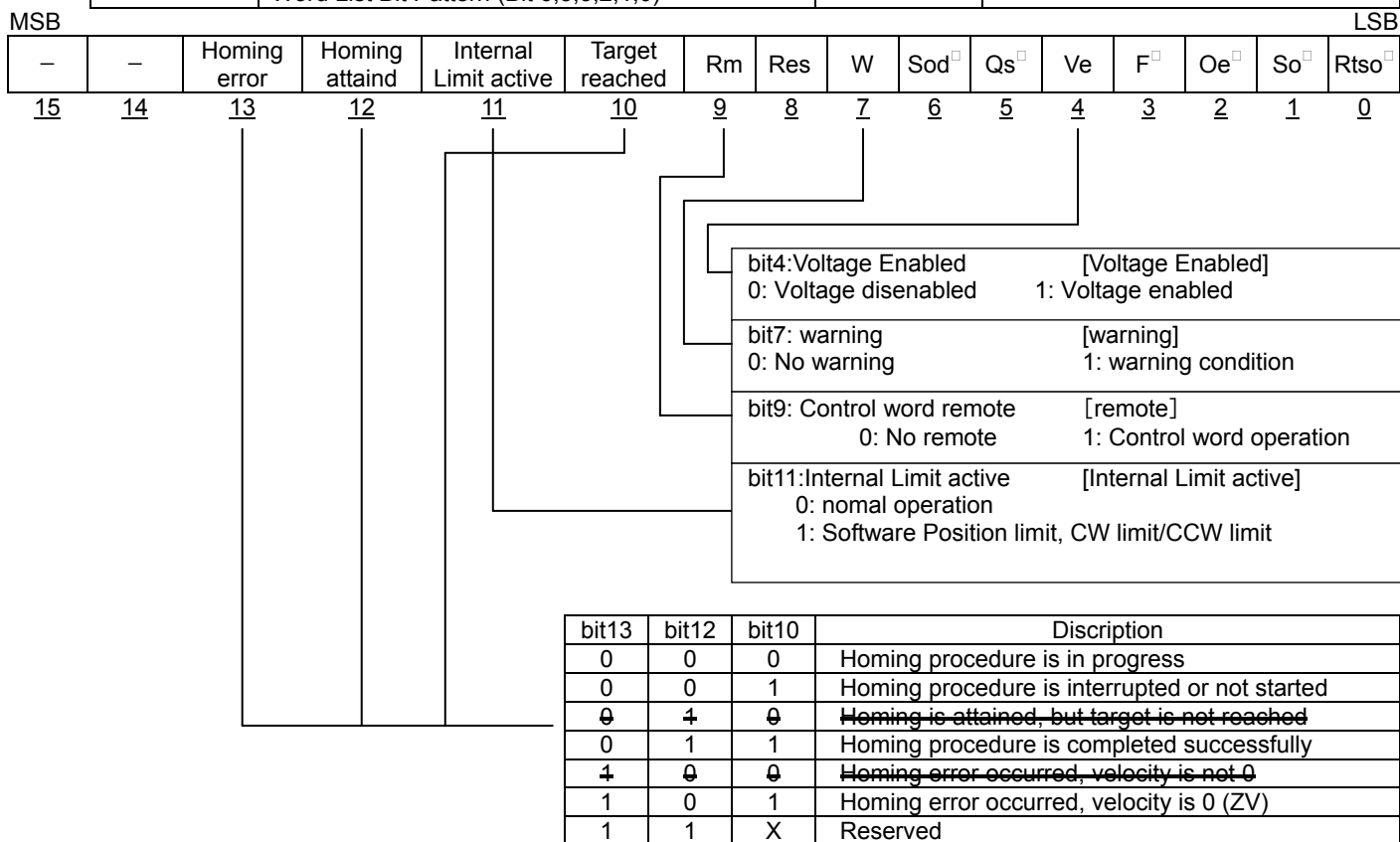
bit4: Homing operation start [Homing operation start]
Start or continue homing procedure

bit8: HALT [HALT]
0: Homing Function enabled (Enable bit4)
1: Motor Stop at ALT Option code (0x605D)

7.Object Dictionary

0x6041:Status Word(Homing Mode: hm)

Index 0x6041		This object indicates Operation Mode Specific bit and Manufacturer Specific bit in Homing Mode.		Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Sub-Idx
0x00	Status Word [STSWORD] *For details on Bit 6, 5, 3, 2, 1 and 0, see the Status Word List Bit Pattern (Bit 6,5,3,2,1,0)		Unsigned16 Range	RO	Possible	0x00
				0x0000-0xFFFF		



7.Object Dictionary

10) Function Group "Touch Probe"

■ Function Group "Touch Probe"

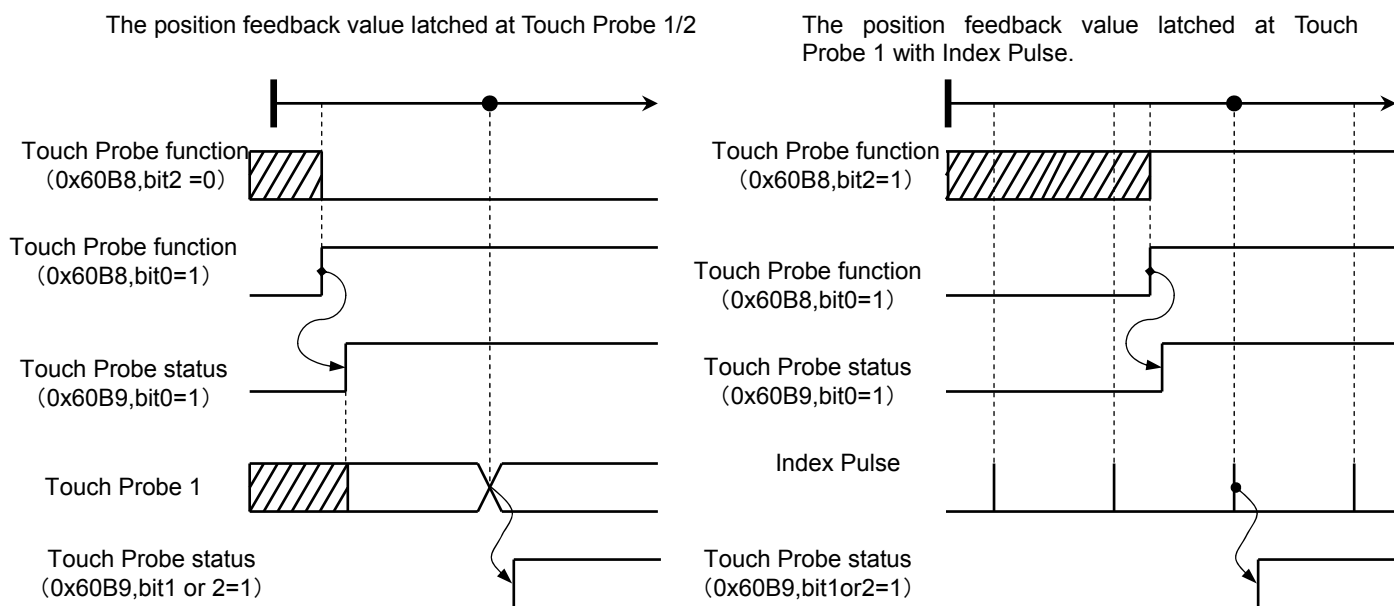
"Touch Probe function" is a latching function to latch the edge-triggered sensor position by digital input. "Touch Probe in the event" is independent from NC cycle time function since it latches the sensor position in the hardware of the slave, therefore, it enables capture it more precisely. This amplifier provides two of channels - Touch Probe 1 (CONT1), for inputting "Touch Probe function". The objects used for "Touch Probe" are indicated in the following list.

Object Lists of Touch Probe			
Index	Sub-Index	Name	PDO Mapping
0x60B8	0x00	Touch Probe Function	Possible
0x60B9	0x00	Touch Probe Status	Possible
0x60BA	0x00	Touch probe pos 1 pos value (positive edge)	Possible
0x60BB	0x00	Touch probe pos 1 neg value (negative edge)	Possible

- Touch probe 1 (CONT1) signal can be triggered with "touch probe 1 input or position sensor index pulse" ^{Note 1} by "0x60B8, bit 2: Trigger selection."

Note1) When setting trigger with position sensor index pulse, if you use incremental sensor Z-phase is used, if you use absolute sensor, "the position that absolute data within single turn is zero" is used as index.

The sequence of Touch Probe Function is indicated as follows.



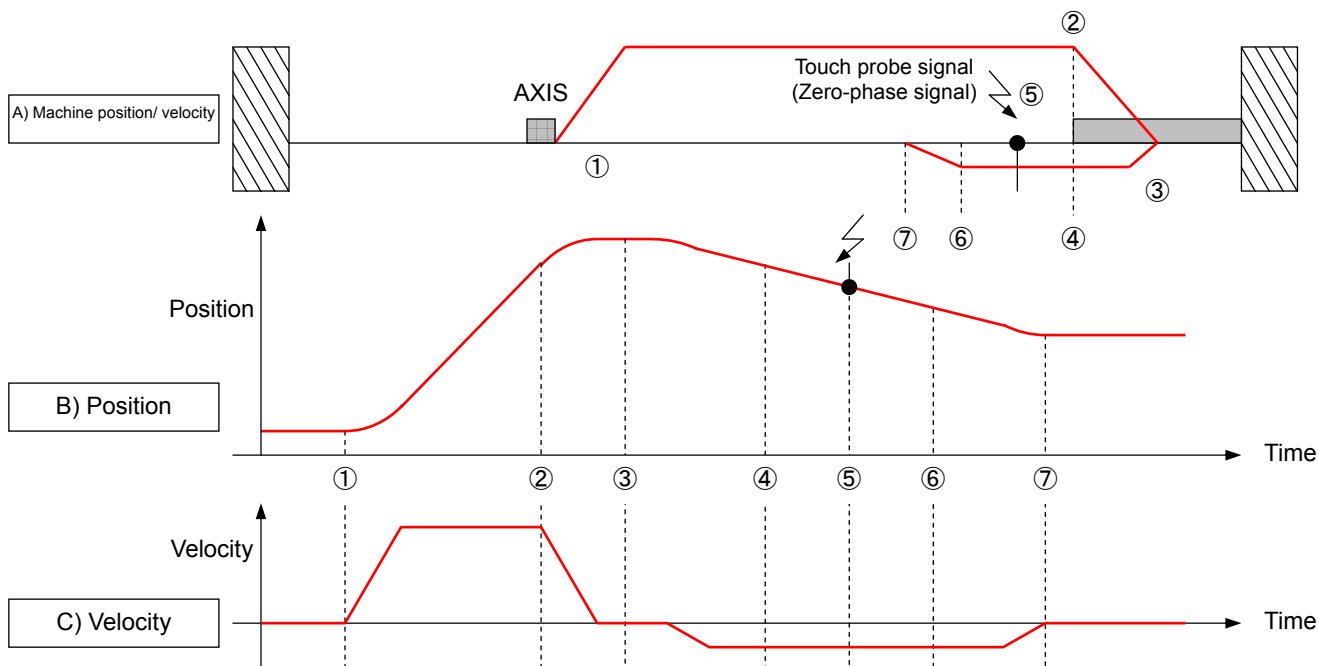
The position value of positive edge latched at Touch Probe 1 (position sensor index pulse) is stored in 0x60BA
The position value of negative edge latched at Touch Probe 1 (position sensor index pulse) is stored in 0x60BB

The position value latched by Touch Probe function

7.Object Dictionary

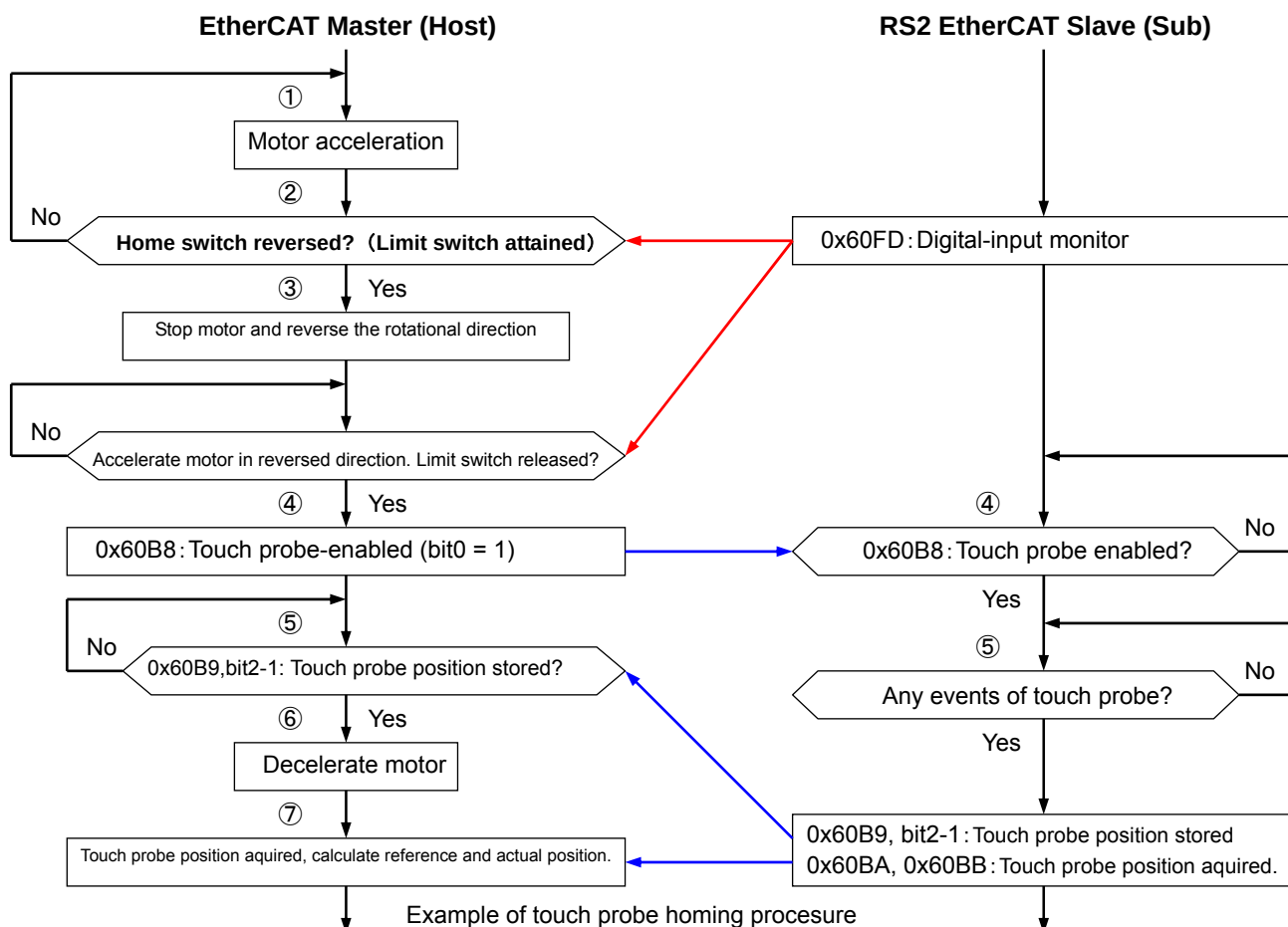
■ Master-led homing (Touch probe homing method): Homing with touch-probe (without Limit Switch)

EtherCAT-support is recommended for touch probe homing to support correct and fast homing. Touch probe events can be accurately captured as the events function separately inside slave hardware, unlike master/ slave sampling frequency. Examples of homing using touch probe function are shown below:



Master-based homing using touch probe

*A) shows machine axis position, the red line shows velocity, B) shows motor position chart, and C) shows motor velocity chart.



Example of touch probe homing procedure

7.Object Dictionary

11) Operation Mode Parameter (Profile Area)

0x6060: Operation Mode

Index	0x6060	Indicates requested operation mode.		Object Code		Variable	
Sub-Idx	Description			Data Type	Access	PDO	Sub-Idx
0x00	Operation Mode [OPMODE]			Integer8	RW	Possible	0x00
	-1 : (csp2) Cycle Sync. Position Mode2 0 : No Mode/Mode is not assigned. 1 : (pp) Profile Position Mode 2 : Reserved 3 : (pv) Profile Velocity Mode 4 : (Reserved) 5 : Reserved 6 : (hm) Homing Mode 7 : Reserved 8 : (csp1) Cycle Sync. Position Mode1 9 : (csv) Cycle Sync. Velocity Mode 10 : Reserved			Setting Range	0xFF - 0x0A (-1 to 10)		
✓ The mode change at the time of motor rotation is dangerous. Make sure to change at the time of the main power supply OFF, Servo-off, or motor stop.							
✓ Refer to the 4th clause for the details of each operational mode.							

0x6061: Operation Mode Display

Index	0x6061	Indicates actual operation mode. Definition is the same as 0x6060: Operation Mode.	Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x00	Operation Mode Display [OPDISP]		Integer8	RO	Possible
	-1 : (csp2) Cycle Sync. Position Mode2 0 : No Mode/Mode is not assigned. 1 : (pp) Profile Position Mode 2 : Reserved 3 : (pv) Profile Velocity Mode 4 : (Reserved) 5 : Reserved 6 : (hm) Homing Mode 7 : Reserved 8 : (csp1) Cycle Sync. Position Mode1 9 : (csv) Cycle Sync. Velocity Mode 10 : Reserved		Setting Range	0xFF to 0x09 (-1 to 9)	

7.Object Dictionary

0x6063: Internal Actual Position (In the case of Absolute Sensor)

Index			0x6063	Indicates actual position of motor sensor.		Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value	
0x00	Internal Actual Position [IACPMON] Real position acquired from the sensor. Monitor unit is indicated with the resolution of motor sensor to be used. Resolution is 32768P/R.			Integer32	RO	Possible	—	
				Setting Range	0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 Pulse)			
				Unit	Pulse			
✓ Code returns positive value in the positive direction according to the set value of 0x607E.								
✓ This Index is not supporting by an incremental sensor.								

0x6064: Position Actual Value

Index	0x6064	Indicates after offset process or the actual position of motor sensor.		Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Actual position [APMON] Internal actual position normalized by offset-process, by homing operation. If no homing operation performed, this position shows the same value as 0x6063: internal actual position, before offset-process (before homing operation not completed). Resolution Incremental Sensor:10000P/R Absolute Sensor :32768P/R		Integer32	RO	Possible	—
			Setting Range	0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 Pulse)		
			Unit	Pulse		
✓ Code returns positive value in the positive direction according to the set value of 0x607E. ✓ When using incremental sensor, the actual position before homing refers the initial position in initialization process as zero. ✓ Resolution of incremental sensor is 500P/R x 4-multiplied =2000, however, code returns the value quintupled this value.						

0x6065: Position Deviation Window (Position Deviation Counter Overflow Value)

0000: Position Deviation Window (Position Deviation Counter Overflow Value)						
Index	0x6065	Allowable position range is set as a position request value relatively to.		Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Position Deviation Window [OFLV] When position actual value crosses position deviation window, becomes Excessive position deviation alarm. Position Actual Value Deviation >= Set Value		Unsigned32	RW	Possible	0x00007530 0x00018000 (3-turn)
			Setting Range	0x00000001 to 0x7FFFFFFF(INC) 0x00000001 to 0x7FFFFFFF(ABS)		
			Unit	Pulse		
✓ When operating in profile position mode or homing mode, alarm of excessive position deviation is activated when the operation in the direction opposite to the command exceeds this setting value.						
✓ Excessive position deviation alarm is not detected in velocity mode.						

7.Object Dictionary

0x6067:Position Window (Input Position Window)

Index	0x6067	Sets up the range permissible as target position attainment. When position actual value of position encoder is in Position Window, means arriving at target position.	Object Code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Position Window [INP] When position deviation counter value is below this preset value, outputs IN-Position signal (INP). When Position Actual Value Deviation ≤ Set Value, outputs Position Window Monitor (INP monitor).		Unsigned32	RW	Possible	0x00000064 0x00000148 (3.6deg)
			Setting Range	0x00000000 to 0x7FFFFFFF(INC) 0x00000000 to 0x7FFFFFFF(ABS)		
			Unit	Pulse		
	Position command pulse frequency monitor Position Deviation Monitor Input Position Window Set Value INP 1 0 1					

✓

When preset value is 0xFFFFFFFF, position window function is OFF.

✓

In the case of profile position mode, it is an effective function.

✓

When operating in cycle synchronous position mode, this setting value is used for “In-Position output” and “Target reached,” however, regard as “Target reached” only when position deviation is within the set range after “the amount of movement =0” acknowledged.

0x606C: Velocity Actual Value

0x606C: Velocity Actual Value									
Index		0x606C		This code has actual velocity value calculated from position sensor.			Object Code	Variable	
Sub-Idx		Description			Data Type		Access	PDO	Initial Value
0x00		Velocity Actual Value [ACVMON]			Integer32		RO	Possible	—
		Incremental Sensor:10000P/R Absolute Sensor :32768P/R			Setting Range		0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 pps)		
					Unit		Pulse/sec		

7.Object Dictionary

0x606D : Velocity Window (Velocity Matching: Number-of-rotations Setup)

Index	0x606D	Sets the range regarded as Velocity matching range by the unit [min ⁻¹].			Object Code	Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Velocity Window [VCMP] Velocity matching is output when the Velocity deviation (difference between the Velocity command and Actual velocity) is within this setting range. VCMP monitor is set when velocity deviation ≤ Set value.		Unsigned16	RW	Possible	0x208D(INC) 0x6AAA(ABS) (50 min ⁻¹)
			Setting Range	0x0000 to 0xFFFF (0 to 65535pulse/s)		
			Unit	Pulse/s		

0x607A:Target Position

Index		0x607A	Target position is set up,when it is used in a profile position and cycle position mode.		Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Target position [TAPOS]			Integer32	RW	Possible	0
	Sets position command per each communication cycle in cycle position mode, or target position in profile position mode. Either absolute position or relative position is selected for the setting value depending on the setting for control word bit6.			Setting Range	0x80000000 to 0xFFFFFFFF		
				Unit	Pulse		

7.Object Dictionary

0x607B:Position range Limit

Index	0x607B	This object shall indicate the configured maximal and minimal position range limits. If input value is zero, Motor can wrap automatically to the other end of the range at the relative behavior of profile position mode (pp).			Object Code Array	
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Number of Entry		—	RO	No	0x2
0x01	Min position range limit [MINPLIM] If input value is zero, Motor can wrap automatically to the other end of the range. Wrap-around is not performed when the set value is 0x80000000.		Integer32	RW	Possible	0x80000000
			Setting Range	0x80000000 or 0x00000000		
			Unit	Pulse		
0x02	Max position range limit [MAXPLIM] If input value is zero, Motor can wrap automatically to the other end of the range. Wrap-around is not performed when the set value is 0x7FFFFFFF.		Integer32	RW	Possible	0x7FFFFFFF
			Setting Range	0x00000000 or 0x7FFFFFFF		
			Unit	Pulse		

✓ No modulo operation available.
 ✓ “Set Point Ack” becomes no reply (=0) when command position exceeds the limit in profile position mode.
 ✓ When wrap-around occurs in cycle synchronous position mode, alarm is detected regardless of this setting value.
 ✓ When operating in velocity mode, wrap-around is allowed regardless of this setting value.

0x607C: Home offset (homing mode)

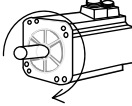
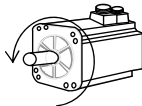
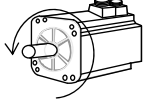
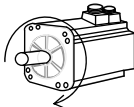
Index	0x607C	Normalizes homing position (mechanical origin) detected in homing mode by homing offset value.	Object Code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Home offset [HOFFSET] ■ The set home offset (0x607C) is used for calculating actual position during homing.		Integer32	RW	Possible	0x00000000 (0 pulse)
			Setting Range	0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 Pulse)		
			Unit	Pulse		
The actual position (0x6064) using homing position during homing is calculated as follows:						
A) Actual position information is not used in homing position. (Calculated excluding present position.) 0x60E6=0 (Absolute homing) Actual position (0x6064) = Homing offset (0x607C)						
B) Actual position information is used. (Calculated including present position.) 0x60E6=1 (Relative homing) Actual position (0x6064) = Present position + Homing offset (0x607C)						
✓ Home offset can be always written, however, this is used in the homing mode only for re-calculating actual position. ✓ Do not use relative homing in incremental sensor-supported driver.						

7.Object Dictionary

0x607D: Software Position Limit

Index		0x607D	Set the software limit. When operating in profile position mode, this is judged when commanded.				Object Code		Array			
Sub-Idx		Description			Data Type		Access		PDO		Initial Value	
0x00		Number of entries			—		RO		No		0x2	
0x01		Minimum Position Limit [SMINLIM]			Integer32		RW		Possible		0x00000000	
					Setting Range		0x80000000 to 0x7FFFFFFF					
					Unit		Pulse					
0x02		Maximum Position Limit [SMAXLIM]			Integer32		RW		Possible		0x00000000	
					Setting Range		0x80000000 to 0x7FFFFFFF					
					Unit		Pulse					
Since the actually used limit value includes Home Offset (0x607C), it is normalized internally before being compared with target position. Minimum Position Limit for Normalization = Minimum Position Limit - Home Offset Maximum Position Limit for Normalization = Maximum Position Limit - Home Offset												
✔ Function is invalid when the Minimum Position Limit >= Maximum Position Limit. ✔ This becomes valid after homing completed. (Ignored during homing operation.) ✔ “Set Point Ack” becomes no reply (=0) when command position exceeds the limit in profile position mode. ✔ When operating in velocity mode or cycle synchronous position mode, motor stops by slowing down at the point actual position reached the set value.												

