1M23Z01402
User's Manual Ver.1.0

RS405CB/RS406CB

Command Type Servo for Robot

Instruction Manual

Caution

- Read this instruction manual before use.
- Keep this manual handy for immediate reference.

For models

Futaba®

1. FOR SAFETY

To use this product safely, please pay your full attention to the followings.
Be sure to read this instruction manual prior to using this product.

Warning Symbols

The warning symbols used in this text are defined as follows:

Indication	Meanings
⚠Danger	Indicates a hazard that will cause severe personal injury, death, or substantial property damage if the warning is ignored.
⚠Warning	Indicates a hazard that can cause severe personal injury, death, or substantial property damage if the warning is ignored.
⚠Caution	Indicates a hazard that will or can cause minor personal injury, or property damage if the warning is ignored

Symbols: ⃠ :**Prohibited** ❗ : **Mandatory**

Cautions for Use

⚠ Caution

⃠ Do not disassemble or alter the servo.
Otherwise, it may cause breakage in the gear box, fire on the servo or explosion of the battery.

⃠ Do not touch the servo case during or some time after operating the servo.
Otherwise, you may get burned on the finger as the motor or electronic circuit in the servo gets very hot.

⃠ Do not let the servo get covered with sandy dust or water.
Otherwise, the servo may stop moving or have a short circuit. The servo is not designed to be waterproof or dust-proof.

⃠ Do not use this product for any application other than indoor hobby-robots.
Futaba is cleared of all responsibility to the results caused by the usage of this product for any application other than indoor hobby-robots.

Do not turn the servo horn forcibly.
Otherwise, the servo will be damaged.

Do not leave the servo locked.
If the servo continues to be locked due to a strong external force, it may cause smoke, fire or damage.

Be careful about the capacity of the power supply.
When the servo is locked (the servo could not work by too big load), a very big electric current is required. Use a power supply (battery) with enough capacity.

Cautions for Storage

Caution

Do not store the servos in the following conditions.
Places where the temperature is over 60℃ or below －20℃.
Places where the Sun directly shines over the servos.
Places where it is very high in humidity.
Places where there is a strong vibration.
Places where there is a lot of dust.
Places where static electricity tends to be induced.
Places where infants can reach.

◆ Storing the servos in the places shown above may cause deformation and failure of the servos, or hazard.

2. Introduction

Components

The following parts are included in RS405CB and RS406CB.

- 1) Servo (RS405CB or RS406CB) 1pcs
  2) Servo Horn for RS405CB/RS406CB 1pcs
  3) Screw to fix Servo Horn (M3x8) 1pcs
  *Servo Horn and Screw are attached to the servo.

- 4) RS405CB/RS406CB Equipments Pack 1set
  Contents of the Pack are bellow;
  5) Axis for Free Horn of RS405CB/RS406CB 1pcs
  6) Free Horn for RS405CB/RS406CB 1pcs
  7) Bearings for Free Horn 2pcs
  8) Screw to fix Axis for Free Horn (M3x12, Tapping) 1pcs
  9) CC-E4E4-150 (RS485 Cable, 150mm) 1pcs
  10) Cover for unused Connector 1pcs

- 11) Usage Precaution 1pcs

Please refer to p.43 “Optional parts” for optional parts and repair parts.

Features

RS405CB/RS406CB is especially designed for robotic applications, having the following features.

● Blushless Motor

DC Blushless Motor is used as a power source.
It enables to enlarge the output torque without increasing weight.

Fig. 2.1 Brushless Motor

● Servos for Both Command-Type and PWM-Type

RS405CB/RS406CB can be controlled either as the Command Type Servo for robots or the PWM Type Servo for existing R/C servos. The type is automatically switched by the first signal sent after these products are connected.
*"BB0131 CC-E3P3-300" is needed to send PWM Pulse to RS405CB/RS406CB.

● Interactive High-Speed RS485 Communication (Only as Command-Type)

RS485 bi-directional communication is used and its maximum baud rate is 460kbps.
It is used not only to send command from PC or Processing Unit, but also to get information of internal sensors of the servo such as angle, current, temperature, voltage.

● Limit Function with Temperature and Current sensors

When temperature suddenly increases, or a very big electric current suddenly flows, the servo will turn off the power and avoid damages.

● Compliance Control

With this feature, the movement of the RS405CB/RS406CB is controlled in accordance with the distance between the present and target positions. This enables the robot to move very smoothly without trembling its arms and legs and to absorb turbulence from external force.

● Calibration

Angular position of every servo is calibrated by our standard gauge before their shipment. Even if another RS405CB/RS406CB is employed, it does not require any bothersome work for adjusting its angular position.

● Free Horn for both-ends supported structure

Bundled parts for Free Horn enable to make both-ends supported structure.