0x607E: Polarity (Position, VelocityCommand/Offset Input Polarity)

Index		0x607E	Sets command for input polarity. When Bit=1, the command value is multiplied by -1, and it serves as a reverse command.		Object Code	Variable	
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Polarity	[CMDPOL]	Unsigned8	RW	No	0x00	
			Setting Range	0x00 to 0xC0			
	Selects the combination of each command polarity over position command, velocity command input, position offset, and velocity offset (velocity addition), from the following contents. <u>Bit7 : Position Polarity "0": Command is multiplied by +1. "1": Multiplied by -1. (only csp enable)</u> - Valid only in Cycle sync. position mode (csp), 0x607A Target position and 0x60B0 Position offset input value are multiplied by -1 with "1", and then command polarity is reversed. <u>Bit6 : Velocity Polarity "0": Command is multiplied by +1. "1": Multiplied by -1.</u> - In Cycle sync. position mode (csp), "1" 0x60B0 Velocity offset input value as velocity compensation is multiplied by -1 with "1", and then compensation polarity is reversed. - In Cycle sync. position mode (csv), 0x60FF Target velocity and 0x60B1 Velocity offset input value are multiplied by -1 with "1", and then command polarity is reversed. <u>Bit5 to 0: Reserved</u> *Direction with positive (+) polarity command supply according to the setting value is shown below. *When command input polarity is standard set value "Bit7=0, Bit6=0", rotates to positive direction (CCW)by command polarity + / to negative direction (CW) by -.  *When command input polarity is standard set value "Bit7=1, Bit6=1", rotates to negative direction (CW) by command polarity + / to positive direction (CCW) by -. 						
✓ Change will be impossible if ESM of this parameter is Operational. Make sure to change after servo-off and shift to Pre-Operational. ✓ Designate the same direction for bit6 and 7.							

7.Object Dictionary

0x607F: Maximum Profile Velocity (Velocity Limit Command)

Index	0x607F	Sets permissible velocity to Velocity command.	Object Code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Maximum Profile Velocity [VCLM] Limit maximal allowed profile velocity (0x6081) during a profiled position (pp) motion.		Unsigned32	RW	Possible	Maximam
			Setting Range	0x00000001 to 0x000B71B0(INC) 0x00000001 to 0x00258000(ABS)		
			Unit	Pulse/sec		

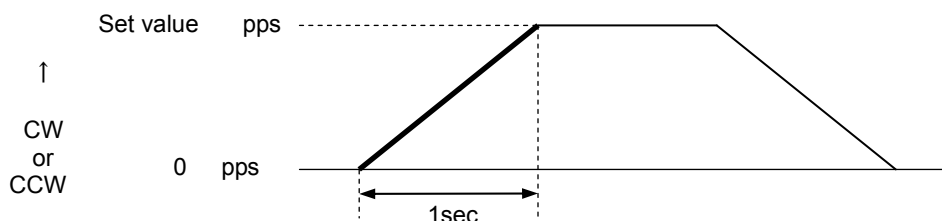
0x6081: Profile Velocity

Index		0x6081		This object shall indicate the configured velocity normally attained at the end of the acceleration ramp during a profile position mode motion.		Object Code		Variable			
Sub-Idx		Description		Data Type		Access		PDO		Initial Value	
0x00		Profile velocity [PROBEL] The value is effective for both of CW and CCW. When exceeding 0x607F, it is restricted with 0x607F preset value.		Unsigned32		RW		Possible		0x000000A6 0x00000222	
				Setting Range		0x00000001 to 0x000B71B0(INC) 0x00000001 to 0x00258000(ABS)					
				Unit		Pulse/sec					

✓ Please note that the maximum velocity operable varies depending on motors.

0x6083: Profile acceleration

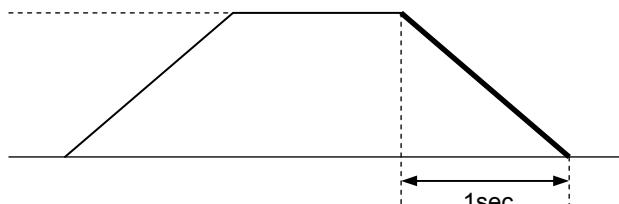
Index		0x6083	Parameters to decide the gradient at the time of motor acceleration during Profile position, Function velocity mode.		Object Code		Variable					
Sub-Idx		Description			Data Type		Access		PDO		Initial Value	
0x00		Profile acceleration [TVCAAC] The parameters to give acceleration incline against preset velocity command, and set the rate of velocity per second.			Unsigned32		RW		Possible		0x00051615 0x0010AAAA	
					Setting Range		0x00000000 to 0x02887FA0 0x00000000 to 0x084D0000					
					Unit		Pulse/sec ²					
↑ CW or CCW Set value pps 0 pps 1sec												



✓ If value is set to "0", the amplifier proceeds it as "1."

7.Object Dictionary

0x6084: Profile Deceleration

Index	0x6084	Parameters to decide the gradient at the time of motor deceleration during Profile position, Function velocity mode.		Object Code		Variable	
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Profile Deceleration [TVCDEC] The parameters to give deceleration incline against preset velocity command, and set the rate of velocity per second.			Unsigned32	RW	Possible	0x00051615 0x0010AAAA
				Setting Range	0x00000000 to 0x02887FA0 0x00000000 to 0x084D0000		
				Unit	Pulse/sec ²		
↑ CW or CCW Set value pps 0 pps 							
✓ If value is set to "0", the amplifier proceeds it as "1."							

0x6085: Quick Stop Deceleration

Index			0x6085	Set the Quick Stop or Halt Deceleration.		Object Code		Variable	
Sub-Idx		Description		Data Type	Access	PDO	Initial Value		
0x00		Quick Stop Deceleration [QSDEC] Slowdown parameter used for motor stop when quick stop function is active and "2" or "6" is set to quick stop code object (0x605A). Used also when Halt option code object (0x605D) are "2."		Unsigned32	RW	Possible	0x00051615 0x0010AAAA		
				Setting Range	0x00000000 to 0x02887FA0 0x00000000 to 0x084D0000				
				Unit	Pulse/sec ²				
✓ If value is set to "0", the amplifier proceeds it as "1."									

7.Object Dictionary

0x6098: Homing method

Index	0x6098	This object shall set the homing method that shall be used.		Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Homing method [HOMETYP] Configured homing method (Origin return method)	Integer8	RW	Possible	0x23 (35)	
		Setting Range	0xFE to 0x23 (-2 to 35)			
✓ Operation direction definition follows the set value of 0x607E. ✓ Refer to section (11) in this chapter for the details of Homing Method operations. ✓ Only 35 is settable when using ABS sensor.						

Method	Homing Mode
-2	Homing on negative Mechanical end
-1	Homing on positive Mechanical end
17	Homing on negative limit switch
18	Homing on positive limit switch
20	Homing on positive home switch
22	Homing on negative home switch
24	Homing on positive limit switch and Homing on positive home switch
28	Homing on negative limit switch and Homing on positive home switch
33	Homing on the index pulse
34	Homing on the index pulse
35	Homing on the current position

0x6099: HOMING VELOCITY

0x0099: HOMING VELOCITY

Index	0x6099	Homing velocity is used during the procedure command "Homing operation"	Object Code		ARRAY	
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Number of entry		Unsigned8	RO	No	0x02
0x01	Switch search speed [SSVCMD] Set the motor speed during search for a end position switch on homing mode	Unsigned32	RW	Possible	0x000000A6 0x00000222	
		Setting Range	0x00000001 to 0x000B71B0(INC) 0x00000001 to 0x00258000(ABS)			
		Unit	Pulse/sec			
0x02	Zero phase search speed [ZSVCMD] Assign the motor speed during search for the index pulse (zero) detection	Unsigned32	RW	Possible	0x000000A6 0x00000222	
		Setting Range	0x00000001 to 0x000B71B0(INC) 0x00000001 to 0x00258000(ABS)			
		Unit	Pulse/sec			

0x609A: Homing acceleration and deceleration

Index		0x609A	This object is the parameters that define the velocity slope of the acceleration and deceleration ramp on homing mode.		Object Code		Variable					
Sub-Idx		Description			Data Type		Access		PDO		Initial Value	
0x00		Homing acceleration and deceleration [HOMEACC] The parameters to Homing velocity that restrain velocity slope of the acceleration and deceleration ramp during acceleration, zero speed, direction change			Unsigned32		RW		Possible		0x00051615 0x0010AAAA	
					Setting Range		0x00000000 to 0x02887FA0 0x00000000 to 0x084D0000					
					Unit		Pulse/sec ²					
		↑ CW or CCW Set value pp s² 0 pp s²										
✓ If value is set to "0", the amplifier proceeds it as "1."												

7.Object Dictionary

0x60B8:Touch probe function

Index	0x60B8	Controls the functions of the touch probe.		Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Touch probe function [TPFUNC] Controls the functions of the touch probe.		Unsigned16	RW	Possible	0x0000
			Setting Range	0x0000 to 0x001F		
<u>bit0: Touch probe 1 switch enable</u> 0: Switch off touch probe 1 1:Enable touch probe 1						
<u>bit1: Touch probe 1 Trigger operation</u> 0:Trigger first event 1:continuous						
<u>bit2: Touch probe 1 Trigger selection</u> 0:Trigger with touch probe 1 input 1:Trigger with position sensor index pulse						
<u>bit4: Touch probe 1 positive edge enable</u> 0:Switch off sampling at positive edge of touch probe 1 1:Enable sampling at positive edge of touch probe 1						
<u>bit5: Touch probe 1 negative edge enable</u> 0:Switch off sampling at negative edge of touch probe 1 1:Enable sampling at negative edge of touch probe 1						
<u>bit8 to 15: Reserved</u>						
✓ When using absolute sensor, the position data within single-turn shall be index pulse. ✓ The touch probe function cannot operate at the time of the axis 1 and 2 said. Please use it, permitting only an arbitrary axis. Moreover, please use 2 axis synchronous operation only in the state of prohibition. ✓ Touch probing function cannot work for both axis 1 and 2 at the same time. Use the function for axis you select with 2-axis operation prohibited.						

0x60B9:Touch probe status

Index	0x60B9	Displays the status of the touch probe.		Object Code		Variable	
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Touch probe status [TPSTS]			Unsigned16	RO	Possible	0x0000
	Displays the status of the touch probe			Setting Range	0x0000 to 0x001F		
	<u>bit0: Touch probe 1 switch enable monitor</u>						
	0:Touch probe 1 is switched off			1:Touch probe 1 is enabled			
	<u>bit1: Touch probe 1 positive edge value stored monitor</u>						
	0:Touch probe 1 no positive edge value stored			1:Touch probe 1 positive edge position stored			
	<u>bit2: Touch probe 1 negative edge value stored monitor</u>						
	0:Touch probe 1 no negative edge value stored			1:Touch probe 1 negative edge position stored			
	<u>bit6: Touch probe 1 Trigger selection monitor (User-defined : for testing)</u>						
	0:Trigger with touch probe 1 input mode			1:Position sensor index pulse trigger mode			
<u>Bit7:Touch probe 1input monitor (User-defined : for testing)</u>							
0:Photocoupler is off (CONT1:OFF)			1:Photocoupler is on (CONT1:ON)				
bit8 to 15:Reserved							

0x60BA:Touch probe pos 1 pos value (positive edge)

Index		0x60BA	Position value of the touch probe 1 at positive edge.		Object Code		Variable	
Sub-Idx	Description			Data Type	Access	PDO	Initial Value	
0x00	Touch probe pos1 pos value [TP1PPOS]			Integer32	RO	Possible	—	
				Setting Range	0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 Pulse)			
				Unit	1 Pulse			

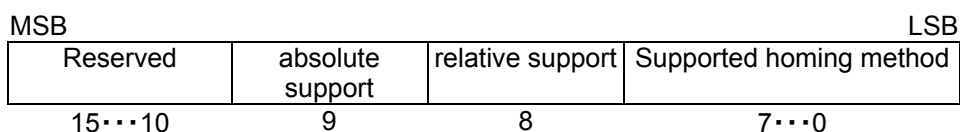
0x60BB:Touch probe pos1 neg value (negative edge)

0x60BB: touch probe pos1 neg value (negative edge)					
Index	0x60BB	Position value of the touch probe 1 at negative edge.	Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x00	Touch probe pos1 neg value [TP1NPOS]		Integer32	RO	Possible
			Setting Range	0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 Pulse)	
			Unit	1 Pulse	

7.Object Dictionary

0x60E3:Support homing method

Index		0x60E3	Specifies the value definition of homing method supported		Object Code		ARRAY
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Number of Entry			Unsigned8	RO	NO	0xDC
0x01	Support homing method 1			Unsigned16	RO	NO	0x01FE
	Supports Homing method 1“Homing on negative Mechanicalend”						
0x02	Support homing method 2			Unsigned16	RO	NO	0x01FF
	Supports Homing method 2“Homing on positive Mechanicalend”						
0x03	Support homing method 3			Unsigned16	RO	NO	0x0111
	Supports Homing method 3“Homing on negative limit switch”						
0x04	Support homing method 4			Unsigned16	RO	NO	0x0112
	Supports Homing method 4 “Homing on negative limit switch”						
0x05	Support homing method 5			Unsigned16	RO	NO	0x0114
	Supports Homing method 5 “Homing on positive home switch”						
0x06	Support homing method 6			Unsigned16	RO	NO	0x0116
	Supports Homing method 6 “Homing on negative home switch”						
0x07	Support homing method 7			Unsigned16	RO	NO	0x0118
	Supports Homing method 7 “Homing on positive limit switch and Homing on positive home switch”						
0x08	Support homing method 8			Unsigned16	RO	NO	0x011C
	Supports Homing method 8 “Homing on negative limit switch and Homing on positive home switch”						
0x09	Support homing method 9			Unsigned16	RW	NO	0x0121
	Supports Homing method 9 “Homing on the index pulse”						
0x0A	Support homing method 10			Unsigned16	RW	NO	0x0122
	Supports Homing method 10 “Homing on the index pulse”						
0x0B	Support homing method 11			Unsigned16	RW	NO	0x0323
	Supports Homing method 11“ Homing on the current position”						



Bit9: Absolute homing method support 0:Unsupported 1: Supported
Bit8: Relative value homing support 0:Unsupported 1: Supported
Bit7-0: Supported homing method Index 6098 corresponding to that indicated on Homing

0x60E6: Actual position calculation method

Index		0x60E6	Defines actual position (0x6064) calculation method in homing procedure.		Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Actual position calculation method [PMON]			Unsigned8	RW	No	0x00
				Setting Range	0x00 to 0x01		
	0: Ccalculates excluding present position. Actual position (0x6064) = Homing offset (0x607C)						
	1: Calculates including present position. (Present position information is used. Actual position (0x6064) = Present position + Homing offset (0x607C)						
2 to 255 : Reserved							
✔ Do not set relative homing (0x60E6=1) for the drivers supporting incremental sensor.							

7.Object Dictionary

0x60F4: Actual Position Deviation (Following error actual value)

Index	0x60F4	This object shall provide the actual value of the following error.		Object Code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Actual Position Deviation [PMON] In the case of profile position mode, the amount of remaining movements is monitored.		Integer32	RO	Possible	0x00000000
			Setting Range	0x80000000 to 0x7FFFFFFF (−2147483648 to 2147483647 Pulse)		
			Unit	Pulse		

0x60FD: Digital inputs

Index		0x60FD		This object shall monitor the input signals.						Object Code			Record		
Sub-Idx		Description						Data Type		Access		PDO		Initial Value	
0x00		Digital inputs monitor [DINPUT] 1: Photocoupler is ON						Unsigned32		RO		Possible		—	
								Setting Range		0x00000000 to 0x0001000F					
—	—	—	—	—	—	—	—	Touch Probe	—	EMR	Home	Positive limit	Negative limit t		
31..24	23	22	21	20	19	18	17	16	15..4	3	2	1	0		

0x60FE: Digital output

Index		Description	Data Type	Access		PDO
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Number of entry		Unsigned8	RO	NO	0x01
0x01	Physical output [DOUTPUT]		Unsigned32	RW	Possible	—
	0: OFF 1: ON (Holding Brake=Hold)		Setting Range	0x00000000 to 0x00010001		
✓ Holding brake control is valid only in the state of servo-off.						
✓ OUT1-output is valid only when 0x4011-output function is general output.						

—	—	—	—	—	—	—	—	OUT1	—	—	—	—	Brake
<u>31</u> · <u>24</u>	<u>23</u>	<u>22</u>	<u>21</u>	<u>20</u>	<u>19</u>	<u>18</u>	<u>17</u>	<u>16</u>	<u>15</u> · <u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>0</u>

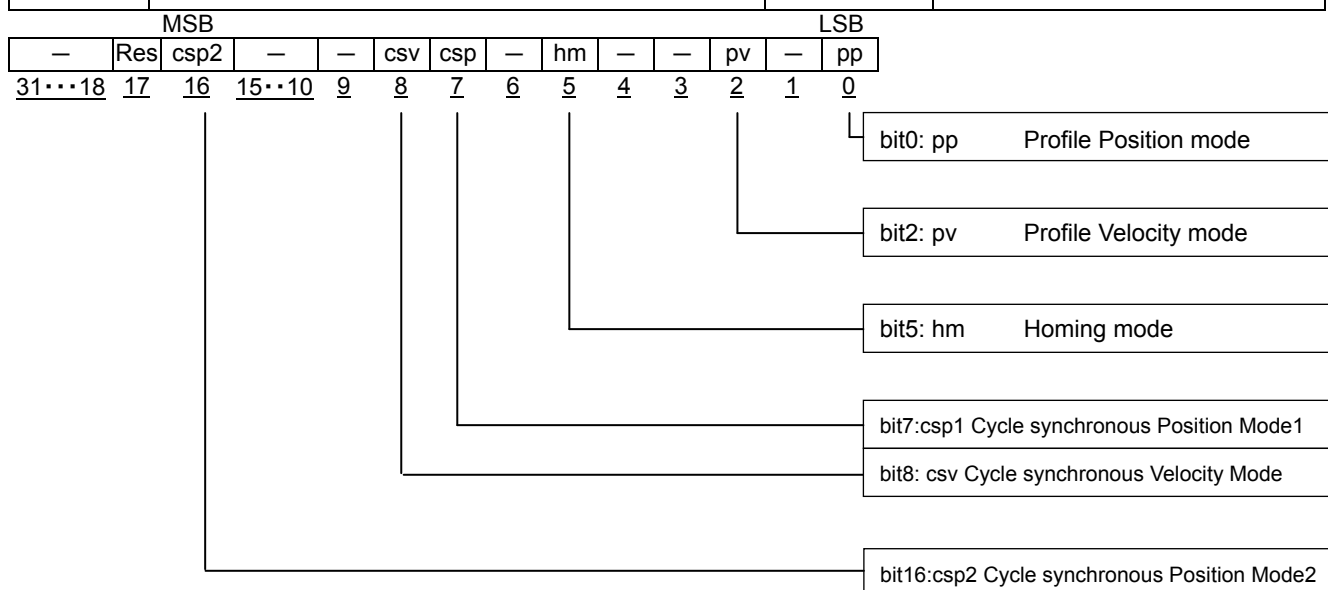
0x60FF: Target Velocity

Index		0x60FF	Indicates to set Target velocity, and used for inputting trajectory generator.		Object Code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial Value
0x00	Target Velocity (Velocity command) [TAVEL]			Integer32	RW	Possible	0
				Setting Range	0xFFFF48E50 to 0x000B71B0(INC) 0xFFDA8000 to 0x00258000(ABS)		
	Velocity command input for Cyclic Sync. Velocity (csv), Profile velocity (pv)			Unit	Pulse/sec		

7.Object Dictionary

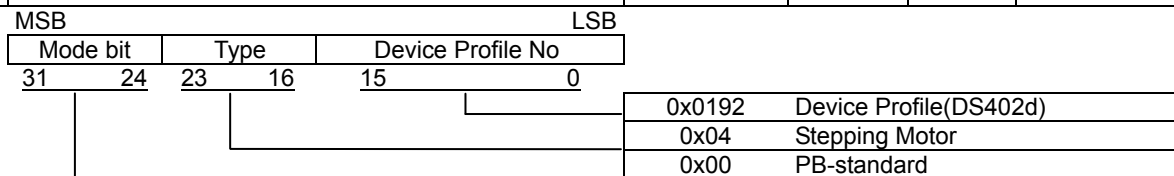
0x6502::Supported Drive mode

Index		0x6502	This object shall provide information on the supported drive modes by the driver.		Object Code		Variable
Sub-Idx		Description		Data Type	Access	PDO	Initial Value
0x00		Support drive mode [SUPMODE] 0:Not supported 1: Supported		Unsigned32	RO	Possible	0x101A5
				Setting Range	0x101A5 to 0x101A5		



0x67FF: Device type

Index	0x1000	Shows device type and profile functions.		Object Code		VAR
Sub-Idx	Description		Data Type	Access	PDO	Initial Value
0x00	Device type [DEVICE]		Unsigned32	RO	No	0x0004192



7.Object Dictionary

7.5 Manufacturer Specific profile area

12) Object group

0x4000 to 0x41FF	Manufacturer Specific Profile Area: Axis 1
0x4200 to 0x43FF	Manufacturer Specific Profile Area: Axis 2

The following table indicates the following items of CoE (CANopen over EtherCAT) manufacturer specific profile area:

- Object
- Compliant/ non-compliant of operation mode
- Target to be saved.
- Access (Dir)
- PDO-mapping
- Operation mode referring parameter “●: Enabled immediately ■:Enabled when control power supply re-turned on”

* All the Index numbers are of axis 1. To get Index numbers of axis 2, add 0x0200 the Index numbers of axis 1.

Manufacturer specific profile area 1

Index	S-Idx	PP	PV	CSP1	CSP2	CSV	hm	Description	Save	Dir	PDO-Mapping	Up-date
0x4000	0x00	○	○	○	○	○	×	Control word 1	—	RW	Possible	●
0x4001	0x00	×	×	○	○	×	×	S-curve profile filter	○	RW	Possible	●
0x4002	0x00	×	×	○	×	×	×	Position loop propotional gain	○	RW	Possible	●
0x4004	0x00	×	×	○	×	×	×	Feed-forward gain	○	RW	Possible	●
0x4005	0x00	×	○	×	×	○	×	Velocity command low-pass filter	○	RW	Possible	●
0x4006	0x00	○	○	○	×	○	○	Velocity feedback Low-pass filter	○	RW	Possible	●
0x4007	0x00	○	○	○	×	○	○	Velocity loop propotional gain	○	RW	Possible	●
0x4008	0x00	○	○	○	×	○	○	Velocity loop integration gainn	○	RW	Possible	●
0x4009	0x00	—	—	—	—	—	—	Current limit	—	RO	No	—
↑	0x01	○	○	○	○	○	○	Current limit when motor stopped in servo-on state	○	RW	Possible	●
↑	0x02	○	○	○	○	○	○	Current limit when motor being driven	○	RW	Possible	●
↑	0x03	○	○	○	○	○	○	Current limit in Switch-on state	○	RW	Possible	●
↑	0x04	○	○	○	×	○	○	Current limit when performing operation of travel to fixed stop	○	RW	Possible	●
0x400A	0x00	×	×	×	○	×	×	csp2 velocity loop propotional gain	○	RW	Possible	●
0x4010	0x00	—	—	—	—	—	—	Input-signal logic	—	RO	No	—
↑	0x01	○	○	○	○	○	○	Limit sensor input-logic in the positive direction	○	RW	No	●
↑	0x02	○	○	○	○	○	○	Limit sensor input-logic in the negative direction	○	RW	No	●
↑	0x03	○	○	○	○	○	○	Home sensor input-logic	○	RW	No	●
0x4011	0x00	○	○	○	○	○	○	Selection of output-port function	○	RW	No	●
0x4012	0x00	○	○	○	○	○	○	Motor code	○	RW	No	*1
0x4013	0x00	○	○	○	○	○	○	Extended station alias	○	RW	No	■
0x4014	0x00	○	○	○	○	○	○	Regenerative resistance overheat detection permitted/ prohibited	○	RW	No	●
0x4015	0x00	○	○	○	○	○	○	Status transition an alarm occurred on the other axis	○	RW	No	●
0x4016	0x00	○	○	○	×	○	○	Time to determine that operation of travel to fixed stop is completed.	○	RW	No	●
0x4017	0x00	○	○	○	○	○	○	Initialization operation type	○	RW	No	●
0x4018	0x00	○	○	○	○	○	○	Servo loop delay time	○	RW	No	●
0x4022	0x00	○	×	×	×	×	×	Two-axis synchronous operation permitted/ prohibited	○	RW	Possible	●
0x4023	0x00	○	×	×	×	×	×	Two-axis synchronous operation gain	○	RW	Possible	●
0x4030	0x00	—	—	—	—	—	—	Alarm detecting condition	—	RO	No	—
↑	0x01	—	—	—	—	—	—	Reserved	○	RW	No	—
↑	0x02	×	×	×	○	×	×	Anomalous threshold of velocity difference	○	RO	No	●
↑	0x03	○	×	×	×	×	×	Anomalous threshold of postion deviation between two axes	○	RW	No	●
↑	0x04	○	○	○	×	○	○	Abnormal detection threshold of overload	○	RW	No	●
↑	0x05	○	○	○	×	○	○	Abnormal detection time of overload	○	RW	No	●
0x4031	0x00	—	—	—	—	—	—	Warning detecting condition	—	RO	No	—
↑	0x01	○	○	○	×	○	○	Warning threshold of of current command attainment	○	RW	No	●
↑	0x02	×	×	○	○	×	×	Position deviation warning threshold	○	RW	No	●
0x4041	0x00	—	—	—	—	—	—	Power Down	—	RO	No	—
↑	0x01	○	○	○	○	○	○	Power Down delay time	○	RW	No	●
↑	0x02	○	○	○	○	○	○	Power Down time constant	○	RW	No	●

○: Supported, ×: Not supported

*1 Please make sure to perform setting before status transition to Switch-on.

7.Object Dictionary

Manufacturer specific profile area 2

Index	S-Idx	PP	PV	CSP1	CSP2	CSV	hm	Description	Save	Dir	PDO-Mapping	Up-date
0x4100	0x00	○	○	○	○	○	○	Status word 1	—	RO	Possible	—
0x4101	0x00	—	—	—	—	—	—	Alarm history	—	RO	No	—
↑	0x01	○	○	○	○	○	○	Present alarm status	—	RO	No	—
↑	0x02	○	○	○	○	○	○	The last alarm status	—	RO	No	—
↑	0x03	○	○	○	○	○	○	The second status from the last	—	RO	No	—
↑	0x04	○	○	○	○	○	○	The third status from the last	—	RO	No	—
↑	0x05	○	○	○	○	○	○	The 4th status from the last	—	RO	No	—
↑	0x06	○	○	○	○	○	○	The 5th status from the last	—	RO	No	—
↑	0x07	○	○	○	○	○	○	The 6th status from the last	—	RO	No	—
↑	0x08	○	○	○	○	○	○	The 7th status from the last	—	RO	No	—
0x4102	0x00	○	○	○	○	○	○	Warning status	—	RO	No	—
0x4103	0x00	○	○	○	○	○	○	Driver temperature monitor	—	RO	No	—
0x4104	0x00	○	○	○	○	○	○	Main circuit power supply voltage monitor	—	RO	No	—

○:Supported, ×:Not supported

7.Object Dictionary

13) "Control command" parameter

0x4000: Control word 1

Index	0x4000	Manufacturer-specific driver control address	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO Initial value
0x00	No functions allocated to this address.		Unsigned16	RW	Possible -

MSB

LSB

	DEVCLR
--	--------

15 to 2

0

bit0: Position deviation clear enabled [PCLR]
1= Clear position deviation. (Level recognition)

bit1 to 15: Reserved

0x4001: S-curve profile filter

0x4001: S-curve profile filter			Object code		Variable	
Index	0x4001	Sets S-curve profile filter time constant for position command.				
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	This is effective for impact lessening and vibration suppression when starting up and stop the motor with loads. Note that the higher the setting, the lesser the synchronous performance for command.		Unsigned16	RW	Possible	0x0000
			Setting range	0x0000 to 0x000F		
			Unit	-		
✓ Do not change the setting during operation. Position gap may occur.						
✓ This is only effective for the operation in cycle synchronous position mode.						

0x4002: Position loop proportional gain

0x4002: Position loop proportional gain			Object code		Variable	
Index	0x4002	Sets proportional gain for position controller.				
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets position loop proportional gain when operating in cycle synchronous position mode 1(only csp1). The higher the setting, the higher the responsiveness.		Unsigned16	RW	Possible	0x0002
			Setting range	0x0001 to 0x000F		
			Unit	-		

0x4004: Feed-forward gain

Index	0x4004	Sets feed-forward compensation of position controller.	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets position loop feed-forward gain when operating in cycle synchronous position mode 1 (only csp1). The higher the setting, the higher the responsiveness.		Unsigned16	RW	Possible	0x0000
			Setting range	0x0000 to 0x00FF		
			Unit	-		

0x4005: Velocity command low-pass filter

0x4005: Velocity command low pass filter			Object code		Variable	
Index	0x4005	Sets low-pass filter time constant for velocity command.				
Sub-Idx	Description		Data Type	Access	PDO Initial value	
0x00	This is effective for velocity mode.		Unsigned16	RW	Possible	0x0000
			Setting range	0x0000 to 0x0003		
			Unit	-		

7.Object Dictionary

0x4006: Velocity feedback low-pass filter

Index	0x4006	Sets velocity feedback low-pass filter.	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	This is effective on the drive modes other than cycle synchronous position 2 (csp2).		Unsigned16	RW	Possible	0x0000
			Setting range	0x0000 to 0x0003		
			Unit	-		

0x4007: Velocity loop proportional gain 1

0x4007: Velocity loop proportional gain 1							
Index		0x4007	Sets proportional gain of velocity controller.		Object code		Variable
Sub-Idx		Description		Data Type	Access	PDO	Initial value
0x00		Sets velocity loop proportional gains in the drive modes other than cycle synchronous position 2(csp2).		Unsigned16	RW	Possible	0x0000
				Setting range		0x0000 to 0x00FF	
				Unit		-	

0x4008: Velocity loop integration gain

0x4008: Velocity loop integration gain			Object code		Variable	
Index	0x4008	Sets integration gain of velocity controller.				
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets velocity loop integration gains in the drive modes other than cycle synchronous position 2(csp2).		Unsigned16	RW	Possible	0x0001
			Setting range	0x0000 to 0x00FF		
			Unit	-		

0x4009: Current limit

Index		0x4009	Sets current limit in each state of driver.		Object code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial value
0x00	Number of entries			Unsigned8	RO	No	0x04
0x01	Current limit when servo-on stopped Sets current limit when servo-on stopped.			Unsigned8	RW	Possible	0x7F
				Setting range	0x00 to 0x7F		
				Unit	Rated current/255		
0x02	Current limit when operating motor. Sets current limit in all the states of driver.			Unsigned8	RW	Possible	0xFF
				Setting range	0x00 to 0xFF		
				Unit	Rated current/255		
0x03	Current limit in the state of Switch On. Sets current limit in the state of Switch On.			Unsigned8	RW	Possible	0x00
				Setting range	0x00 to 0x7F		
				Unit	Rated current/255		
0x04	Current limit for operation of travel to fixed stop Sets Current limit for operation of travel to fixed stop. ✓ In cycle synchronous position 2 (csp2) operation modes, operation of travel to fixed stop cannot be performed.			Unsigned8	RW	Possible	0x00
				Setting range	0x00 to 0x7F		
				Unit	Rated current/255		

0x400A: csp2 velocity loop gain

0x400A: csp2 velocity loop gain			Object code		Variable	
Index	0x400A	Sets velocity loop proportional gain.				
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets velocity loop proportional gain in cycle synchronous position 2 (csp2) operation mode.		Unsigned*	RW	Possible	0x0005
			Setting range	0x0000 to 0xFFFF		
			Unit	-		

7.Object Dictionary

0x4010: Input signal logic

Index		0x4010	Sets enabled/ disabled and logic of input signal. Rotational direction follows 0x607E.		Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO		Initial value
0x00	Number of entries		Unsigned8	RO	No		0x03
0x01	Sets enabled/ disabled and logic of Limit input function for Positive rotation.		Unsigned8	RW	No		0x01
			Setting range	0x00 to 0x02			
			Unit	0:Disabled 1:On active 2:OFF Active			
0x02	Sets enabled/ disabled and logic of Limit input function for negative rotation.		Unsigned8	RW	No		0x01
			Setting range	0x00 to 0x02			
			Unit	0:Disabled 1:On active 2:OFF Active			
0x03	Sets enabled/ disabled and logic of Home input function.		Unsigned8	RW	No		0x00
			Setting range	0x00 to 0x02			
			Unit	0:Disabled 1:On active 2:OFF Active			

0x4011: General output function

0x4011: General output function						
Index	0x4011	Sets functions of general output.		Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets functions of general output 1 (for axis 1). Refer to list of general input functions for all the functions. Output logic: On-active		Unsigned8	RW	No	0x00
			Setting range	0x00 to 0x07		
			Unit	-	Save	Yes

■ List of general output functions

Setting value	Function	Function outline	Output logic (On)
0	Alarm output	Outputs when alarm occurs.	In alarm-state
1	Warning output	Outputs when warning occurs (latches).	Warning
2	Attaining torque limit	Outputs when operation attained the set value of 0x4031.	Attaining
3	Traveling to fixed stop	Outputs the state of operation of travel to fixed stop.	Traveling to fixed stop
4	SON-state monitor	Outputs servo-on state.	Servo-on
5	Bit Out 1	For control OUT1 with 0x60FE.	Set value of 0x60FE=1
6	Battery warning	Settable only when using ABS sensor.	Warning
7	In-Position output	This is positioning completion output, and the determined width follows the set value of 0x606.	In-Position

0x4012: Motor code

0x4012: Motor code			Object code		Variable	
Index	0x4012	Sets motor code.				
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets compatible motor codes. Settable by using digital operator.		Unsigned16	RW	No	0x00
			Setting range	0x00 to 0x06		
			Unit	-		
✓	Setting is needed only for incremental sensor-compatible amplifiers.					
✓	Make sure to set motor code before status transition to Switch on.					

Compatible motors

Motor model numbers	Setting value	Motor model numbers	Setting value
PBM282	0	PBM565	4
PBM284	1	PBM603	5
PBM423	2	PBM604	6
PBM503	3	-	-

7.Object Dictionary

0x4013: Extended station alias

Index	0x4013	This is an extended parameter to set over station alias 0x10.		Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Extended station alias [EXALIAS]		Unsigned16	RW	No	0x0000
			Setting range	0x0000 to 0xFF00		
	This is a parameter (rotary switch setting range: 0 to 15) to set address: 16 to 65535 to slave-specific station alias <Reg: 0x0012, 0x0013>. To get station alias value, add this address value to rotary switch setting value: bit3 to 0 (0x0 to 0xF) and digital operator setting value at amplifier initialization.					
✓	The setting value becomes enabled by re-turning on control power.					
✓	This command updates both axis 1 and 2 setting value regardless of which axis is used.					

0x4014: Permitted/ prohibited of regenerative resistance overheat detection

Index	0x4014	Sets Prohibited/ permitted of regenerative resistance overheat detection	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	If you install a regenerative resistor with temperature-sensing function, please use the resistor by previously setting this as “permitted.”		Unsigned8	RW	No	0x00
			Setting range	0x00 to 0x01		
			Unit	0: Prohibited 1: permitted		
✓	This command updates both axis 1 and 2 setting value regardless of which axis is used.					
✓	If regenerative resistor is not used, note that setting “1” detects regenerative resistor overheat abnormality.					

0x4015: Status transition when an alarm occurred on the other axis

0x4015: Status transition when an alarm occurred on the other axis						
Index	0x4015	Sets status transition when the other axis detects an alarm.	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Stopping procedure follows Fault Reaction.		Unsigned8	RW	No	0x01
			Setting range	0x00 to 0x01		
			Unit	0: No status transition 1: Transition to Fault-state		
✓ This command updates both axis 1 and 2 setting value regardless of which axis is used.						

0x4016: Time to determine that operation of travel to fixed stop is completed

Index	0x4016	Sets time to determine that operation of travel to fixed stop is completed.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO Initial value
0x01	In-Position signal is turned on after a lapse of this setting time, after current limit of operation of travel to fixed stop attained.		Unsigned8	RW	No 0x0A
			Setting range	0x00 to 0xFF	
			Unit	1ms/LSB	

0x4017: Initialization operation type

Index	0x4017	Set the initialization operation type.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO Initial value
0x01	Set The initialization operation Type when first-time Switch On state. Please set up "1", when the state where load runs against obstacles, such as mechanical end position, occurs. 0: when There is No mechanical End (Operating Angle 3.2 Degree Max) 1: when There is mechanical End (Operating Angle 10.4 Degree Max)		Unsigned8	RW	No 0x00
			Setting range	0x00~0x01	
			Unit	—	

7.Object Dictionary

0x4018: Servo loop delay time

Index	0x4018	Set the Servo loop delay time.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x01	In a case [SM2], the delay time from IRQ interruption to the operation start of a servo loop is set up. Please set up, when Gitta of a synchronization frame has.		Unsigned8	RW	No
			Setting range	0x00~0x0F	
			Unit	62.5μs	

0x4022: Two-axis synchronous operation allowed

Index	0x4022	Sets two- axis synchronous operation permitted/ prohibited.	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	This is effective only for the operation in profile position mode after origin return operation completion. Adjust to optimum gain with 0x4023.		Unsigned8	RW	No	0x00
			Setting range	0x00 to 0x01		
			Unit	0: Prohibited 1: permitted		
✓ This command updates both axis 1 and 2 setting value regardless of which axis is used. ✓ If setting this as "permitted," alarm is detected when position deviation between axes is over the value set with 0x4021. ✓ The axis 2 also starts operation by the start of the axis 1 of operation. ✓ When an arbitrary axis occur the alarm during operation, all the axial are stop [not being based on 0x4015 (at the time of other axis alarm generating change state) preset value].						

0x4023: Two-axis synchronous operation gain

0x4023: Two-axis synchronous operation gain			Object code		Variable	
Index	0x4023	Sets the gain when performing two-axis synchronous operation.				
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Sets velocity compensation proportional gain when performing two-axis synchronous operation. The higher the value, the higher the gain.		Unsigned16	RW	No	0x00
Setting range			0x0000 to 0xFFFF			
Unit			-			
✓ Note that if the value is too high, motor may vibrate.						

0x4030: Alarm detecting condition

Index	0x4030	Sets alarm detecting condition.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x00	Number of entries		Unsigned8	RO	No
0x01	(This function is reserved.)		Unsigned32	RW	No
			Setting range	0x00000000 to 0xFFFFFFFF	
			Unit	Pulse/s ²	
0x02	Anomalous threshold of velocity difference Alarm is activated when the difference between command velocity and actual velocity exceeds this setting value. This is detected only when operating in cycle synchronous position 2 (csp2) mode.		Unsigned32	RW	No
			Setting range	0x00000000 to 0xFFFFFFFF	
			Unit	Pulse/s	
0x03	Anomalous threshold of position deviation between two axes This is detected only when in profile position mode and 0x4022 is set to 1.		Unsigned32	RW	No
			Setting range	0x00000000 to 0xFFFFFFFF	
			Unit	Pulse	
0x04	Abnormal detection threshold of overload Sets detection threshold of current command. Alarm is detected when current command keeps the state over threshold value during the setting time of 0x05. This is not detected when operating in cycle synchronous position 2 (csp2) mode.		Unsigned8	RW	No
			Setting range	0x00 to 0xFF	
			Unit	-	
0x05	Abnormal detection time of overload		Unsigned16	RW	No
			Setting range	0x0000 to 0xFFFF	
			Unit	1ms/LSB	

7.Object Dictionary

0x4031: Warning detecting condition

Index	0x4031	Sets alarm detecting condition.	Object code			Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Number of entries		Unsigned8	RO	No	0x02
0x01	Warning threshold of current command attainment This is not detected when operating in cycle synchronous position 2 (csp2) mode. ✓ This is set when this threshold has been attained for even a moment.		Unsigned8	RW	No	0xFF
			Setting range	0x00 to 0xFF		
			Unit	-		
0x02	Position deviation warning threshold		Unsigned32	RW	No	0xFFFFFFFF
			Setting range	0x00000000 to 0xFFFFFFFF		
			Unit	Pulse		

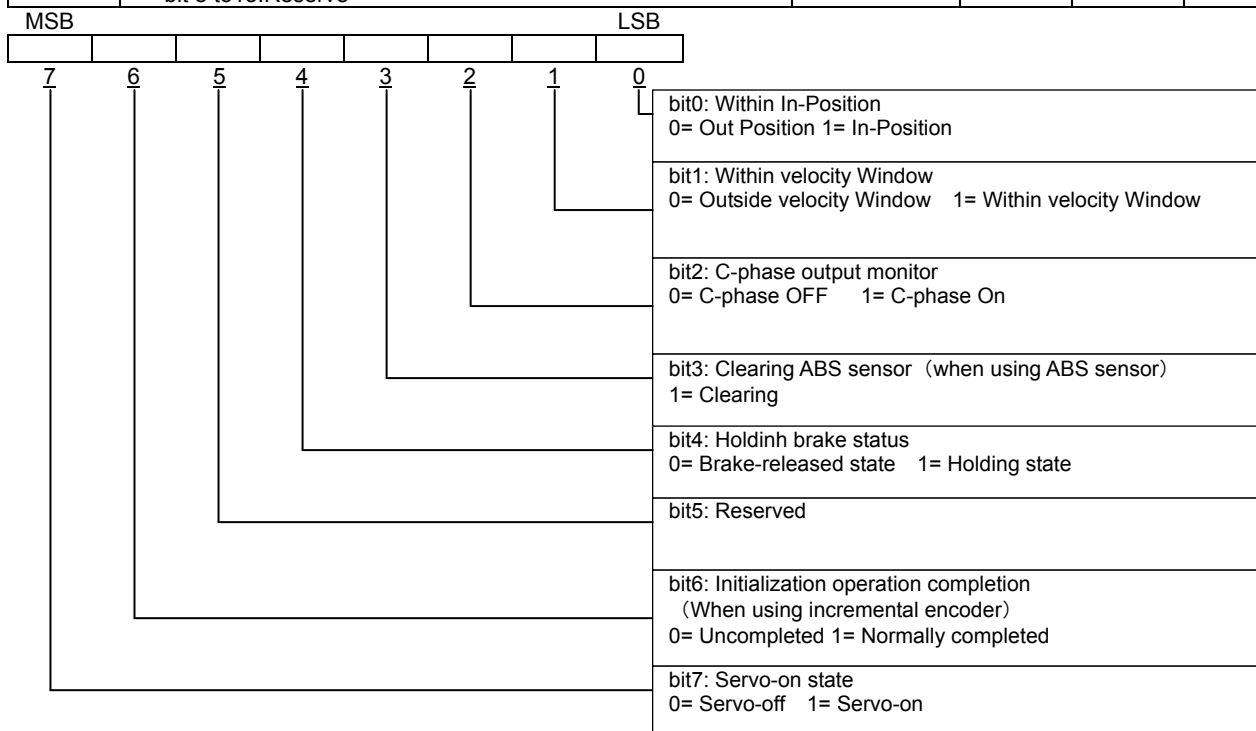
0x4041: Power Down

Index	0x4031	Set Power Down condition when drive stops.	Object code			Variable
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Number of entries		Unsigned8	RO	No	0x02
0x01	Power Down delay time Sets Power Down delay time after operation completion.		Unsigned8	RW	No	0x7F
			Setting range	0x00 to 0xFF		
			Unit	1ms/LSB		
0x02	Power Down time constant Sets current time constant at Power Down. Sets the amount of current change per 1ms.		Unsigned32	RW	No	0xFF
			Setting range	0x01 to 0xFF		
			Unit	-		

7.Object Dictionary

0x4100: Status word 1

Index 0x4100			Manufacturer specific driver status		Object code		Variable
Sub-Idx	Description			Data Type	Access	PDO	Initial value
0x00	Status word 1 Sends back various driver states. *bit 8 to 15: Reserve			Unsigned16	RO	Possible	-



0x4101: Alarm history

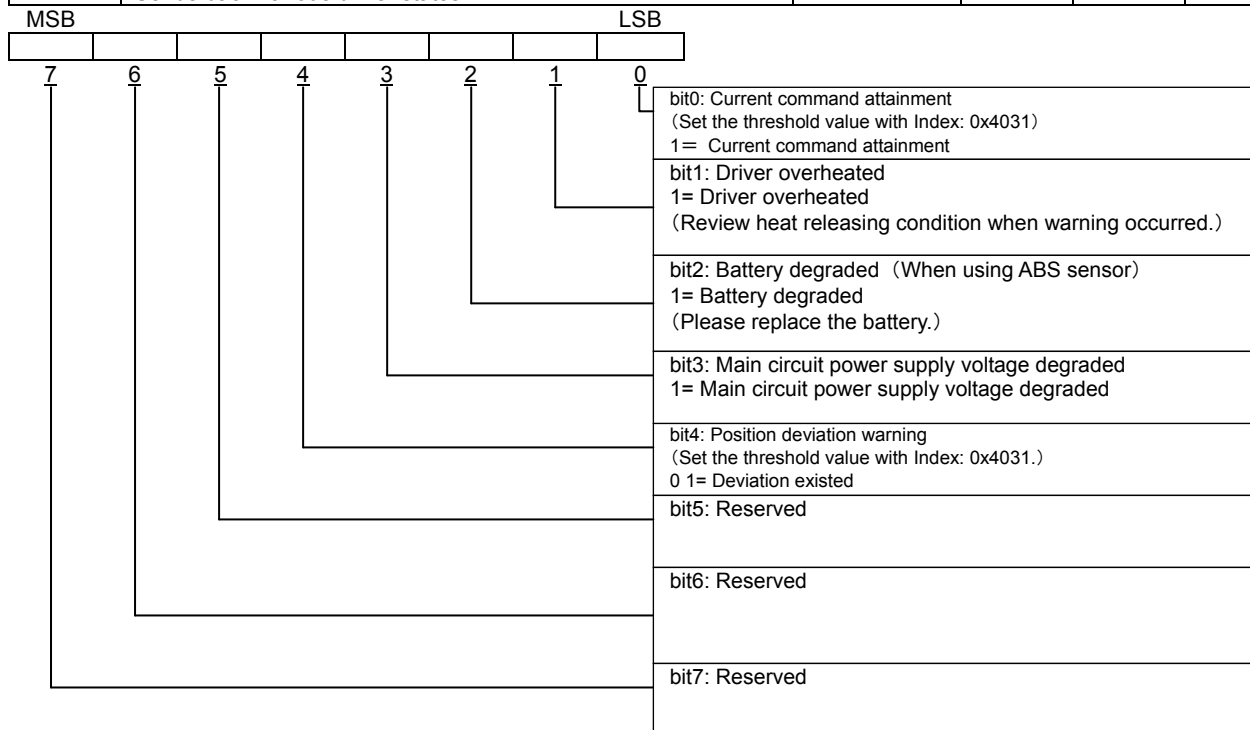
0x4101: Alarm history

Index	0x4101	Displays history of alarms presently occurring or occurred in the past. Refer to section 10.3 for the details of alarm codes to be saved.	Object code		Variable	
Sub-Idx	Description		Data Type	Access	PDO	Initial value
0x00	Number of entries (Number of alarm messages)		Unsigned8	RO	No	0x08
0x01	Present alarm code		Unsigned8	RO	Possible	-
0x02	The last alarm status		Unsigned8	RO	No	-
0x03	The second status from the last		Unsigned8	RO	No	-
0x04	The third status from the last		Unsigned8	RO	No	-
0x05	The 4th status from the last		Unsigned8	RO	No	-
0x06	The 5th status from the last		Unsigned8	RO	No	-
0x07	The 6th status from the last		Unsigned8	RO	No	-
0x08	The 7th status from the last		Unsigned8	RO	No	-

7.Object Dictionary

0x4102: Warning status

Index	0x4102	Displays warning occurrence state. Displays all the warnings occurred after turning on power supply. Warning status is cleared by turning off the power supply.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x00	Warning status Sends back various driver states.		Unsigned16	RO	Possible



0x4103: Driver temperature monitor

Index	0x4103	Reads out driver temperature.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x00	Reads out driver temperature.		Unsigned16	RO	No
			Unit	1 °C	

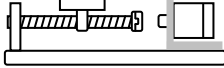
0x4104: Main circuit power supply voltage monitor

Index	0x4104	Reads out main circuit power supply voltage.	Object code		Variable
Sub-Idx	Description		Data Type	Access	PDO
0x00	Reads out main circuit power supply voltage.		Unsigned16	RO	No
			Unit	0.1V	

8. Operation

8.1 Test operation

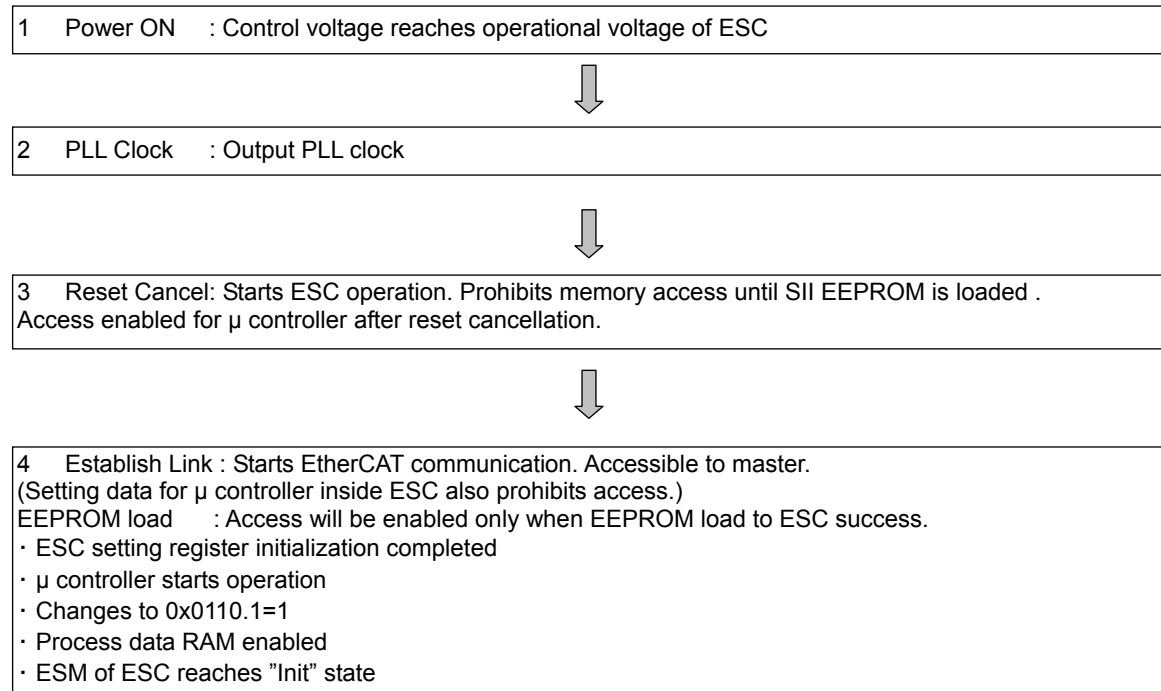
Installation, wiring and jog operation

Process	Items and Contents
1	Installation
	Install driver and motor according to "Installation : chapter 2" . Motor shaft should be in disengaged state and machine should not be connected. 
2	Set the motor code (In the case of an incremental sensor)
	Please wire only a power supply in accordance with the contents of "wiring (Chapter 3)." Turn on a control circuit power supply (DC24V). Please set up Motor Code with reference to "a digital operator (Chapter 4)." ▪ Slide Switch=On (Parameter mode) ▪ The function 6 (7) is chosen by SW1. ▪ Data=Motor code→SET ▪ After SET, after 3 sec or more passes, please intercept a control power.
3	jog operation
	Please wire a motor and encoder in accordance with the contents of "wiring (Chapter 3)." However, please do not connect CN0 (port 0), CN1 (port 1), and CN7 (IO) to a driver. Switch on a control power (DC24V). Check that alarm LED (7SEG) is not displayed . When alarm code is displayed, please take a measure in accordance with the contents of "Trouble-shooting (Chapter 11)." Switch on a Main power (DC24/48V). Check that alarm LED (7SEG) is not displayed . When alarm code is displayed, please take a measure in accordance with the contents of "Trouble-shooting (Chapter 11)." Please check that a motor turns normally by Jog operation with reference to "a digital operator (Chapter 4)." ▪ Slide Switch On (Parameter mode) ▪ The function 9 (A) is chosen by SW1. ▪ Data=1→SET→2→SET→3→SET (Switch on state) ▪ Slide-switch OFF (Status indication mode) ,then Please check becoming 7SEG LED = Figure-of-eight ▪ Slide-switch On (Parameter setting mode) ▪ The function 1 is chosen by SW1 and it is arbitrary Jog speed setting. ▪ The function 2 or 3 is chosen by SW1 and drive the Jog operation.

8. Operation

8.2 ESC Power ON Sequence

Shows PB EtherCAT driver power ON sequence at input of control power supply.



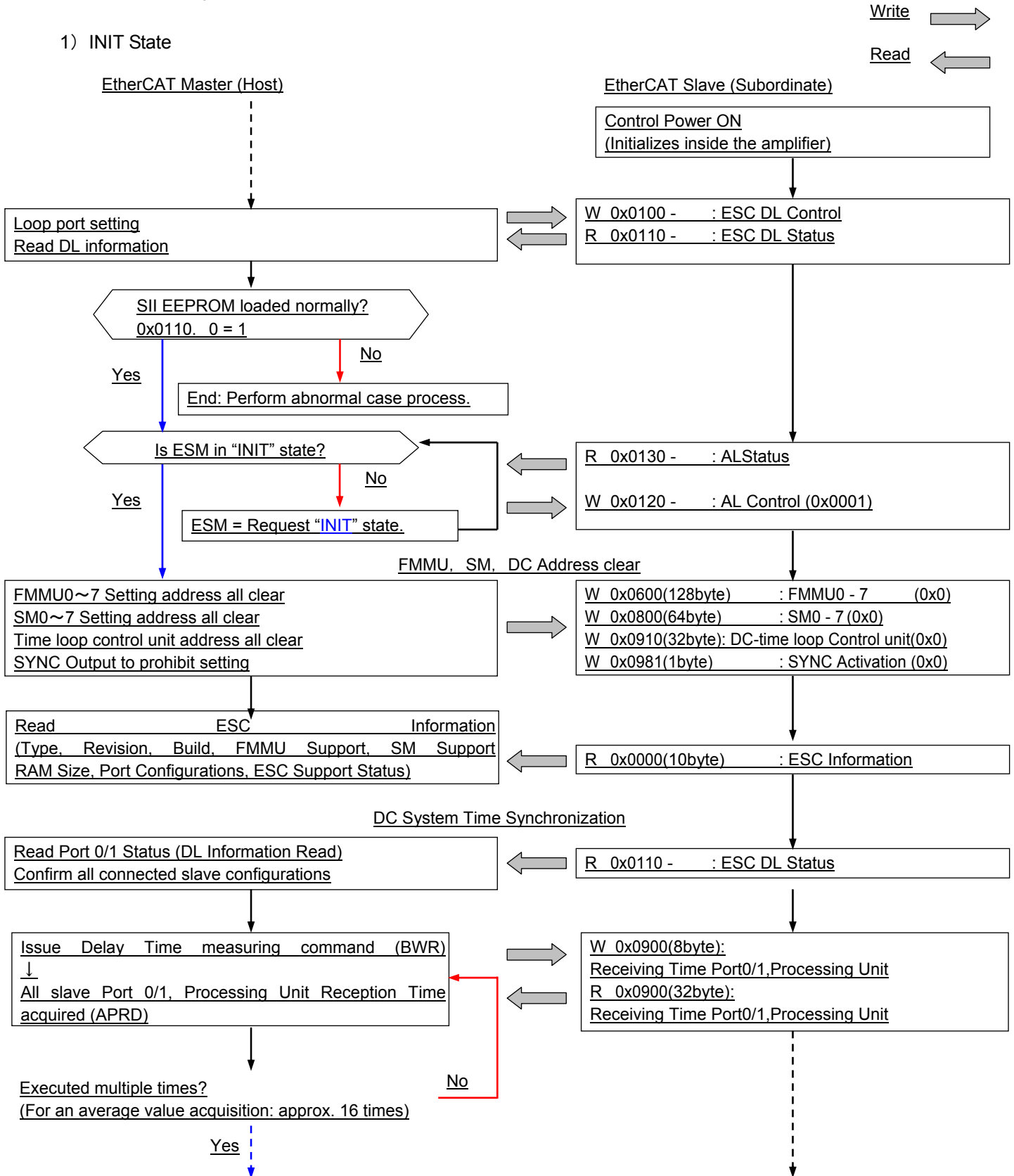
ESC Power ON Sequence

8. Operation

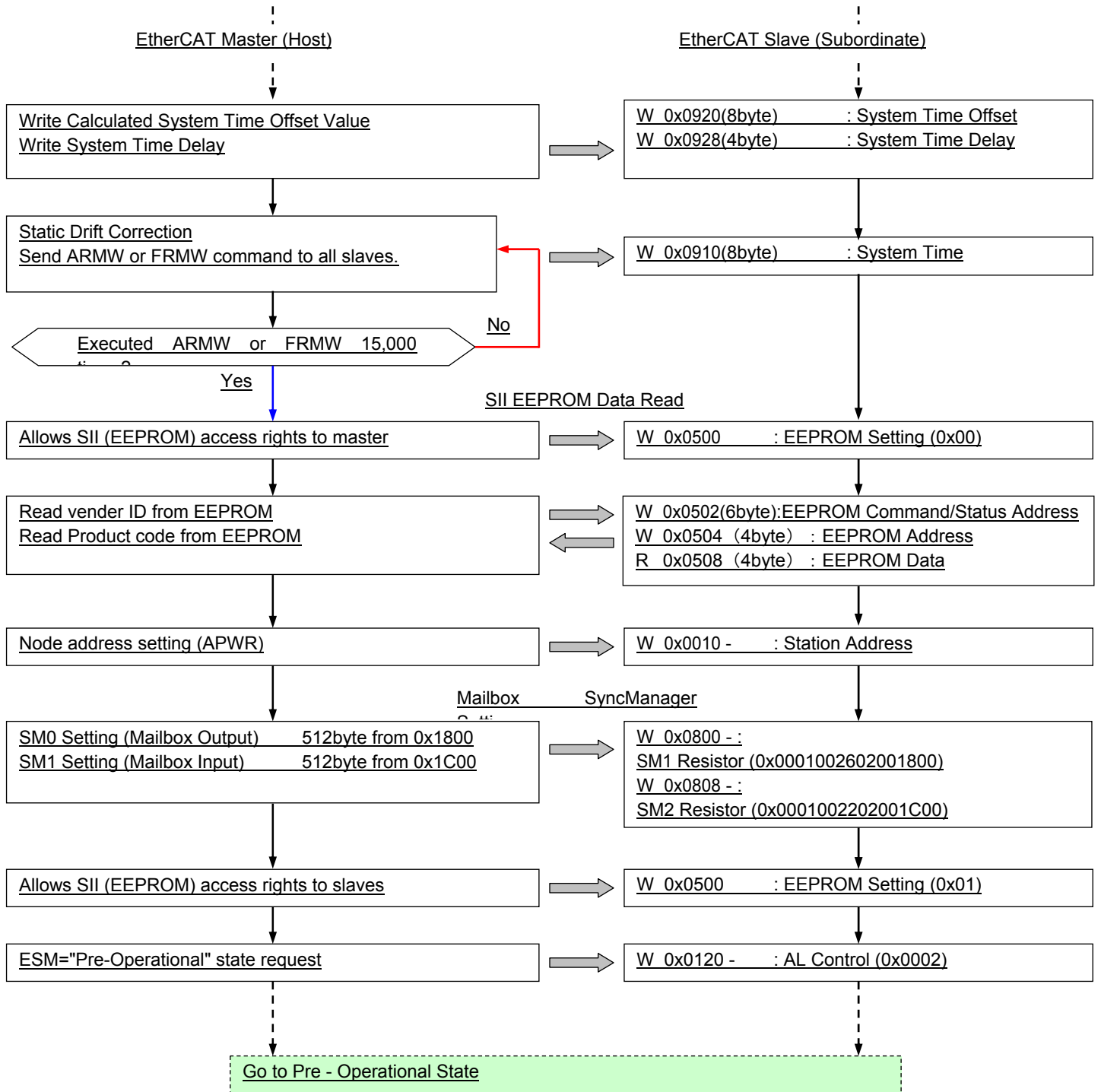
8.3 EtherCAT Initialization Process

Various parameter settings from master to slave datalink layer and application layer are required to begin cyclic communication after control power of slave amplifier has been established.
The following procedure is an example of the initialization process:

1) INIT State



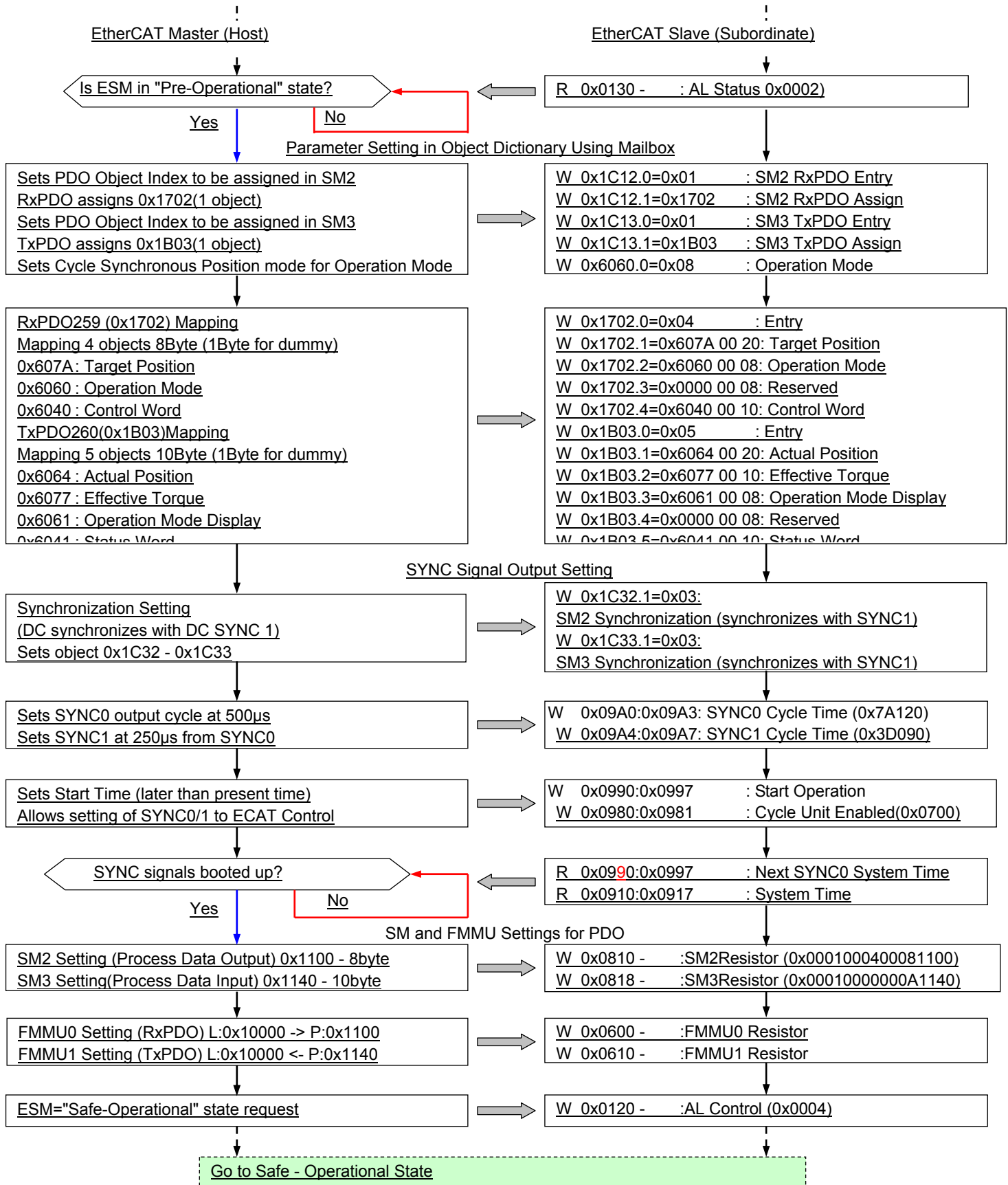
8. Operation



Initialization Procedure Example "INIT State" -2

8. Operation

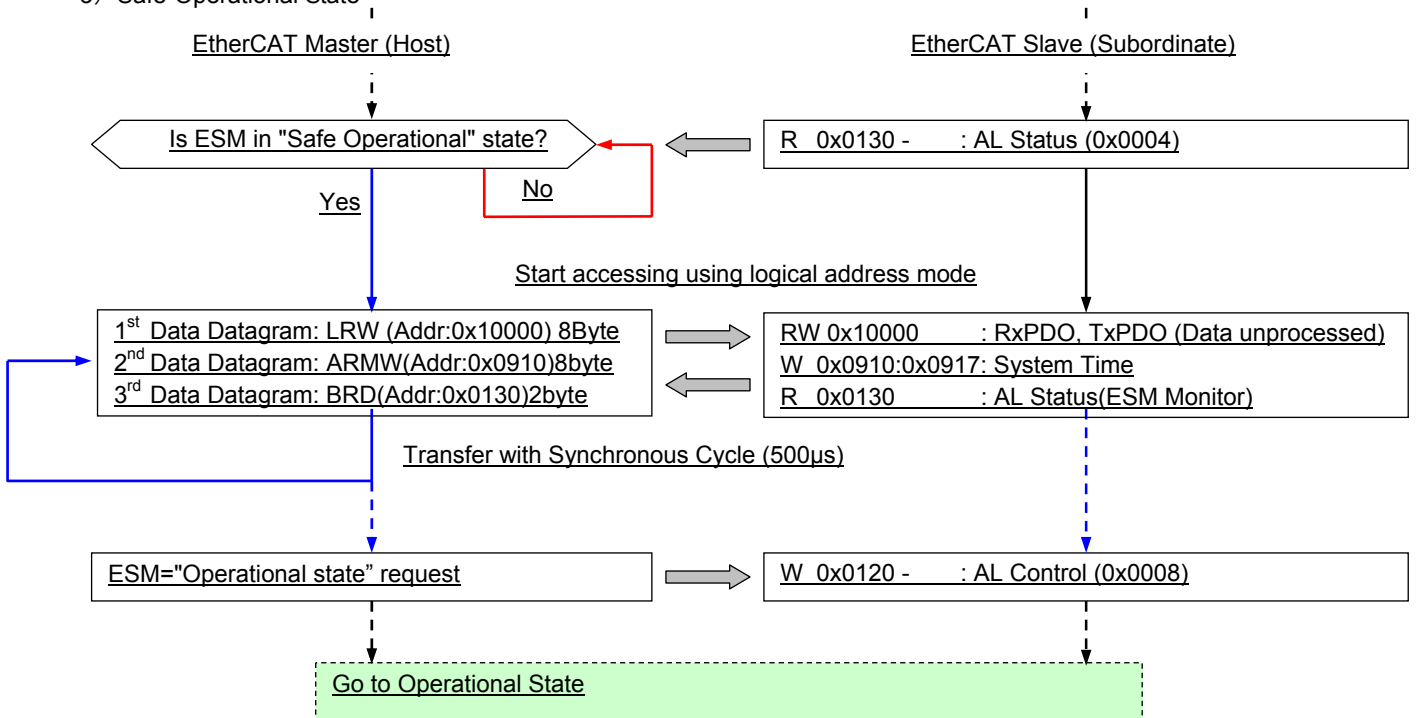
2) Pre-Operational State



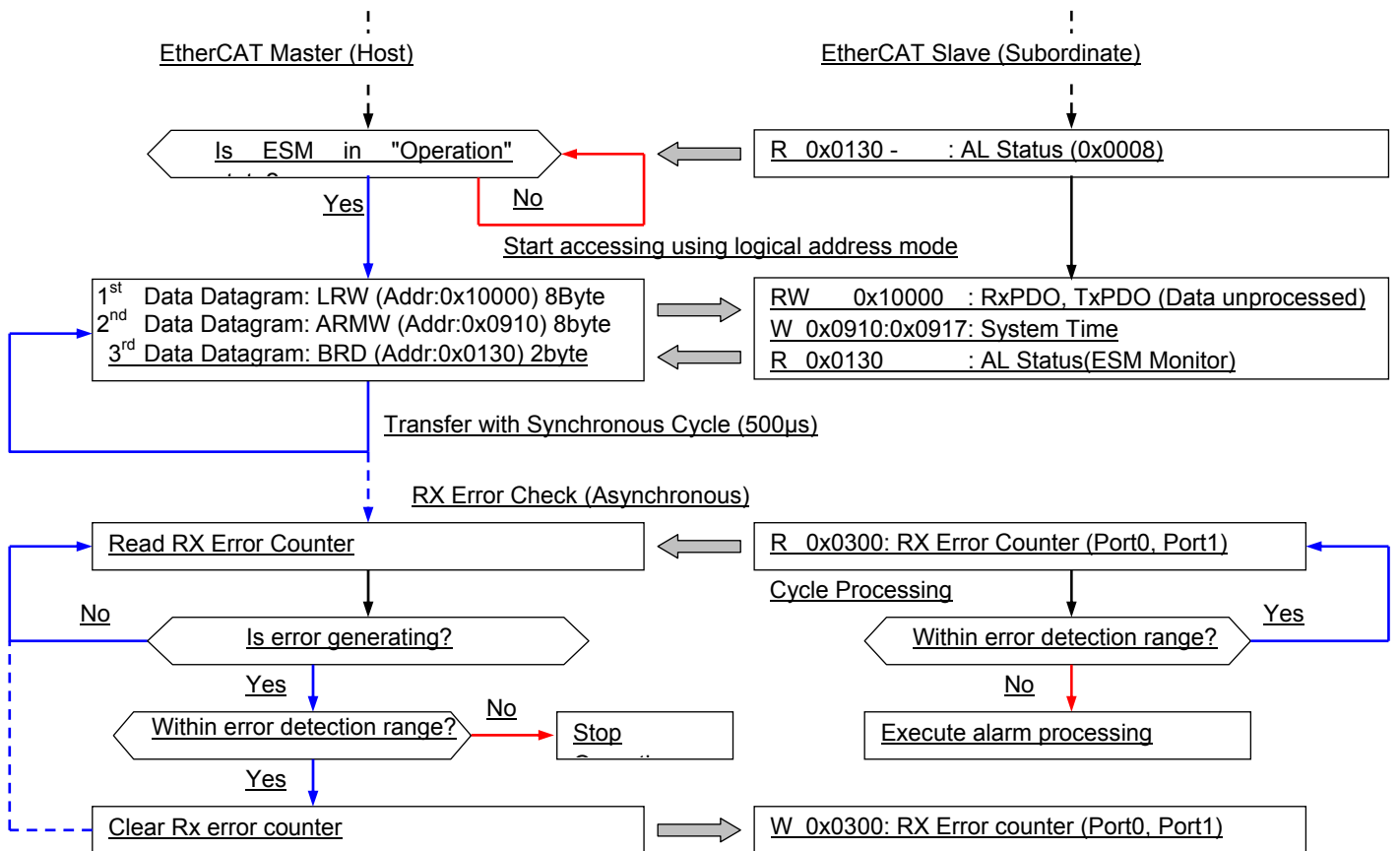
Initialization Procedure Example (Pre-Operational State)

8. Operation

3) Safe-Operational State



4) Operational State



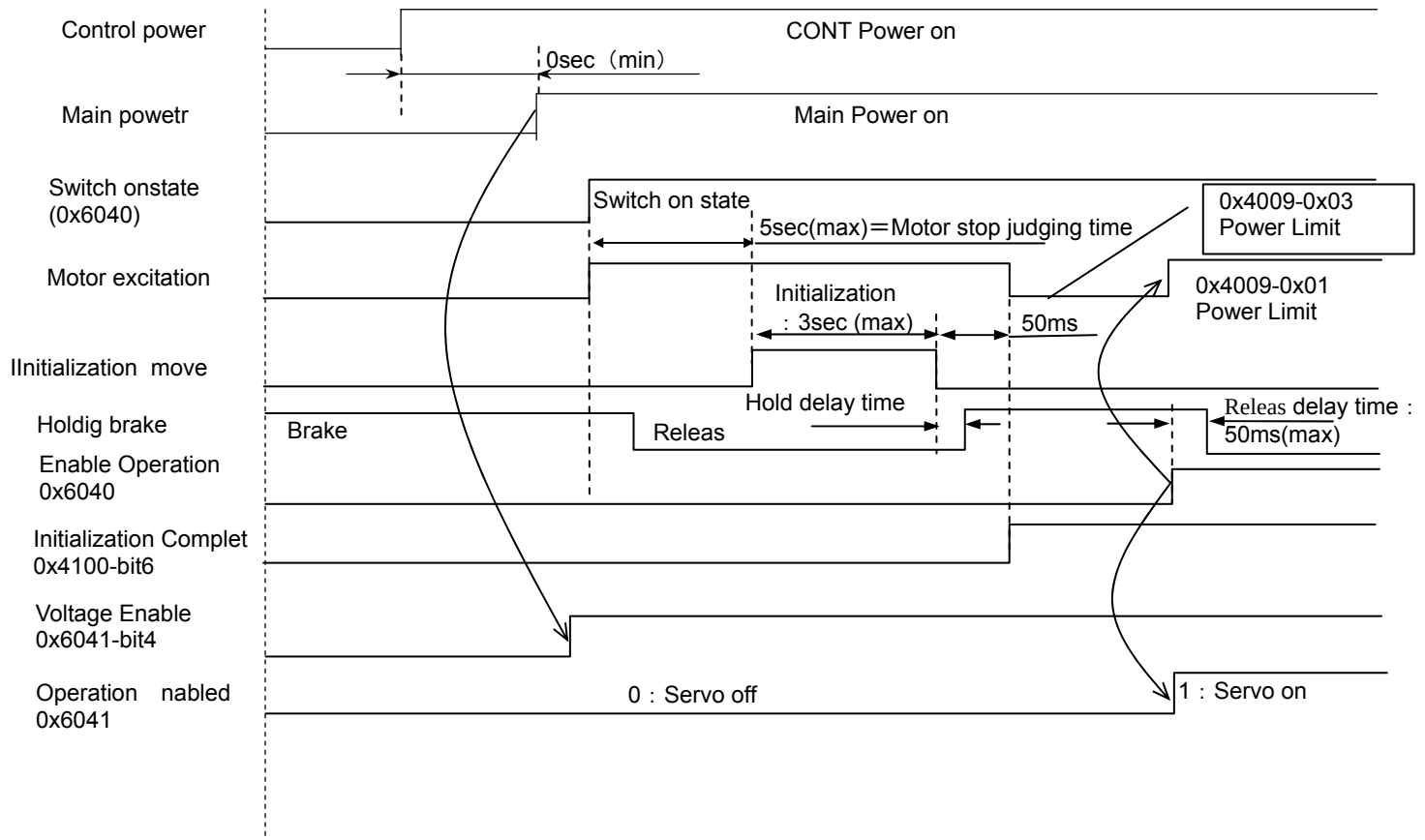
Initialization Procedure Example (Operational State)

8. Operation

8.4 Operation Sequence

Operation Sequence from Power ON to Power OFF(in case of incremental sensor type)

1) Power on → Servo on



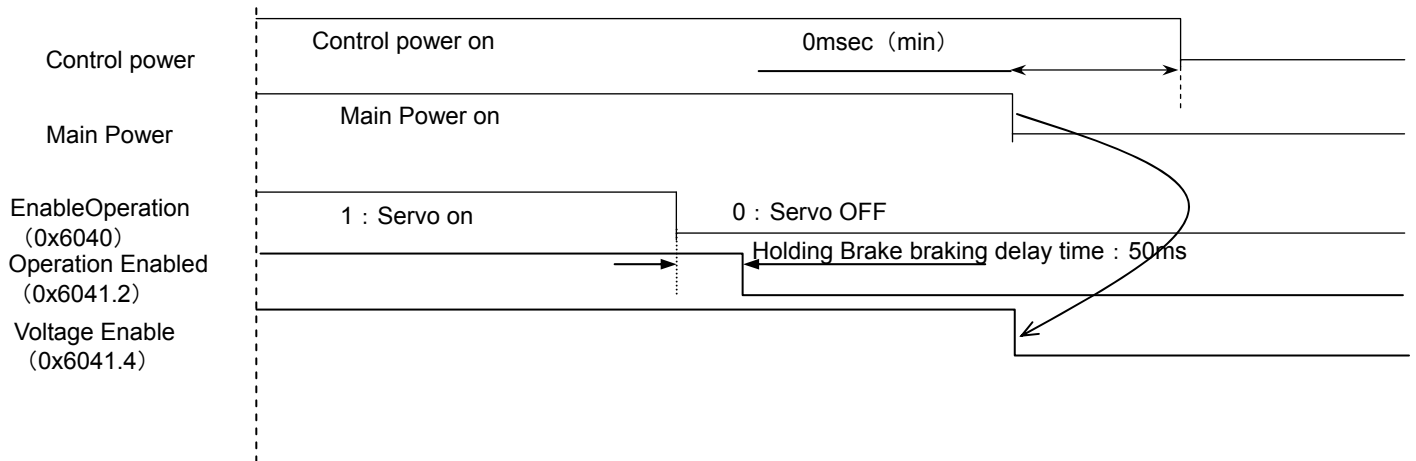
Initialization operation is performed only at the time of a first time power supply injection. In initialization operation, the motor shaft move.

A driver controls a holding brake. In a servo OFF state, control by 0x60FE is possible. A holding brake has releas delay time. So please do not operation at 50 ms after servo-on.

- * Power ON/OFF cannot occur over 30 times a day and 5times/houre.
- * Power reset must occur after more than 10 minute have elapsed from Power OFF.

8. Operation

2) Servo OFF → Power OFF



3) Motor Stop method

Trigger	F S A	Motor stop method	motor excitation state after a stop
Main Power OFF	Switch on Disable	Gate OFF	No excitation
HWGOFF input=On	Switch on Disable	Gate OFF	No excitation
Disable Voltage	Switch on Disable	Gate OFF	No excitation
Shut Down	Ready to Switch on	Gate OFF	No excitation
Disable Operation	Switch on	Gate OFF	Followed 0x4009-0x03
Quick Stop	Followed 0x605A	Followed 0x605A	based on the state after changes.
Halt	Operation enable	Followed 0x605D	Followed 0x4009-0x01

8. Operation

8.5 Adjustments

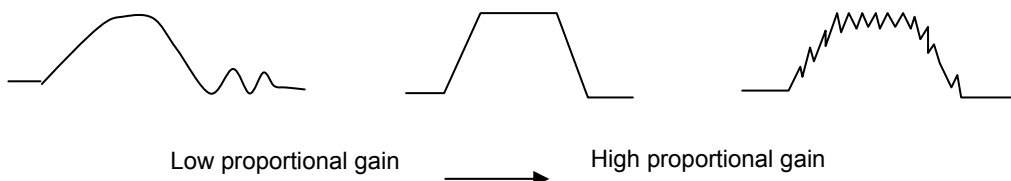
Adjustments parameter is different with operational modes.

Operation mode		Adjustments parameter :Index
pp/hm	Profile position mode /Homing	Velocity loop proportional gain : 0x4007 Velocity loop integral time constant : 0x4008 Velocity feedback LPF : 0x4006 Two-axis synchronous operation gain : 0x4023 *1
csp1	Cycle Synchronization Position Mode1	Position loop proportional gain : 0x4002 Velocity loop proportional gain : 0x4007 Velocity loop integral time constant : 0x4008 Feed Forward : 0x4004 S-Shape filter : 0x4001 Velocity feedback LPF : 0x4006
csp2	Cycle Synchronization Position Mode2	csp2 Velocity loop proportional gain : 0x400A S-Shape filter : 0x4001 Velocity feedback LPF : 0x4006
csv	Cycle Synchronization Velocity Mode	Velocity loop proportional gain : 0x4007 Velocity loop integral time constant : 0x4008 Velocity feedback LPF : 0x4006
pv	Profile Velocity mode	Velocity loop proportional gain : 0x4007 Velocity loop integral time constant : 0x4008 Velocity feedback LPF : 0x4006

*1 When 2 axis synchronous operation is permitted

■ Velocity loop proportional gain : 0x4007/0x400A

Increase the proportional gain of the velocity loop gradually as long as there is no oscillation in the motor or the load. As the gain increases, the velocity waveform changes as shown below. By increasing the proportional gain as much as possible without oscillation, high response can be achieved.



■ Velocity loop integral time constant : 0x4008

As this is the delay factor for the servo system, a low setting will adversely affect responsiveness. On the other hand, a high setting may render the servo system unstable. Select an appropriate value after checking the vibration and oscillation status of the mechanical system.

■ Position loop proportional gain : 0x4002

By increasing the proportional gain of the position loop, the responsiveness becomes higher and shortens the positioning time. However, it may reduce oscillation in case of low rigidity in the mechanical system. Adjust the gain within the range of no oscillation of the load.

■ Feed Forward : 0x4004

Increase the setting value gradually, as long as there is no oscillation, to improve the ability to follow the position command. It is not necessary to set this when the position deviation is not a problem during operation.

When the setting value is too high, the oscillation or the noise of the motor will increase.

■ Adjustment according to operation profile

If overshooting during acceleration or undershooting during stoppage is not solved by gain adjustment, it may be due to torque shortage.

Check the motor size, load conditions or operation profile (moderate acceleration/deceleration rate).

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9. Specifications

9.1 Driver Basic Specifications

Driver Basic Specifications					
Driver Model		PB4D003E2D0		PB4D003EAD0	
Sensor		Incremental sensor (500P/R)		Absolute sensor (17bit+16bit)	
Related motor		PBM282,284,423,603,604		PBM423,603,604	
Power supply		Main Power supply DC24/48V ±10% Control Power supply DC24V ±10%			
Control Mode		PWM control SIN drive method			
Environment	Ambient Temp.	Operating		0~55℃	
		Storage		-20~65℃	
	Operating and Storage Humidity		Maximum 90% RH (non-condensing)		
	Vibration Resistance		0.5G (tested with frequency range 10 to 55 Hz, X, Y, Z each direction 2H)		
	Shock		5G		
	Elevation		Below 1000 m from the sea level		
	Structure		Tray structure Rear mounting type		
Weight		Approximately 0.5Kg			
Dimensions		W45×H160×D95			
Functions	Rotation Speed		0 ~ 4500 min ⁻¹ (The maximum speed difference with power supply voltage or motors.)		
	Resolution (P/R)		10000		32768
	Regeneration Process		Regeneration resistance (Option)		
	Holding Brake Control		Internal		
	Protective Functions		Power Voltage Error, Regeneration Voltage Error, Over-speed, Encoder Disconnection, Wrap around, CPU Error, Overload Stop, Servo error, Motor Overheat, Amplifier Overheat, Zero-return Error, Nonvolatile Memory Error, Initialization Error, Over-current, OVF etc		
	Display		7SEG LED Display(2 pieces)		
	Digital Operator		Related motor, Jog drive, Node address, Holding brake Control		
	The physical layer/protocol		100BASE-TX／IEEE802.3 Ethernet		
	Communication speed		100Mbit/s full duplex		
	Communication port / topology		2 port(RJ45)／Daisy chain (a maximum of 65535 node)		
	Device profile		Co E (IEC61800-7-201), Fo E (ASCII code Access)		
	Synchronization		SM2 Event Synchronization, DC Mode (SYNC0/1 Event Synchronization), Free Run Mode * 0x1C32,0x05: Minimum Cycle Time=1ms		
In/output signal	Input Signals		Interactive input Photocoupler DC5~24V Positive/negative limit, HOME, Touch probe, Hard gate off		
	Output signals		Open collector DC30V／15mA max Hard gate off monitor, General purpose output		

9. Specifications

9.2 Motor Standard Specifications (No Gear, no holding brake)

9.2.1 Motor Standard Features

Motor Model	Unit	PBM282FXE50	BM284FXE50	BM423FXE50	PBM603FXE50	BM604FXE50
Maximum Stored Torque	N·m	0.055	0.12	0.39	1.3	1.9
Rotor Inertia	$\times 10^{-4} \text{kg} \cdot \text{m}^2$	0.008	0.016	0.056	0.4	0.84
Thrust Load Tolerance	N	9.8	9.8	9.8	14.7	14.7
Radial Load Tolerance *	N	33	33	49	167	167
Motor Weight	Kg	0.16	0.25	0.35	0.85	1.42

9.2.2 Load Tolerances

Motor Model	Unit	PBM282FXE50	BM284FXE50	BM423FXE50	PBM603FXE50	BM604FXE50
Maximum Inertia Tolerance	$\times 10^{-4} \text{kg} \cdot \text{m}^2$	0.08	0.16	0.56	4	8.4
Maximum Friction Torque	N·m	0.013	0.036	0.15	0.52	0.76
Maximum Side Load Tolerance	N·m	0.009	0.024	0.15	0.52	0.76

9. Specifications

9.2.3 Motor Common Specifications

Motor Model		—	PBM282,PBM284	PBM423,PBM603,PBM604
Encoder Specifications	Basic Divisions	P/R	500× 4 multiplier	
	Number of Channels	—	3	
	Maximum Response Frequency	kHz	37.5	
	Output Method	—	Line driver	
Absolute sensor	Resolution	—	2 ¹⁷	
	Multi-rotation resolution	—	65536	
	Response velocity at backup	min ⁻¹	10000	
	Response velocity	min ⁻¹	7500	
Common Specifications	Environment	Ambient Temperature	°C	-10 to +40°C (0°C to 40°C with Harmonic gear)
		Ambient Humidity	%RH	20 to 90 (non-condensing)
	Vibration Resistance		G	15 (Tested with frequency range 10~70 Hz Oscillation 1.52mm 70~2000 Acceleration 15G) Tested with sweep time 15 minutes / number of cycle sweeps X,Y,Z 12 times each
	Shock Tolerance		G	30 (Shock wave ; half sine wave, shock time ; 11ms X,Y,Z directions 3 times each)
	Withstand Voltage		V	AC500V 50/60Hz 1MIN AC1500V 50/60Hz 1MIN
	Insulation Resistance		MΩ	DC500V more than 100MΩ
	Insulation Class		-	Class B (130°C)
	Protection Class		-	IP40 Fully enclosed, self-cooling type
	Allowable Motor Surface Temperature		°C	Max 85°C. (Consider a radiation cooling method to ensure the temperature is below the specified limit)

9. Specifications

9.3 Motor Option Specifications

9.3.1 Spur Gear

1) PBM282

Motor Model	Unit	PBM282FGAE50	PBM282FGBE50	PBM282FGEE50	PBM282FGGE50	PBM282FGJE50	PBM282FGLE50
Reduction Gear Ratio	—	1:3.6	1:7.2	1:10	1:20	1:30	1:50
Torque Tolerance	N·m	0.1	0.15	0.2	0.35	0.5	0.5
Rotation Tolerance	min ⁻¹	800	400	300	150	100	60
Backlash	degree	2	2	2	1.5	1.5	1.5
Rotational Direction	Compared to the CMD	Forward	Forward	Reverse	Forward	Forward	Forward
Rotor Inertia	×10 ⁻⁴ kg·m ²	0.017					
Thrust Load Tolerance	N	10					
Radial Load Tolerance*	N	15					
Motor Weight	Kg	0.22					

9.3.2 Low-backlash gear

1) PBM423

Motor Model	Unit	PBM423FGAE50	PBM423FGBE50	PBM423FGEE50	PBM423FGGE50	PBM423FGJE50
Reduction Gear Ratio	—	1:3.6	1:7.2	1:10	1:20	1:30
Torque Tolerance	N·m	0.343	0.7	0.98	1.47	1.47
Rotation Tolerance	min ⁻¹	500	250	180	90	60
Backlash	degree	0.6	0.4	0.35	0.25	0.25
Rotational Direction	Compared to the CMD	Forward	Forward	Forward	Reverse	Reverse
Rotor Inertia	×10 ⁻⁴ kg·m ²	0.056				
Thrust Load Tolerance	N	15				
Radial Load Tolerance*	N	20				
Motor Weight	Kg	0.48				

9. Specifications

2) PBM603

Motor Model	Unit	PBM603FGAE50	PBM603FGBE50	PBM603FGEE50	PBM603FGGE50	PBM603FGJE50
Reduction Gear Ratio	—	1:3.6	1:7.2	1:10	1:20	1:30
Torque Tolerance	N·m	1.25	2.5	3	3.5	4
Rotation Tolerance	min ⁻¹	500	250	180	90	60
Backlash	degree	0.55	0.25	0.25	0.17	0.17
Rotational Direction	Compared to the CMD	Forward	Forward	Reverse	Reverse	Reverse
Rotor Inertia	×10 ⁻⁴ kg·m ²	0.4				
Thrust Load Tolerance	N	30				
Radial Load Tolerance*	N	100				
Motor Weight	Kg	1.22				

* There is no gear option for the PBM284 and PBM604.

* The load point is at 1/3 length from the output shaft.

9.3.3 Harmonic Gear

Motor Model	Unit	PBM282FHLE50	PBM282FHME50	PBM423FHJE50	PBM423FHLE50	PBM423FHME50
Reduction Gear Ratio	—	1:50	1:100	1:30	1:50	1:100
Torque Tolerance	N·m	1.5	2	2.2	3.5	5
Instantaneous Torque Tolerance	N·m	2.7	3.6	4.5	8.3	11
Rotation Tolerance	min ⁻¹	70	35	116	70	35
Lost Motion	minute	0.4~3 (±0.06N·m)	0.4~3 (±0.08N·m)	—	—	—
Hysteresis Loss	minute	—	—	3.6	2.4	2.4
Rotational Direction	Compared to the CMD	Reverse	Reverse	Reverse	Reverse	Reverse
Rotor Inertia	×10 ⁻⁴ kg·m ²	0.012		0.068		
Thrust Load Tolerance	N	9.8		1150		
Radial Load Tolerance*	N	33		209		
Motor Weight	Kg	0.27		0.54		

9. Specifications

Motor Model	Unit	PBM603FHLE50	PBM603FHME50
Reduction Gear Ratio	—	1:50	1:100
Torque Tolerance	N·m	5.5	8
Instantaneous Torque Tolerance	N·m	14	20
Rotational Tolerance	min ⁻¹	70	35
Lost Motion	minute	0.4~3 (±0.28N·m)	0.4~3 (±0.4N·m)
Hysteresis Loss	minute	—	—
Rotational Direction	Compared to the CMD	Reverse	Reverse
Rotor Inertia	×10 ⁻⁴ kg·m ²	0.435	
Thrust Load Tolerance	N	400	
Radial Load Tolerance*	N	360	
Motor Weight	Kg	1.45	

* There is no harmonic gear option for the PBM284 and PBM604.

* The load point is at 1/3 length from the output shaft.

9. Specifications

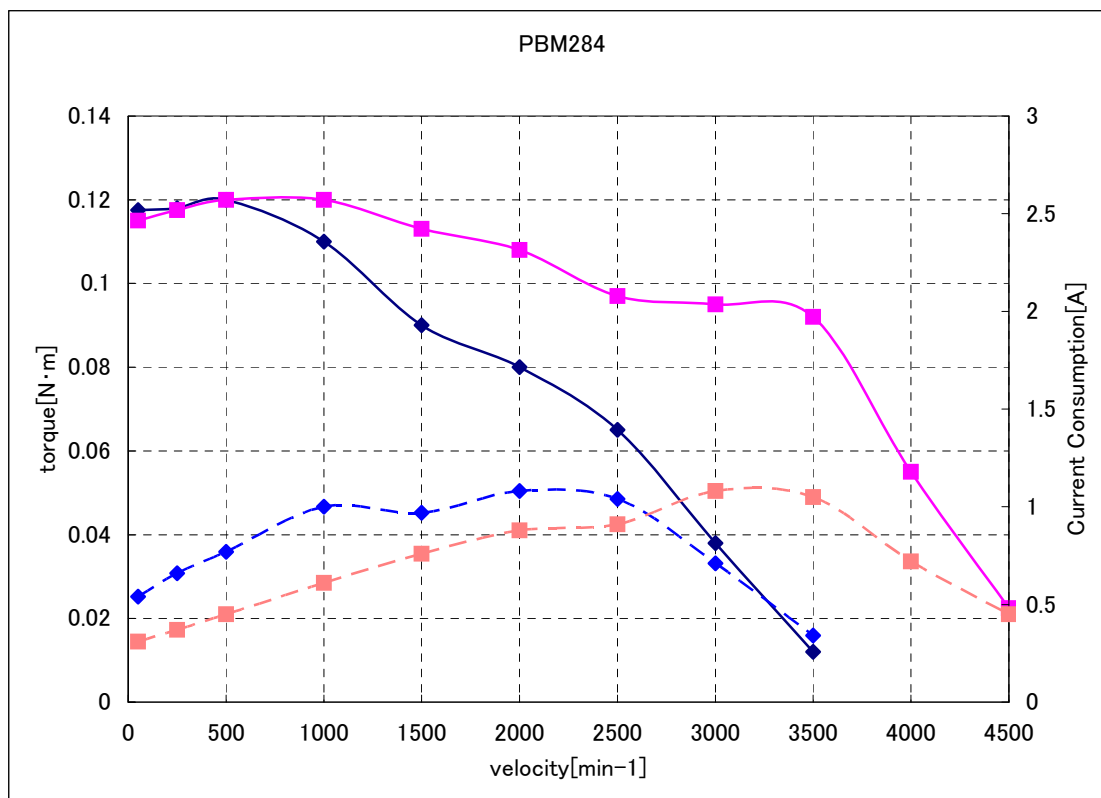
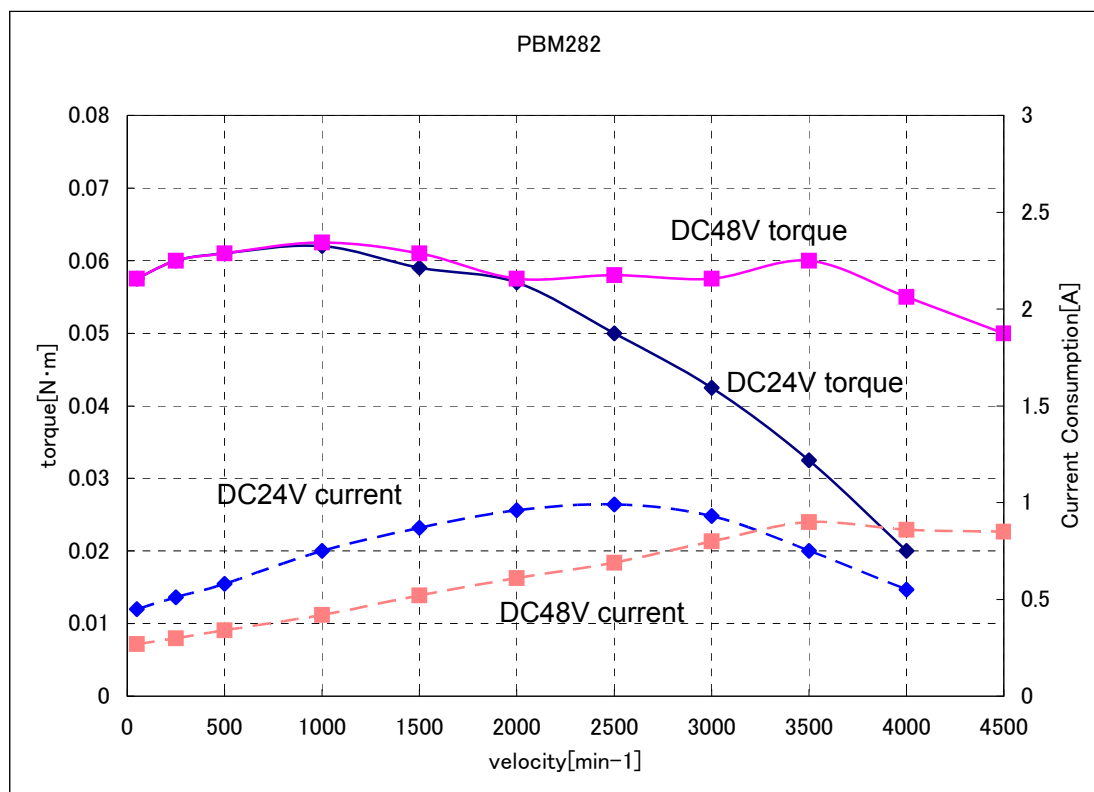
9.3.4 Holding brake

Motor Model	Unit	PBM282FCE50	BM284FCE50	BM423FCE50	PBM603FCE50	BM604FCE50
Operation Method	—			Non-excitation type		
Excitation Current	A	0.15	0.15	0.08	0.25	0.25
Power Consumption	W	3.6	3.6	2	6	6
Friction Torque	N·m	0.049	0.049	0.22	0.78	0.78
Motor Weight	Kg	0.28	0.35	0.5	1.19	1.76
Release Delay Time	ms			Max. 100		
Control Delay time	ms			Max. 50		

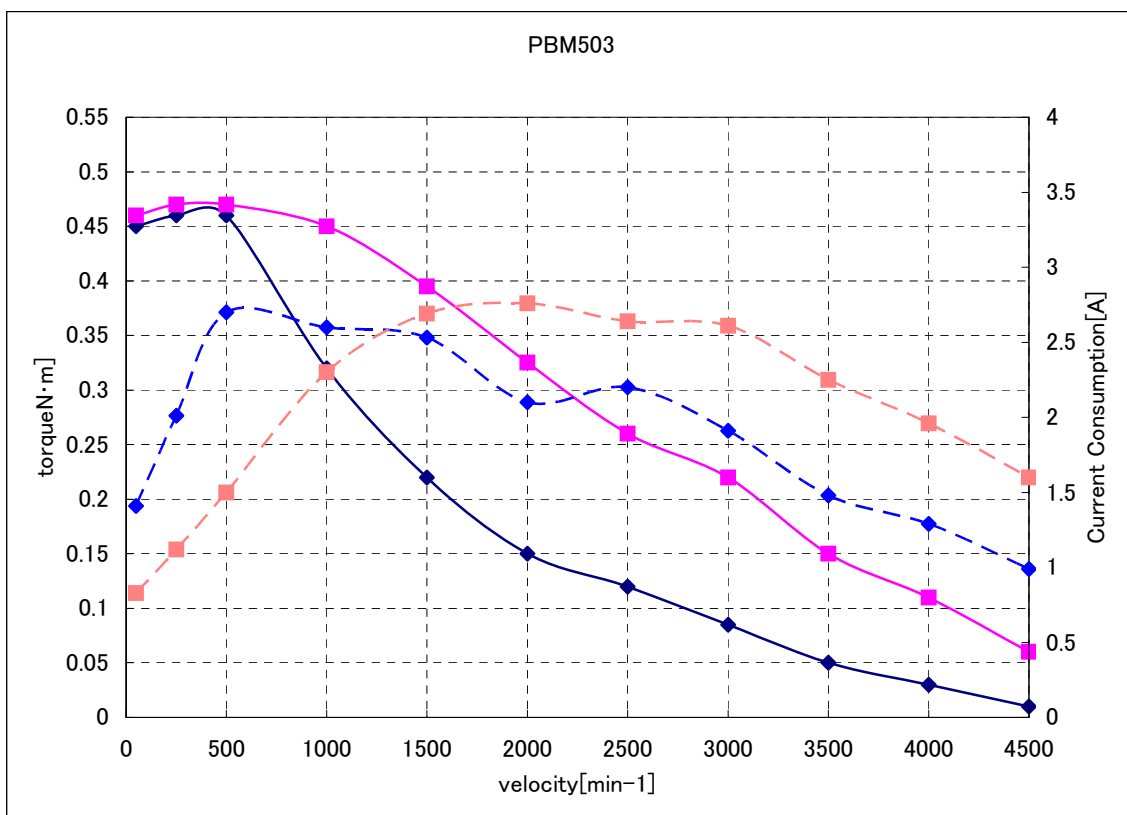
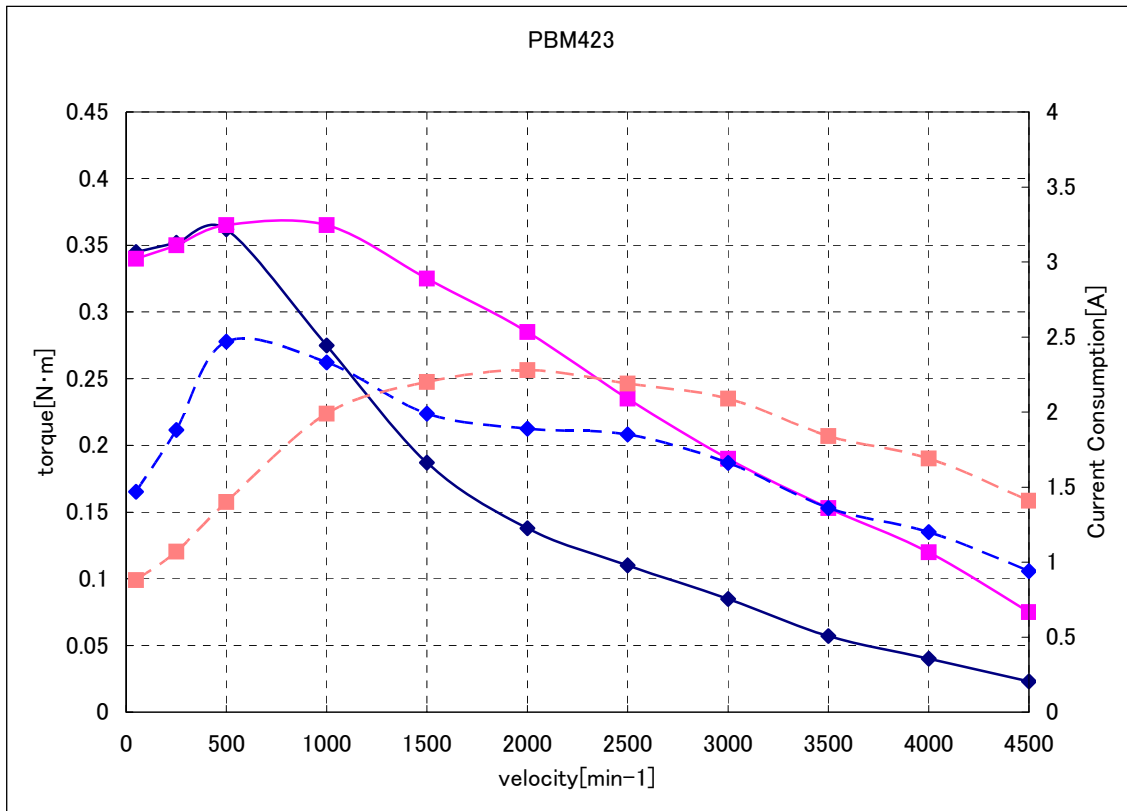
* The holding brake control function is built into the amplifier.

9. Specifications

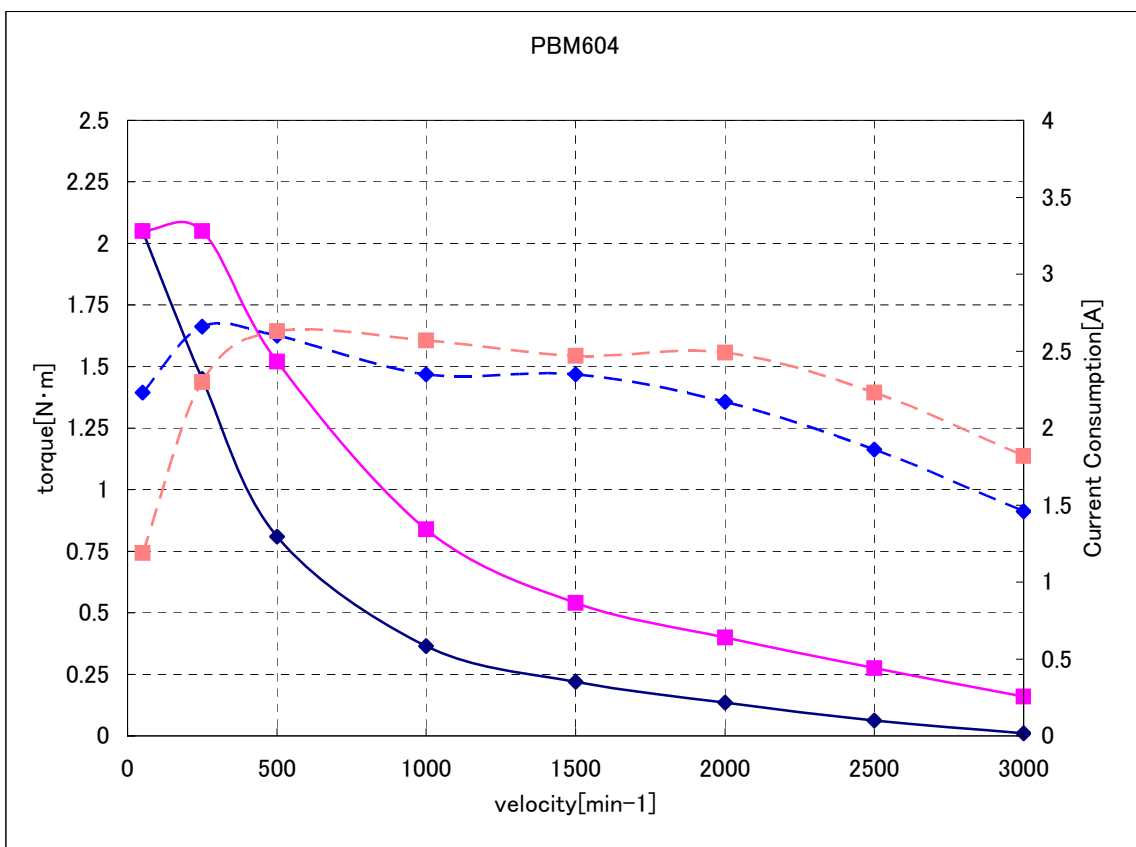
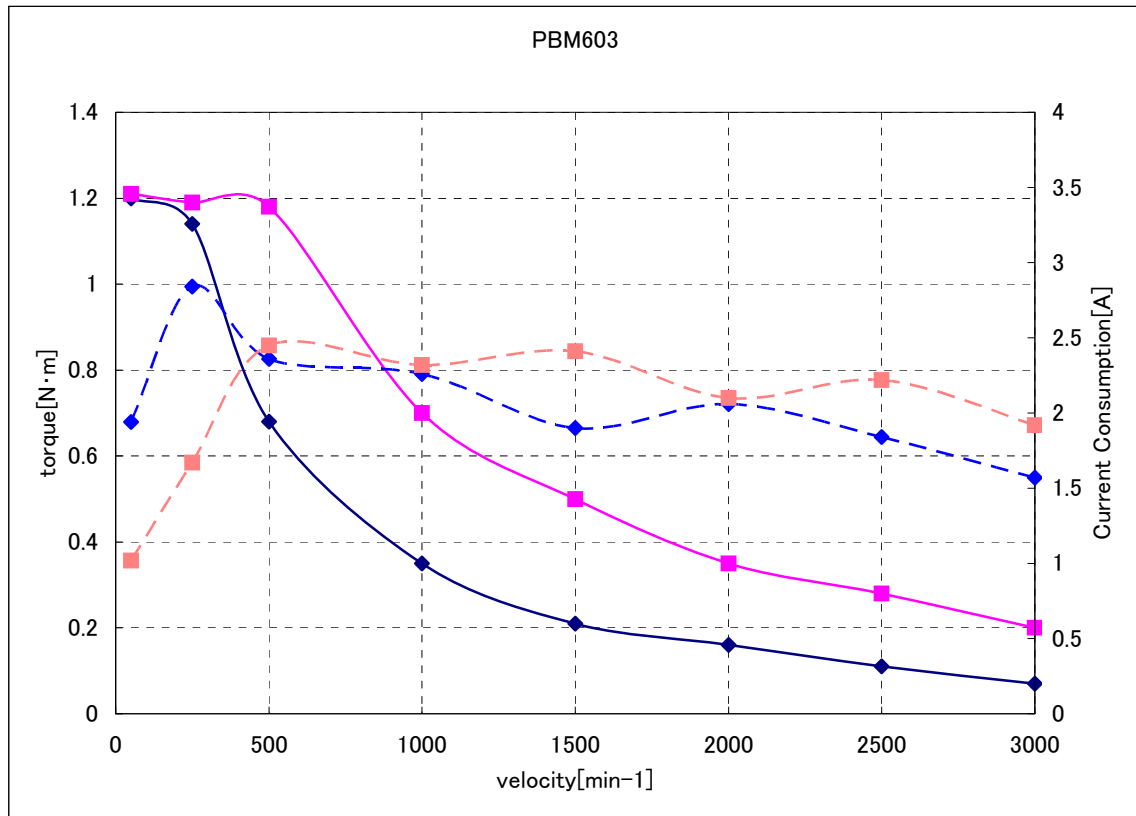
9.4 Velocity — Torque, Current Consumption (during drive) Characteristics



9. Specifications



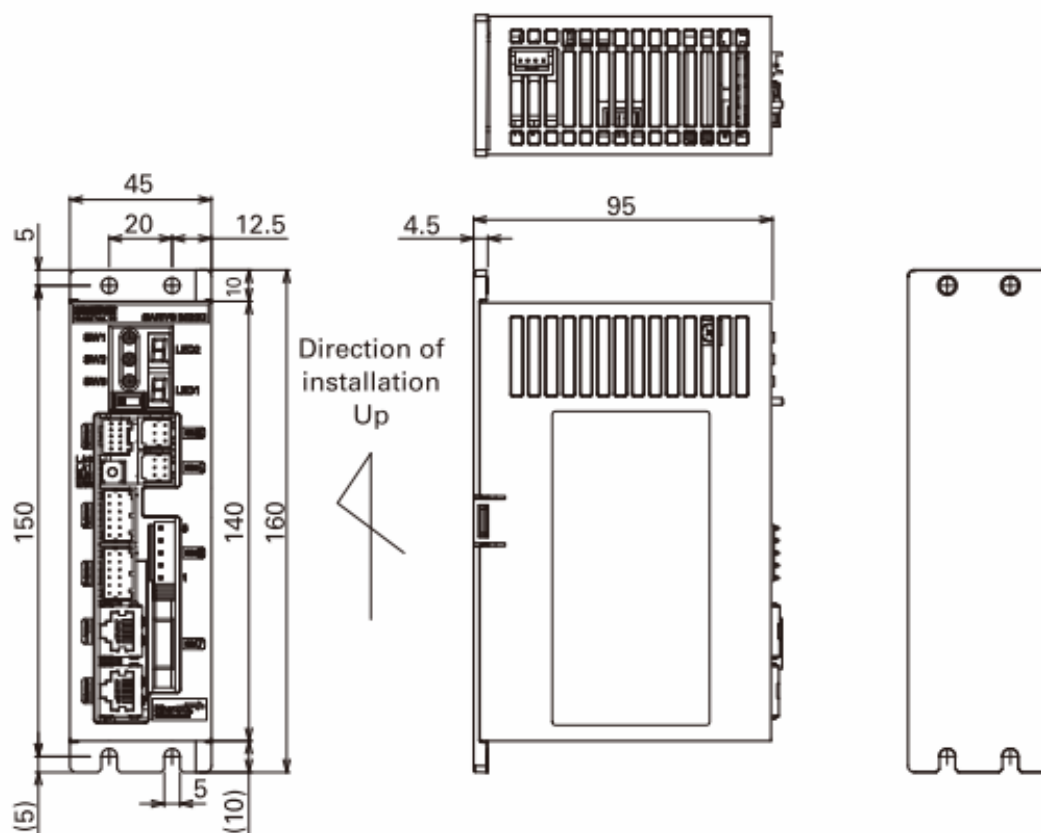
9. Specifications



9.Specifications

9.5 Dimensions

- 1) Driver dimensions



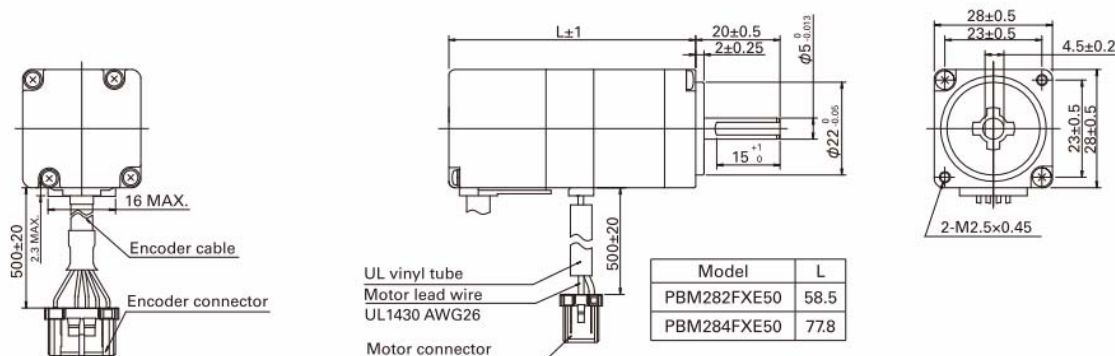
9.Specifications

2) MOTOR dimensions

28mm sq. (Incremental encoder)

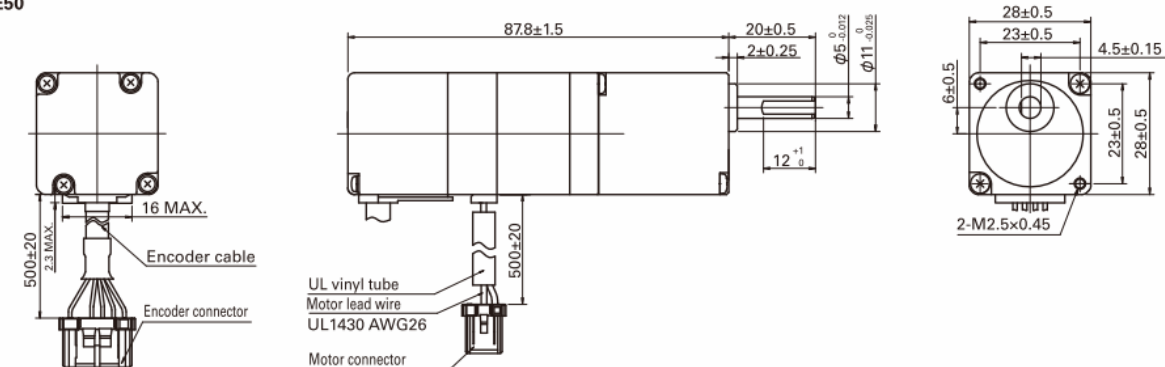
● Standard Model

PBM282FXE50
PBM284FXE50



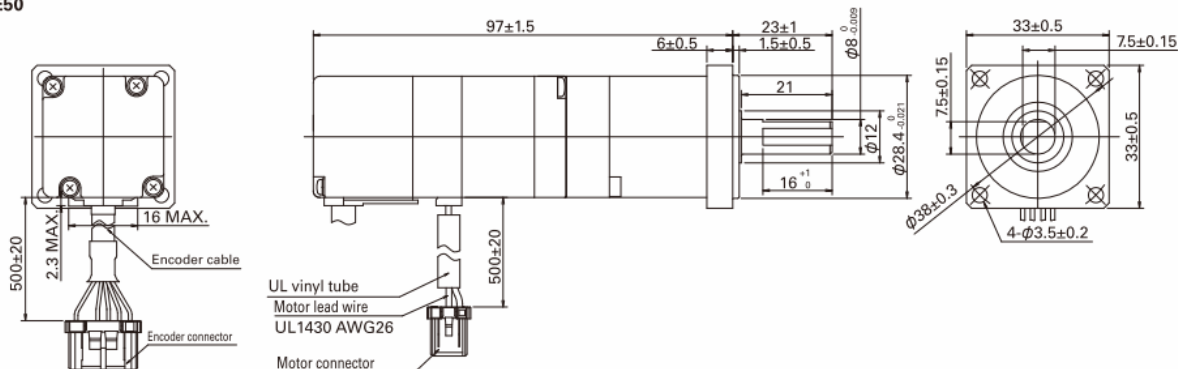
● Spur Gear Model

PBM282FG□E50



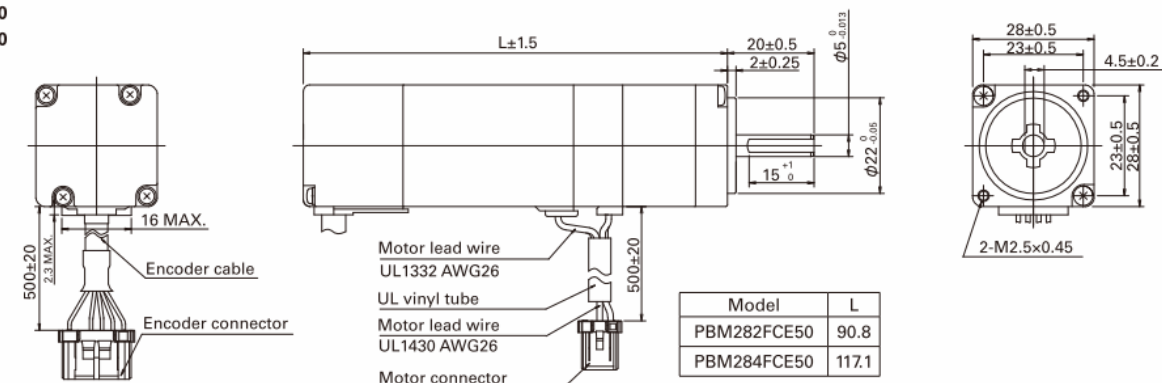
● Harmonic Gear Model

PBM282FH□E50



● Electromagnetic Brake Model

PBM282FCE50
PBM284FCE50

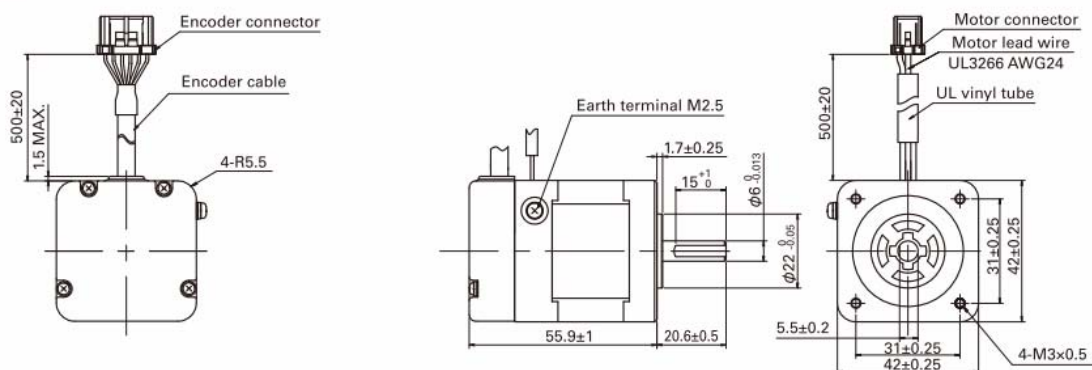


9.Specifications

42mm sq. (Incremental encoder)

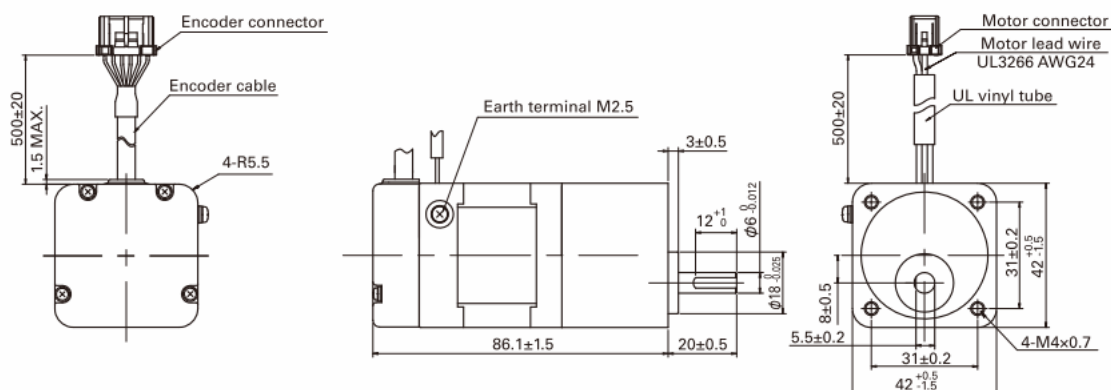
● Standard Model

PBM423FXE50



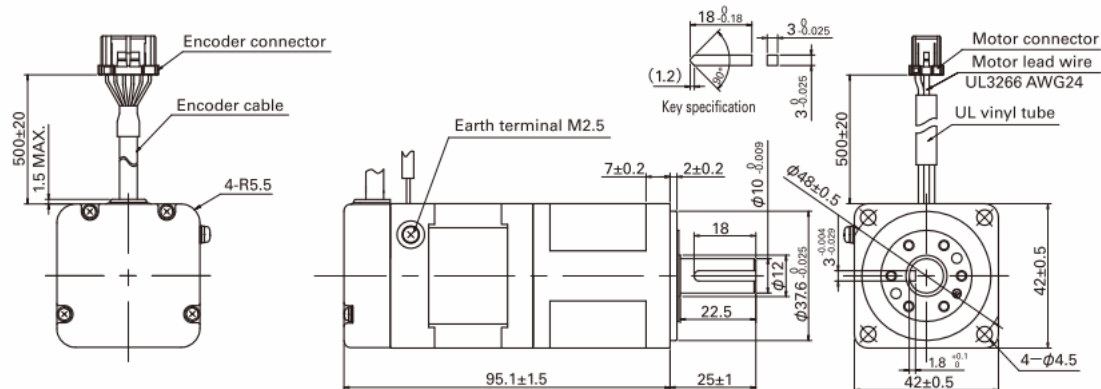
● Low-backlash Gear Model

PBM423FG□E50



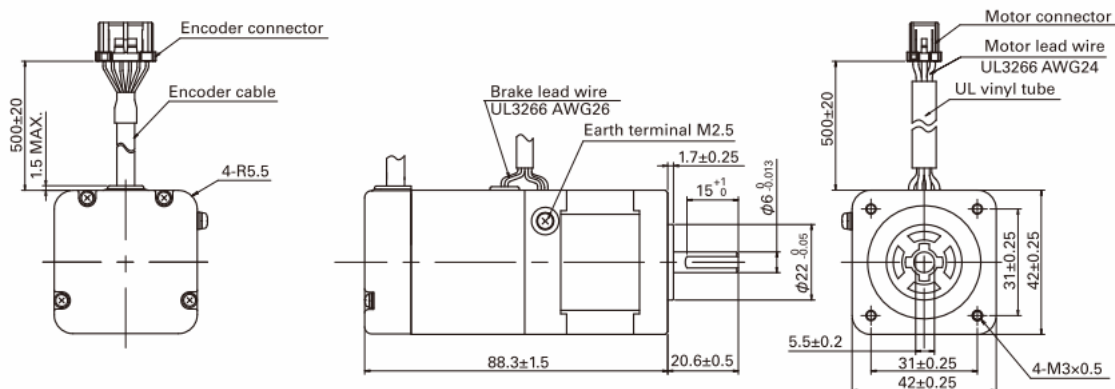
● Harmonic Gear Model

PBM423FH□E50



● Electromagnetic Brake Model

PBM423FCE50

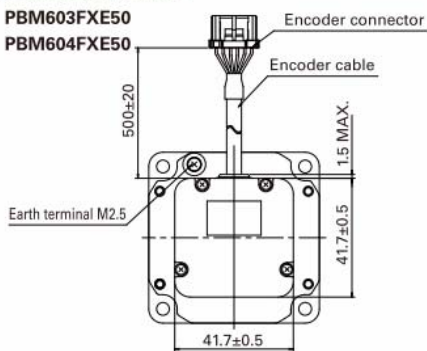


9.Specifications

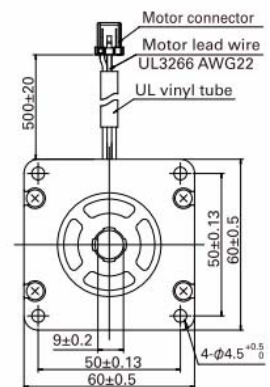
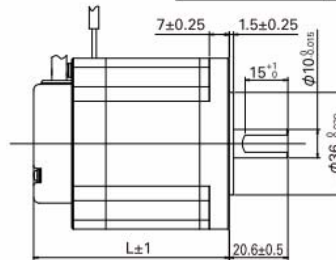
60mm sq. (Incremental encoder)

● Standard Model

PBM603FXE50
PBM604FXE50

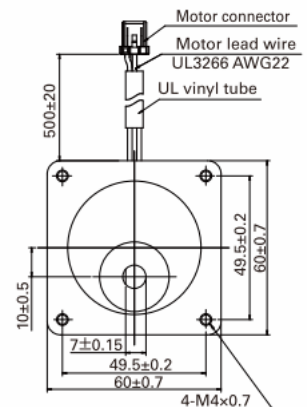
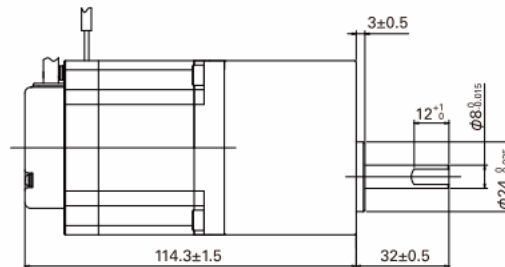
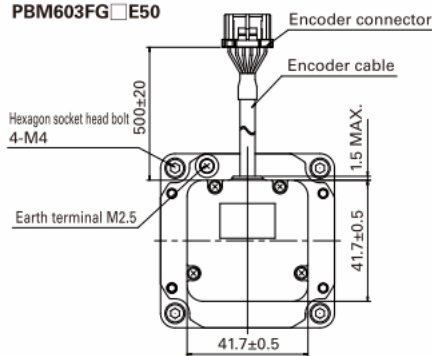


Model	L
PBM603FXE50	68.8
PBM604FXE50	100.8



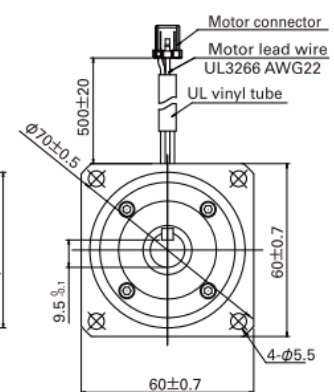
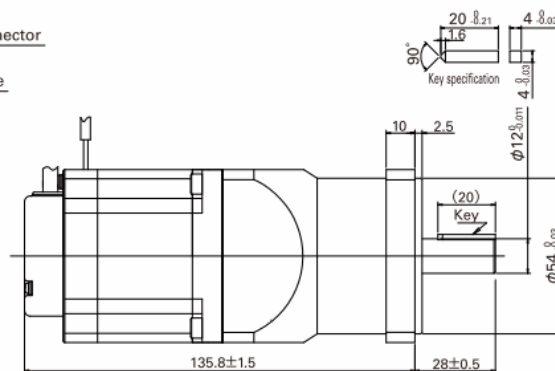
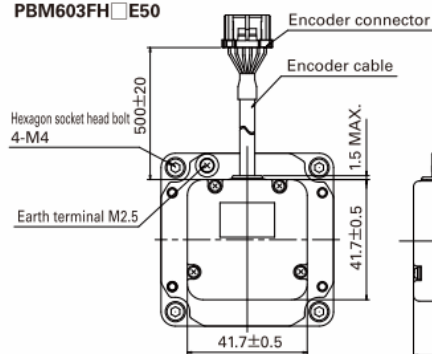
● Low-backlash Gear Model

PBM603FG□E50



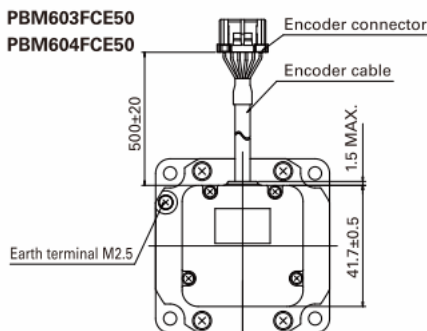
● Harmonic Gear Model

PBM603FH□E50

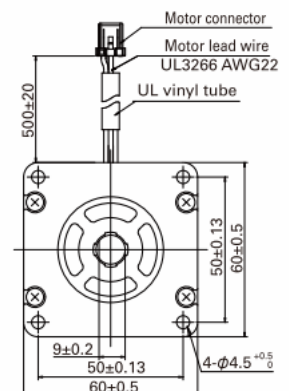
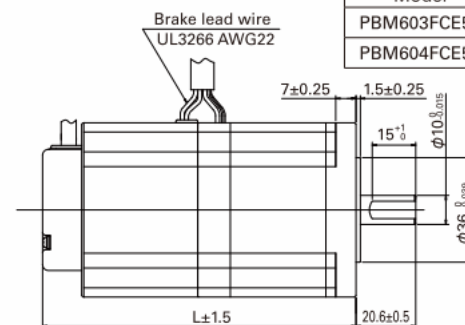


● Electromagnetic Brake Model

PBM603FCE50
PBM604FCE50



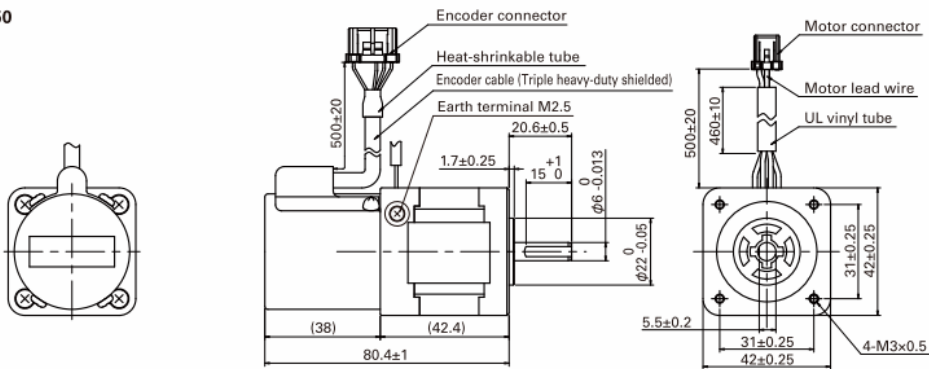
Model	L
PBM603FCE50	108.1
PBM604FCE50	140.1



9.Specifications

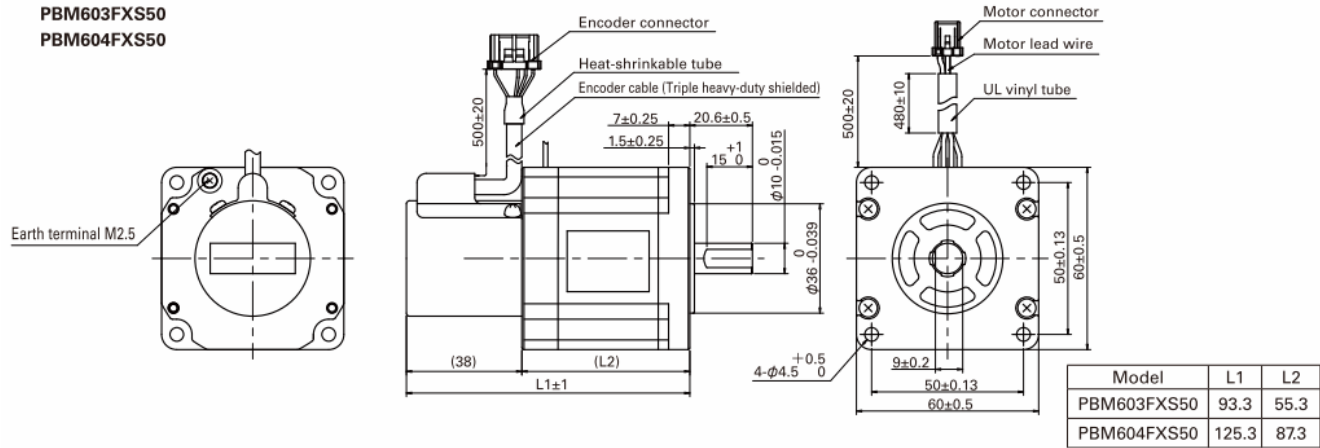
42mm sq. (Absolute encoder)

- Standard Model
- PBM423FXS50



60mm sq. (Absolute encoder)

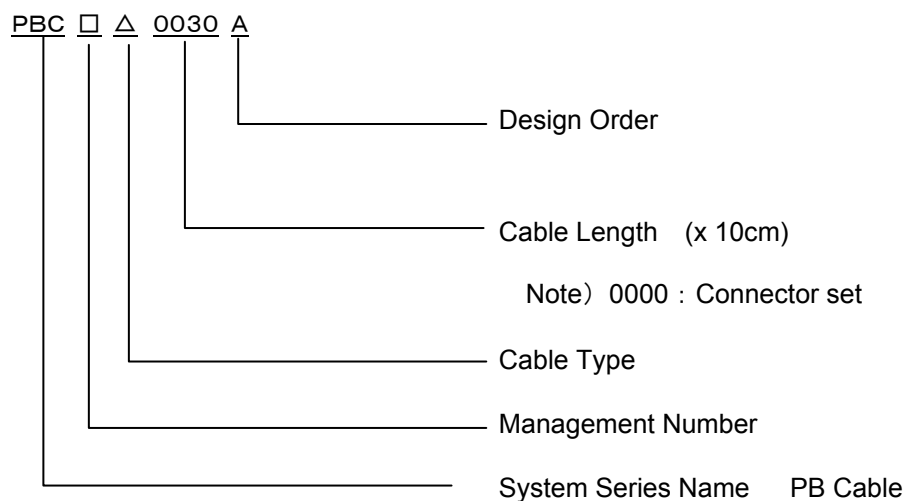
- Standard Model
- PBM603FXS50
- PBM604FXS50



9.Specifications

9.6 Option

Optional Cable Model Number Nomenclature



Optional Cable Model Numbers

Cable Type	Cable Standard Model Number	Standard Length	Maximum Length	Connector SET
Power cable	PBC9P0010A	2m	3m	PBC9P0000A
Motor extension cable	PBC8M0030A	3m	20m	PBC8M0000A
Encoder extension cable (Incremental sensor) (Absolute sensor : : no Battery case) (Absolute sensor : : with Battery case) * The battery is not attached.	PBC7E0030A PBC8E0030A PBC8E0030E	3m	20m	PBC7E0000A PBC8E0000A
I/O cable (Non-shilded) (Shilded)	PBC1S0010A PBC1S0010C	1m	2m	PBC1S0000A
Communication unit for PCIF	PBFM-U6	—	—	—
Regeneration resistance	PBFE-R1	—	—	—
Battery for ABS	AL-00697958-01	—	—	—

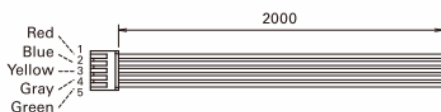
* Please inquire with us if another length of cable other than the standard one is needed.

* Inquire with us when robot cable is needed as well.

9.Specifications

● Power Cable

PBC9P0020A Cable with connectors



Connector Connection of Driver Side

Pin No.	Lead color	Signal name
1	Red	Main power supply DC24/48V
2	Blue	GND
3	Yellow	Control power supply DC24V
4	Gray	GND
5	Green	FG

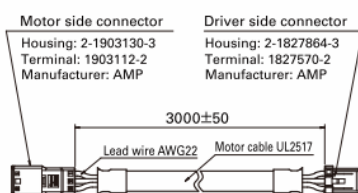
Connector Set Model No.: PBC9P0000A

Manufacturer	Type	Qty.
JST	Contact: SVH-21T-P1.1 Housing: VHR-5N	5 1

Set comprising of connectors only.

● Motor Ext. Cable

PBC8M0030A Cable with connectors



Connector Connection of Motor Side

Pin No.	Lead color	Signal name
A1	Blue	Motor lead wire
B1	Orange	Motor lead wire
A2	Red	Motor lead wire
B2	Yellow	Motor lead wire
A3	White	Brake lead wire
B3	Black	Brake lead wire

Connector Connection of Driver Side

Pin No.	Lead color	Signal name
A1	Blue	Motor lead wire
B1	Orange	Motor lead wire
A2	Red	Motor lead wire
B2	Yellow	Motor lead wire
A3	White	Brake lead wire
B3	Black	Brake lead wire

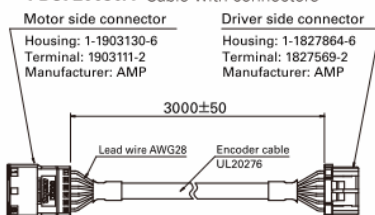
Connector Set Model No.: PBC8M0000A

Manufacturer	Type	Qty.
AMP	Housing: 2-1827864-3 Contact: 1827570-2 Housing: 2-1903130-3 Contact: 1903112-2	1 6 1 6

Set comprising of connectors only.

● Encoder Ext. Cable (Incremental Encoder)

PBC7E0030A Cable with connectors



Connector Connection of Motor Side

Pin No.	Lead color	Signal name
A1	Blue	Channel A
B1	Brown	Channel A
A2	Green	Channel B
B2	Purple	Channel B
A3	White	Channel C
B3	Yellow	Channel C
A4	Red	+5V
B4	Black	0V
A5	N.C.	—
B5	Orange	Over heat
A6	Black	Shield
B6	N.C.	—

Connector Connection of Driver Side

Pin No.	Lead color	Signal name
A1	Blue	Channel A
B1	Brown	Channel A
A2	Green	Channel B
B2	Purple	Channel B
A3	White	Channel C
B3	Yellow	Channel C
A4	Red	+5V
B4	Black	0V
A5	N.C.	—
B5	Orange	Over heat
A6	Black	Shield
B6	N.C.	—

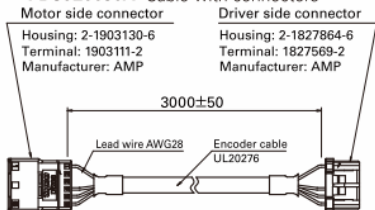
Connector Set Model No.: PBC7E0000A

Manufacturer	Type	Qty.
AMP	Housing: 1-1827864-6 Contact: 1827569-2 Housing: 1-1903130-6 Contact: 1903111-2	1 10 1 10

Set comprising of connectors only.

● Encoder Ext. Cable (Absolute Encoder)

PBC8E0030A Cable with connectors



Connector Connection of Motor Side

Pin No.	Lead color	Signal name
A1	Brown	ES+
B1	Blue	ES-
A2	N.C.	—
B2	N.C.	—
A3	N.C.	—
B3	N.C.	—
A4	Red	+5V
B4	Black	0V
A5	Pink	BAT+
B5	Purple	BAT-
A6	Black	Shield
B6	N.C.	—

Connector Connection of Driver Side

Pin No.	Lead color	Signal name
A1	Brown	ES+
B1	Blue	ES-
A2	N.C.	—
B2	N.C.	—
A3	N.C.	—
B3	N.C.	—
A4	Red	+5V
B4	Black	0V
A5	Pink	BAT+
B5	Purple	BAT-
A6	Black	Shield
B6	N.C.	—

Connector Set Model No.: PBC8E0000A

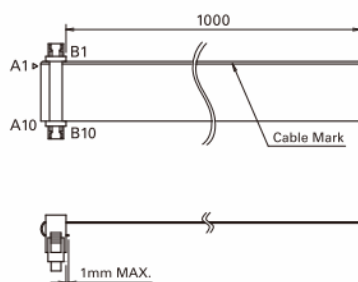
Manufacturer	Type	Qty.
AMP	Housing: 2-1827864-6 Contact: 1827569-2 Housing: 2-1903130-6 Contact: 1903111-2	1 7 1 7

Set comprising of connectors only.

9.Specifications

● I/O Cable (unshielded)

PBC1S0010A

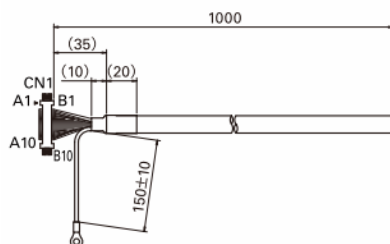


Cable Connection

Cable 1	Cable 2
A1-No.1	B1-No.1
A2-No.2	B2-No.2
A3-No.3	B3-No.3
A4-No.4	B4-No.4
A5-No.5	B5-No.5
⋮	⋮
A9-No.9	B9-No.9
A10-No.10	B10-No.10

● I/O Cable (shielded)

PBC1S0010C



CN1 Wiring Chart

CN1 Pin.No.	Mark display	Mark	Line color	CN1 Pin.No.	Mark display	Mark	Line color
A1		Red	Orange	B1		Red	Orange
A2		Black		B2		Black	
A3		Red	Gray	B3		Red	Gray
A4		Black		B4		Black	
A5		Red	White	B5		Red	White
A6		Black		B6		Black	
A7		Red	Yellow	B7		Red	Yellow
A8		Black		B8		Black	
A9		Red	Pink	B9		Red	Pink
A10		Black		B10		Black	

● USB/RS-485 Converter Unit

PBFM-U6

Package Contents

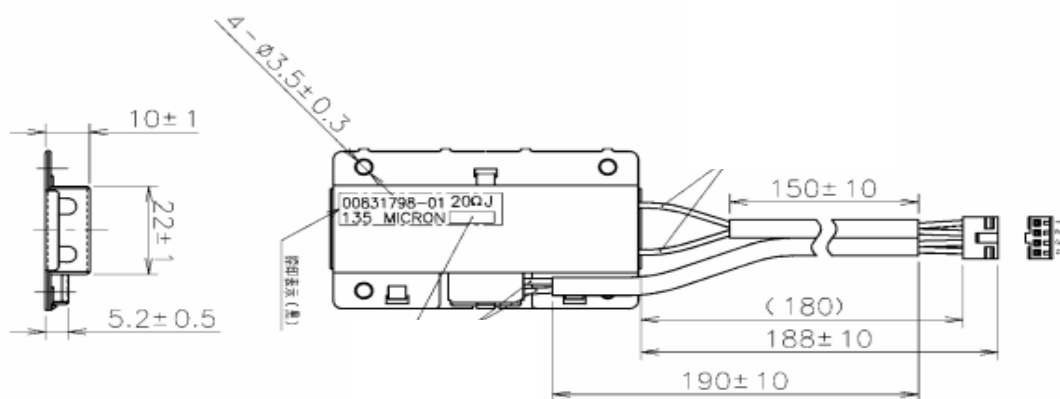
Uport 1130 Adapter (Manufacturer: MOXA)	USB/RS-485 Adapter	Adapter with USB cable
	CD-ROM	Documents and driver software for the adapter
	Connector terminal	Connects to cable (between adapter and driver)
Cable (between adapter and driver)		Model No.: PBC6T0005A Cable length: 500±20mm Connector attached on driver side

Pin Arrangement of Connector Terminal

Pin No.	Signal name	Cable (between adapter and driver) lead colors
1	—	—
2	—	—
3	DATA+ (A)	Yellow
4	DATA- (B)	White
5	GND	Black

- * Please refer to the Installation manual or Home Page (<http://www.moxa.com/>) enclosed in the packing for the details of driver installation and methods of use of Uport 1130.
- * Please understand in advance that any errors caused by Uport 1130 are not our responsibility.

● Regeneration resistance PBF-E-R1



9.Specifications

9.7 International Standards Conformity

PB driver conforms to the international standards below.

Mark	International standards	Standard number	Certification Organization
	UL standard	UL508C	UL (Underwriters Laboratories inc.) UL file number: E179775
	CSA standard	UL508C	
	Low Voltage Directive : LVD	EN61800-5—1	EN61800-3 TÜV (TÜV SÜD Japan, Ltd.)
	EMC Directive : EMC	EN61000-6-2 EN61000-6-4	

PB motor has an article for following standards.

Mark	International standards	Standard number	Certification Organization
	UL standard	UL1004	UL (Underwriters Laboratories inc.)
	EN standard	EN60034-1 EN60034-5	TÜV (TÜV SÜD Japan, Ltd.)

- * Corresponding motor to standardized product and standard model are different. Please refer to 1.3 Motor model specification for further information.

Please use establishment environment with the following category environment / pollution degree.

overvoltage category	pollution level
I	2

- * The control panel installation configuration (under IP54) must exclude exposure to water, oil, carbon, dust, etc.
- * The power supply input department please use IEC or a reinforcement insulation transformer of EN standard conformity.

9.Specifications

EMC Directive

1) TEST Item

Directive classification	Classification	Test	Test standard
EMC	Emission	Conducted emission	EN55011: A2/2007
		Radiated emission	EN55011: A2/2007
	Immunity	Electrostatic discharge immunity	EN61000-4-2: A2/2001
		Radiated electromagnetic field immunity	EN61000-4-3: A1/2002
		Electrical first transient/ burst immunity	EN61000-4-4: 2004
		Conducted disturbance immunity	EN61000-4-6: A1/2001
		Surge immunity	EN61000-4-5: A1/2001
		Adjustable speed electrical power drive system	EN61800-3/ 2004

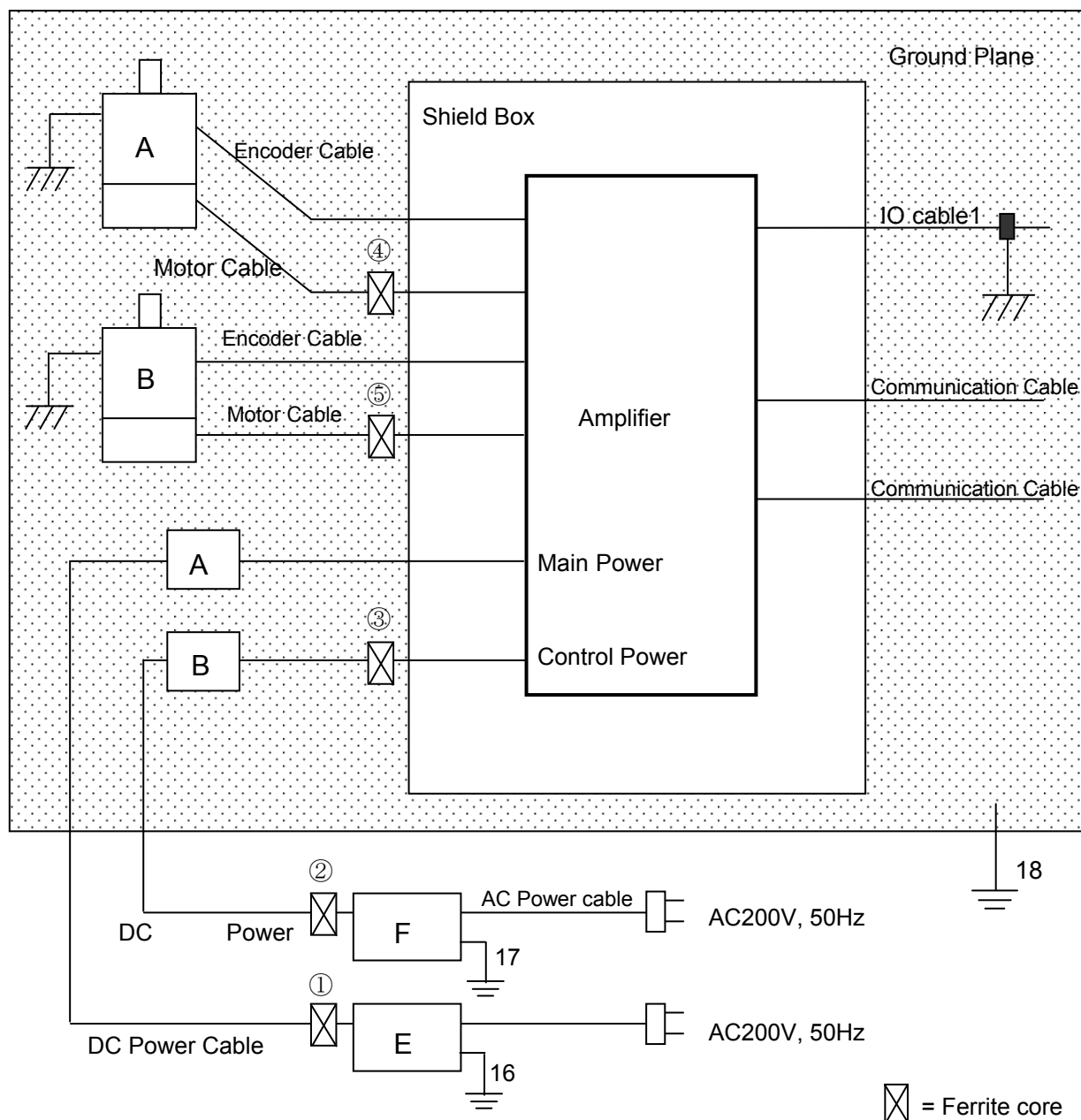
9.Specifications

Precautions for EMC Directives

For the EMC Directives, tests are performed by general installation and countermeasure methods, in our company as machines and configurations differ depending on customers' needs.

This driver has been authorized to display CE marking based on the recognition certificate issued by a separate, third-party certifying authority. Accordingly, customers are instructed to perform the final conformity tests for all instruments and devices in use.

Use the following guidelines below for the PB system in order to conform the customer's equipment and devices to the EMC Directives.



Noise suppression components:

Noise Filter:

A: SUP-EL10-ER-6(OKAYA)

B: NAH:-06-472(COSEL)

Ferrite core:

①~⑤: E04SR401932(SEIWA) 3turns

No Text on This Page.

10. Troubleshooting

10.1 Troubleshooting

When any troubles occurred without any alarm codes displayed, investigate the cause and take appropriate corrective action by referring to the following items. If any alarm codes are displayed, perform appropriated procedures of "Troubleshooting when alarm activated."

- Motor will not operate.
 - Check that the motor setting is appropriate for the motor connected. (When using incremental system.)
 - Check if Gate-OFF signal or Limit-signal is ON.
 - Check that setting value of software limit is appropriate.
 - Check if any incorrect wirings or contact failure in power line or holding brake line (when holding brake equipped).
- Position gap occurs.
 - Check if any mechanical causes existed such as coupling looseness.
 - Check if any errors in setting of relative displacement or absolute displacement
 - Check if any errors in settings of operation modes.
 - Check if Gate-OFF signal or Limit-signal is ON in the state not intended.
 - Check that setting value of software limit is appropriate.

- Motor will not operate as intended.

If overshoot or undershoot occurs, adjust gain or drive profile after checking velocity waveform and current command monitor. Refer to Chapter 8 for adjustment procedures.

- * Refer to document NO. M0010065 for the details of PCIF operating procedure.

10. Troubleshooting

10.2 Warning

1) Outline of warnings

When a warning activated, the corresponding Bit in Warning monitor (Index: 0x4102) is set.
Driver can normally operate even if in detecting warning, however any alarms may occur if the operation is continued. Please recheck operation conditions before any alarms activated.
Warning-detected state is latched while power supply is being turned on.

2) List of warnings

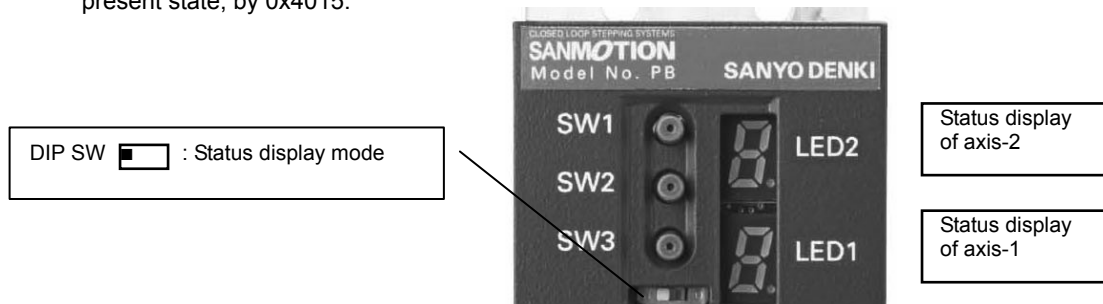
List of warnings		
Warning name	Details of warning	Related Index
Current command attainment Warning	Indicates that current command reached the setting value of 0x4031. Check if any problems with operation conditions (operation profile or load) as needed.	0x4031
Driver overheated	Detected when driver internal temperature is high. Review heat releasing conditions when any warning activated. Examine installation conditions so that the temperature of driver heat sink is 70°C or less including the ambient temperature.	-
Battery degraded	Detected when using ABS-sensor. Replace battery when warning activated.	-
Main circuit power supply voltage dropped	Check that power supply voltage is within the range of use and power voltage capacity is sufficient.	-
Position deviation Warning	Indicates that position deviation reached the setting value of 0x4031. Check if any problems with operation conditions and torque needed.	0x4031

10. Troubleshooting

10.3 Alarm

1) Alarm indication (display)

When alarm is activated, alarm codes with respect to each axis are displayed in 7-segment LED. For this driver, you can set that when optional axis becomes alarm, the other axis as Fault-state or maintain the present state, by 0x4015.



List of codes for error register (0x1001), error code (0x603F), and driver definition (0x4101) are shown in section (3).

Note that operation when alarm activated is defined with (0x605E).

➤ To get index number of axis 2, add the offset with respect to each object to the above index.

Table 10.1 List of LED display status and 0x4101 Alarm codes

Status display	INC used	ABS used	0x4101 Code
-	Switch On disable	Switch On disable	0x00
=	Ready to Switch on	Ready to Switch on	0x00
≡	Switch On	Switch On	0x00
figure-of-eight	Operation enable	Operation enable	0x00
0	The other axis ALM	The other axis ALM	0xFF
1	Wrap Around	Wrap Around	0x66
2	Deviation counter OVF	Deviation counter OVF	0x6A
3	Peripheral circuit	Peripheral circuit	0x60, 0x61
4	Overvoltage	Overvoltage	0x21, 0x23
5	Voltage dropped	Voltage dropped	0x20
6	Regeneration error	Regeneration error	0x24
7	Sensor disconnection	Sensor disconnection	0x0A
8	Initialization operation error	Motor code error	0x68/0x64
9	2-axis synchronization error	2-axis synchronization error	0x65
	Velocity difference error	Velocity difference error	0x52
	Position deviation error	Position deviation error	0x50
	Overload error	Overload error	0x53
b	Operation error of travel to fixed stop	Operation error of travel to fixed stop	0x6b
C	Origin return error	Origin return error	0x69
d	Winding overcurrent	Winding overcurrent	0x11
E	Bus overcurrent	Bus overcurrent	0x10
F	Memory error	Memory error	0x63
H	Regenerative resistance overheated	Regenerative resistance overheated	0x32
L	Driver overheated	Driver overheated	0x30
U	-	ABS-error	0x03 to 0x06, 0x09
∩	-	BAT-error	0x01

10. Troubleshooting

2) List of alarm codes

Bit definition of error register (0x1001) is as follows.

⚠ Alarms not related to axes are common to the two axes.

Bit7: Manufacturer-defined error Bit6: Reserved

Bit5: Device profile definition error

Bit4: Communication error

Bit3: Temperature error

Bit2: Voltage error Bit1: Current error

Bit0: General error

List of alarm codes

0x1001 Error Resister	0x603F Error Code	0x4101 Code	Alarm name	Alarm description	Alarm reset
0	0x0000	0x00	Normal	-	-
Bit4	0x7510	0x40	Port 0 Rx invalid frame error	Invalid frame continuously received with port 0	Yes
		0x41	Port 1 Rx invalid frame error	Invalid frame continuously received with port 1	Yes
		0x42	Port 0 Rx CRC error	Port 0 Rx error continuously occurred.	Yes
		0x43	Port 1 Rx CRC error	Port 1 Rx error continuously occurred.	Yes
		0x44	Port 0 Tx error	Port 0 TX error continuously occurred.	Yes
		0x45	Port 1 Tx error	Port 1 TX error continuously occurred.	Yes
	0x7520	0x46	Port 0 lost link	Cable of port 0/1 is disconnected in the state of servo-on.	Yes
		0x47	Port 1 lost link	Master power supply is disconnected.	Yes
	0x7510	0x48	Communication timeout	Output data not received during specified cycle time.	Yes
Bit1	0x5400	0x10	Main circuit overcurrent detection	Detects overcurrent of main circuit power supply line. Alarm activated for both two axes.	No
	0x5210	0x11	Motor overcurrent detection	Detects motor overcurrent with respect to each axis.	No
Bit2	0x3220	0x20	Main circuit power supply voltage drop	Detected when internal power supply decreased though main circuit power supply input is normal. Alarm activated for both two axes.	Yes
	0x3211	0x21	Main circuit power supply overvoltage	Detects overvoltage of main circuit power supply. Alarm activated for both two axes.	Yes
	0x3210	0x23	Control power supply overvoltage	Detects overvoltage of control circuit power supply. Alarm activated for both two axes.	Yes
	0x3212	0x24	Regenerative voltage error	Detects regenerative voltage error while motor is being driven.	Yes
Bit3	0x4110	0x30	Driver temperature error	Detects driver internal overheat.	Yes
	0x4310	0x32	Regenerative resistance overheated	Detects regenerative resistor overheated. Detected when with-regenerative resistance is set by 0x4014.	Yes
Bit0	0x8611	0x50	Position deviation error	Detected when position deviation exceeds the setting of 0x6065. Not detected when operating in velocity mode.	Yes
	0x8400	0x51	Overvelocity error	Detected when the maximum motor velocity is 5200min ⁻¹ or over.	Yes
	0x8400	0x52	Velocity difference error	Detected when velocity difference set with Index: 0x4030 occurred. The detection threshold value in the csp2 mode serves as internal fixation.	Yes
				Detects the state of overload due to obstacles. Detecting condition is set with index: 0x4030.	Yes
	0x8500	0x53	Overload error	Not detected in csp2 mode.	Yes

10. Troubleshooting

0x1001 Error Resister	0x603F Error Code	0x4101 Code	Alarm name	Alarm description	Alarm reset
Bit0	0x7305	0x0A	Incremental encoder disconnection	Incremental encoder A, B, and Z-phase signal disconnected.	No
	0x7300	0x0A	ABS encoder communication error	CRC, SYNC, FORM, command error occurred in communication with sensor.	No
		0x0B	ABS encoder initialization process error	Absolute encoder initialization process error Cable disconnected.	No
Bit0	0x7300	0xA0	Serial encoder internal error 0	•Amount of turning overflow of absolute encoder •Multiple-turn counter overflow	No
		0xA1	Serial encoder internal error 1	•Multiple-turn error •Battery voltage degraded	Yes
	0x7310	0xA3	Serial encoder internal error 3	Overvelocity error	
	0x7300	0xA4	Serial encoder internal error 4	Encoder internal EEPROM access error	
		0xA5	Serial encoder internal error 5	Detection of single-turn coefficient failure	
		0xA6	Serial encoder internal error 6	Detection of multiple-turn coefficient failure	
		0xA9	Serial encoder internal error 9	Motor-built in encoder overheated	
Bit7	0x5530	0x60	EEPROM-access error	Detects non-volatile memory access error.	No
	0x5510	0x61	GA1063-access error	Internal circuit error	No
	0x6310	0x63	EEPROM Checksum error	Checksum error of non-volatile memory	No
	0x6320	0x64	Motor code error	Detected when motor code is not correct, only when using ABS encoder.	No
	0xFF00	0x65	Deviation error between 2 axes	Detects deviation error between two axes, when synchronous operation is enabled. The detecting threshold follows 0x4030.	Yes
	0xFF01	0x66	Wrap Around	Detects code inversion of position coordinate inside of driver. When performing relative displacement in profile position mode, detected when the setting value of index: 0x607B is ≠0. □ Not detected in csp or Homing mode.	Yes
	0xFF03	0x68	Initialization operation error	Detects initialization operation error when using incremental encoder.	No
	0xFF04	0x69	Origin return error	Detects Original return error. Error cause varies depending on Return origin types.	Yes
	0xFF05	0x6A	Deviation counter OVF	Detects position deviation counter overflow inside of driver.	Yes
	0xFF06	0x6 B	Push error	Detects when wide swing is generated during the push operation.	Yes
	0xFF20	0xFF	The other axis ALM	When the 0x4015 set the 1 、 one of other axes become alarm.	Yes

10. Troubleshooting

3) Troubleshooting when alarm activated

The following alarm codes are of 0x4101.

Alarm code 40 (Port 0 Rx invalid frame error)

Alarm code 41 (Port 1 Rx invalid frame error)

Alarm code 42 (Port 0 Rx CRC error)

Alarm code 43 (Port 1 Rx CRC error)

Alarm code 44 (Port 0 Tx error)

Alarm code 45 (Port 1 Tx error)

- Detecting condition: after control power supply turned on
- Occurrence cause and corrective action

Defective communication cable	Check if any contact failures in wiring of communication cable.
False operation due to noise.	• Check that driver earth wire is correctly grounded. • Check shielding process of encoder cable. • Take appropriate measure against noise such as addition of ferrite core
Defective control printed-circuit board	Replace driver.

Alarm code46 (Port 0 lost link)

Alarm code47 (Port 1 lost link)

- Detecting condition: detected in Safe-OP state, or OP state
- Occurrence cause and corrective action

Cable disconnected.	Inserting and removing cable shall be performed in the state of INIT or Pre-OP.
Disconnection of communication cable Contact failure between connector and terminal	Examine wiring between motor encoder and driver, is any errors, correct it.

Alarm code48 (Communication timeout)

- Detecting condition: detected in Safe-OP state, or OP state
- Occurrence cause and corrective action

Command not received during the time specified by communication timeout setting value. (SM2-event: not able to receive PDO output data)	Re-examine that the output data are output according to the communication timing of controller.
False operation due to noise.	• Check that driver earth wire is correctly grounded. • Check shielding process of encoder cable. • Take appropriate measure against noise such as addition of ferrite core

10. Troubleshooting

Alarm code 10 (main circuit overcurrent detection)

Alarm code 11 (motor overcurrent detection)

- Detecting condition: detected in Switch-on state and Servo-on state
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Short-circuit or earth fault of motor line	Check if any errors on wiring of power line or motor winding.
False operation due to noise	• Check that driver earth wire is correctly grounded. • Take appropriate measure against noise such as addition of ferrite core

Alarm code 20 (Main circuit power supply voltage drop)

- Detecting condition: detected only in the state of servo-on
- * Make sure to disconnect the main circuit power supply only after transition to the state of Switch-on. In this case, FSA shall transit to the state of "Switch on Disabled."
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Insufficient power supply current capacity	Check specifications for power supply and then use appropriate power supply.
False operation due to noise.	• Check that driver earth wire is correctly grounded. • Take appropriate measure against noise such as addition of ferrite core

Alarm code 21 (Main circuit power supply overvoltage)

- Detecting condition: detected in Switch-on state and Servo-on state
- * Driver automatically acknowledges power supply voltage: 24/48V in the state of "Ready to switch on" after turning on main circuit power supply. After acknowledging that, driver transits to the state of "Switch on" to detect overvoltage.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Main circuit power supply voltage is outside the specifications.	Decrease power supply voltage to the scope of specifications.
False operation due to noise.	• Check that driver earth wire is correctly grounded. • Take appropriate measure against noise such as addition of ferrite core

Alarm code 23 (Control power supply overvoltage)

- Detecting condition: always detected.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Main circuit power supply voltage is outside the specifications.	Decrease power supply voltage to the scope of specifications.
False operation due to noise.	• Check that driver earth wire is correctly grounded. • Take appropriate measure against noise such as addition of ferrite core

Alarm code 24 (Regenerative voltage error)

- Detecting condition: detected during motor operation
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Contact failure of regenerative resistance	Check connection of regenerative resistance
Overload operation	Review acceleration/ deceleration and load condition.
Regenerative operation	Add regenerative resistance (optional)
False operation due to noise.	• Check that driver earth wire is correctly grounded. • Take appropriate measure against noise such as addition of ferrite core

10. Troubleshooting

Alarm code 30 (Driver overheated)

- Detecting condition: always detected.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Operation and load condition are severe.	Review operation and oar conditions.
Ambient temperature of driver is outside the specification. Insufficient heat releasing for driver	Check the temperature inside of control cabinet (ambient temperature of driver), and review driver installation method and cabinet cooling method so that the temperature is 55°C or less.

* Examine the installation conditions so that driver heat sink temperature is 70°C or less including the ambient temperature.

Alarm code 32 (Regenerative resistance overheated)

- Detecting condition: always detected.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Operation and load condition are severe.	Review operation and oar conditions.
Insufficient heat releasing for regenerative resistance	Review installation method of regenerative resistance and cooling method.

* When using regenerative resistor, make sure to set "regenerative resistance overheat detection permitted" with 0x4014.

Alarm code 50 (Position deviation error)

- Detecting condition: Detected during operation in profile position mode (PP), homing (hm), and cycle synchronous position mode (csp). Detecting threshold of position deviation error follows the setting value of 0x6065.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Motor encoder internal circuit failure	Replace motor.
Torque needed is outside the range of torque.	Check if current command monitor reached current limit when driving. Calculate necessary torque based on load and operation condition, and review operation or load condition. Replace with larger sized motor.
Motor combination failure (When using incremental system.)	Check that the motor you use conforms to motor model number setting, if does not conform, correct it.
Motor holding brake not released.	Check that wiring of holding brake is correct, if any errors, correct it.
Wiring failure between driver and motor.	Check if any contact failures.
Work hit the mechanical end.	Check if any errors in command.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to sensor line.

* Detects alarm when the operation in the opposite direction to command exceeds the threshold, for operation in profile position mode and homing mode.

Alarm code 51 (Overvelocity error)

- Detecting condition: alarm is activated at the time motor velocity exceeds 5200min⁻¹.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Motor encoder internal circuit failure	Replace motor.
Torque needed is outside the range of torque or allowable load.	Check for any excessive acceleration and deceleration, and that load condition is within the allowance.
Motor combination failure (When using incremental system.)	Check that the motor you use conforms to motor model number setting, if does not conform, correct it.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to sensor line.

10. Troubleshooting

Alarm code 52 (Velocity difference error)

- Detecting condition: detected during operation in cycle synchronous position mode (csp2) Detecting threshold follows the setting value of 0x4030-0x02.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Motor encoder internal circuit failure	Replace motor.
Torque needed is outside the range of torque.	Calculate necessary torque based on load and operation condition, and review operation or load condition. Replace with larger sized motor.
Motor combination failure (When using incremental system.)	Check that the motor you use conforms to motor model number setting, if does not conform, correct it.
Motor holding brake not released.	Check that witting of holding brake is correct, if any errors, correct it.
Wiring failure between driver and motor.	Check if any contact failures.
Work hit the mechanical end.	Check if any errors in command.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to sensor line.

Alarm code 53 (Overload error)

- Detecting condition: detected during motor operation. A detection threshold value follows the preset value of 0x4030-0x04 and 0x05. It does not detect in CSP2 operational mode.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
Motor encoder internal circuit failure	Replace motor.
Torque needed is outside the range of torque.	Calculate necessary torque based on load and operation condition, and review operation or load condition. Replace with larger sized motor.
Motor combination failure (When using incremental system.)	Check that the motor you use conforms to motor model number setting, if does not conform, correct it.
Motor holding brake not released.	Check that witting of holding brake is correct, if any errors, correct it.
Wiring failure between driver and motor.	Check if any contact failures.
Work hit the mechanical end.	Check if any errors in command.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to encoder line.

10. Troubleshooting

Alarm code A (Sensor disconnection: for incremental sensor)

Alarm code A (ABS-sensor communication error)

- Detecting condition: always detected.
- Occurrence cause and corrective action

In wiring for encoder: ◆ Wiring is incorrect. ◆ Connectors disconnected ◆ Contact failure of connector ◆ Encoder cable is too long. ◆ Encoder cable is too thin.	Check the wiring, if incorrect, correct the wiring. Check that motor encoder power supply voltage is 4.75V or over, if not, correct it.
Driver internal circuit failure	Replace driver.
Motor encoder internal circuit failure	Replace motor.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to sensor line.

Alarm code B (ABS-sensor initial process error)

- Detecting condition: detected when control power supply is turned on
- Occurrence cause and corrective action

In wiring for encoder: ◆ Wiring is incorrect. ◆ Connectors disconnected ◆ Contact failure of connector ◆ Encoder cable is too long. ◆ Encoder cable is too thin.	Check the wiring, if incorrect, correct the wiring. Check that motor encoder power supply voltage is 4.75V or over, if not, correct it.
Driver internal circuit failure	Replace driver.
Motor encoder internal circuit failure	Replace motor.
Initial setting of position data cannot performed as motor has been rotating at rotational velocity of over 250min ⁻¹ when power supply was turned on.	Re-turn on the power supply with motor being stopped.

Alarm code A1 (ABS-sensor internal error 1)

- Detecting condition: detected when control power supply is turned on
- Occurrence cause and corrective action

Contact failure of battery cable	Check battery connector supplied with encoder cable.
Battery voltage degraded.	Check battery voltage.
Contact failure of encoder connector	Check the wiring between motor encoder and driver, if incorrect, correct it.
Motor encoder internal circuit failure	Re-turn on the power supply, if cannot be restored, replace the servo motor.

Alarm code A3 (ABS-sensor internal error 3)

- Detecting condition: always detected
- Occurrence cause and corrective action

Motor encoder internal circuit failure	Re-turn on the power supply, if cannot be restored, replace the servo motor.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Check shielding process of encoder cable. Take appropriate measure against noise such as addition of ferrite core to sensor line.
Motor rotational velocity exceeds the allowable velocity.	Review operation conditions, and then reduce the maximum rotational velocity.

10. Troubleshooting

Alarm code A4 to A6 (ABS-sensor internal error 4 to 6)

- Detecting condition: always detected.
- Occurrence cause and corrective action

Motor encoder internal circuit failure	Re-turn on the power supply, if cannot be restored, replace the servo motor.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Check shielding process of encoder cable. Take appropriate measure against noise such as addition of ferrite core to sensor line.

Alarm code A9 (ABS-sensor internal error 9)

- Detecting condition: always detected
- Occurrence cause and corrective action

Motor encoder internal circuit failure	Re-turn on the power supply, if cannot be restored, replace the servo motor.
Servo motor does not produce heat but ambient temperature is too high.	Review the cooling method so that the ambient temperature of encoder is 80 ° or less.
Motor is overheated.	Review cooling method for motor.

Alarm code 60 (EEPROM Access error)

- Detecting condition: This alarm is detected at the time of parameter save or after a power supply injection.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to sensor line.

Alarm code 61 (GA1063 Access error)

- Detecting condition: This alarm is detected at the time of after a power supply injection.
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
False operation due to noise.	Check that earth wire of driver is correctly grounded. Take appropriate measure against noise such as addition of ferrite core to sensor line.

Alarm code 63 (EEPROM Checksum error)

- Detecting condition: detecting after Power on
- Occurrence cause and corrective action

Driver internal circuit failure	Replace driver.
power supply off during parameter save.	Please consult about recovery disposal to our company.

Alarm code 64 (Motor Code error: In the case of an ABS sensor)

- Detecting condition: detects at the time of a power supply injection.
- Occurrence cause and corrective action

The combination of a motor is incongruent.	It checks in a conformity motor.
Sensor internal circuit failure	Exchange a motor

10. Troubleshooting

Alarm code 65 (Deviation error between 2 axes)

- Detecting condition: With it being effective (0x4022), when it carries out, a synchronous gap is detected for synchronous operation.
- Occurrence cause and corrective action

A detection threshold value is unsuitable.	It is improved whether the preset value of 0x4030-0x03 is proper.
Insufficient a torque	Please check whether there is any enough motor torque.

Alarm code 66 (Wrap Around)

- Detecting condition: Alarm detection is carried out [not being based on a 0x607B preset value] when a wrap around occurs in cycle synchronous position mode.
- Occurrence cause and corrective action

A position setup is unsuitable.	A homing offset value is improved.
---------------------------------	------------------------------------

Alarm code 68 (initialization operation error: In case of incremental sensor)

- Detecting condition: In the case of an incremental sensor, operation for detecting the initial phase of an encoder is performed. Alarm detection is carried out when this operation cannot carry out normally.
- Occurrence cause and corrective action

Wiring of an encoder and a motor line is unusual.	It is checked whether there is any error in order of connection, such as pin arrangement. Or it is checked whether there is any loose connection of a motor line.
The state where the motor cannot operate	Over Load Check the holding brake is Opened
encoder count miss by a noise	It is checked whether the driver earth wire is grounded correctly. Shield processing of an encoder cable is checked. A ferrite core etc. are added and the measure against a noise is implemented.

Alarm code 69 (Homing error)

- Detecting condition: Homming error is different with a homing method.
- Occurrence cause and corrective action

external sensor=Home position	When the external sensor to be used is set up invalid by 0x4010
Index pulse homming	When an index pulse is undetectable in motor 1 rotation (Encoder wiring, encoder breakage)
Except an index pulse	When the movements becomes 0x10000000 or more

10. Troubleshooting

Alarm code 6A (Deviation counter overflow)

- Detecting condition : Detect the deviation counter overflow
- Occurrence cause and corrective action

Excessive instructions of the amount of movements	Set the movements value is less than 0x7FFFFFFF.
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Alarm code 6B (Push error)

- Detecting condition : Detected the wide swing at the time of push operation.
- Occurrence cause and corrective action

It reaches target position when push operation in profile position mode	Reexamination a forcing current limit value or detection time value. checked whether there is any case where it will not be in a Pusu state.
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10. Troubleshooting

10.4 Inspection

Corrective Actions for Problems During Operation

For maintenance purposes, a daily inspection is typically sufficient. Upon inspection, refer to the following description.

Inspection location	Testing conditions			Inspection Items	Inspection Methods	Solution if abnormal
	Time	During operation	While stopping			
motor	Daily	V		Vibration	Check for excessive vibration.	Contact dealer/sales office.
	Daily	V		Sound	Check if there is no abnormal sound as compared to normal sound.	
	Periodic		V	Cleanliness	Check for dirt and dust.	Clean with cloth or air. Note 1)
	Yearly		V	Measure value of insulation resistance	Contact dealer or sales office.	
driver	Periodic		V	Cleaning	Check for dust accumulated in the accessories.	Clean with air. Note 1)
	Yearly		V	Loose screws	Check for loose connections.	Fasten the screws properly.
Battery for serial encoder	Regularly Note 2)		V	Battery voltage	Confirm that battery voltage is more than DC3.6V.	Replace the Battery.
Temperature	Periodic	V		Measure temperature	Ambient temperature Motor frame temperature	Set the ambient temperature within the specified range. Check the load condition.

Note 1) While cleaning with air, confirm that there is no oil content and/or moisture in the air.

Note 2) The life expectancy of the battery is approximately 2 years, when its power is OFF throughout the year. For replacement, a lithium battery (ER3V: 3.6V, 1000mAh) manufactured by Toshiba Corp. is recommended.

10. Troubleshooting

10.5 Maintenance Parts

Parts may deteriorate over time. Perform periodic inspection for preventive maintenance.

No.	Part name	Number of average replacement years	Corrective measures / usage conditions
1	Capacitor for smoothing main circuit	5 Years	Replacement with new part is necessary. Load ratio : 50% of rated output current of amplifier. Usage condition: Average temp. 40°C year-round.
2	Lithium battery for serial encoder [ER3V]	3 Years	Replacement with new part is necessary.
3	Electrolysis capacitor (other than condenser for smoothing main circuit)	5 Years	Replacement with new part is necessary. Usage condition: Average temp. 40°C year-round. Annual usage period is 4800 hours.
4	Fuse	10 Years	Replacement with new part is necessary.

■ Capacitor for smoothing the main circuit

- ◆ If the driver is in use for more than 3 years, contact the dealer or sales office. The capacity of the capacitor for smoothing the main circuit is reduced due to the frequency of motor output current and main circuit power ON/ OFF during usage, and it may cause damage.
- ◆ When the capacitor is used with an average 40°C throughout the year, and exceeds more than 50% of the rated output current of driver, it is necessary to replace the condenser with a new part every 5 years.
- ◆ When used in an application where the power turn ON/OFF is repeated more than 30 times a day, consult our representatives.

■ Lithium battery for ABS encoder

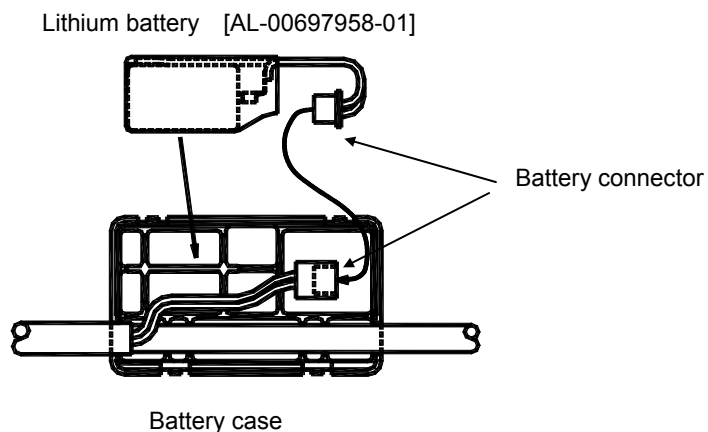
- ◆ The standard replacement period recommended by our company is the life expectancy of lithium battery based on normal usage conditions. However, if there is high frequency of turning the power ON/OFF, or the motor is not used for a long period, then the life of lithium battery is reduced. If the battery power is less than 3.6 V during inspection, replace it with new one.

- At SANYO DENKI, the overhauled driver is shipped with the same parameters as the ones before overhauling, however, be sure to confirm the parameters before use.

10. Troubleshooting

How to Replace the Battery for Motor Encoder

Process	Description
1	Turn ON the servo amplifier control power supply.
2	Prepare the replacement lithium battery. [Our model number: AL-00697958-01]
3	Open the battery case.
4	Remove the battery connector.
5	Take out the used lithium battery and put in the new replacement one.
6	Attach the connector in the right direction.
7	Close the battery case.



- ✓ If the battery is replaced while the control power is OFF, multiple rotation counter (position data) of the motor encoder may be instable. When the amplifier control power is turned ON in this status, an alarm (Serial Encoder Error) may be issued. For this, execute encoder clear and alarm reset to release the alarm status. Also, absolute encoder position data may be instable. Check and adjust the relations between position data and machine coordinate system.



■ECO PRODUCTS

Sanyo Denki's ECO PRODUCTS are designed with the concept of lessening impact on the environment in the process from product development to waste. The product units and packaging materials are designed for reduced environmental impact.

We have established our own assessment criteria on the environmental impacts applicable to all processes, ranging from design to manufacture.

■Precautions For Adoption

Failure to follow the precautions on the right may cause moderate injury and property damage, or in some circumstances, could lead to a serious accident.

Always follow all listed precautions.

Cautions

- Read the accompanying Instruction Manual carefully prior to using the product.
- If applying to medical devices and other equipment affecting people's lives please contact us beforehand and take appropriate safety measures.
- If applying to equipment that can have significant effects on society and the general public, please contact us beforehand.
- Do not use this product in an environment where vibration is present, such as in a moving vehicle or shipping vessel.
- Do not perform any retrofitting, re-engineering, or modification to this equipment.
- The Products presented in this Instruction Manual are meant to be used for general industrial applications. If using for special applications related to aviation and space, nuclear power, electric power, submarine repeaters, etc., please contact us beforehand.

* For any question or inquiry regarding the above, contact our Sales Department.

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*Remarks : Specifications are subject to change without notice.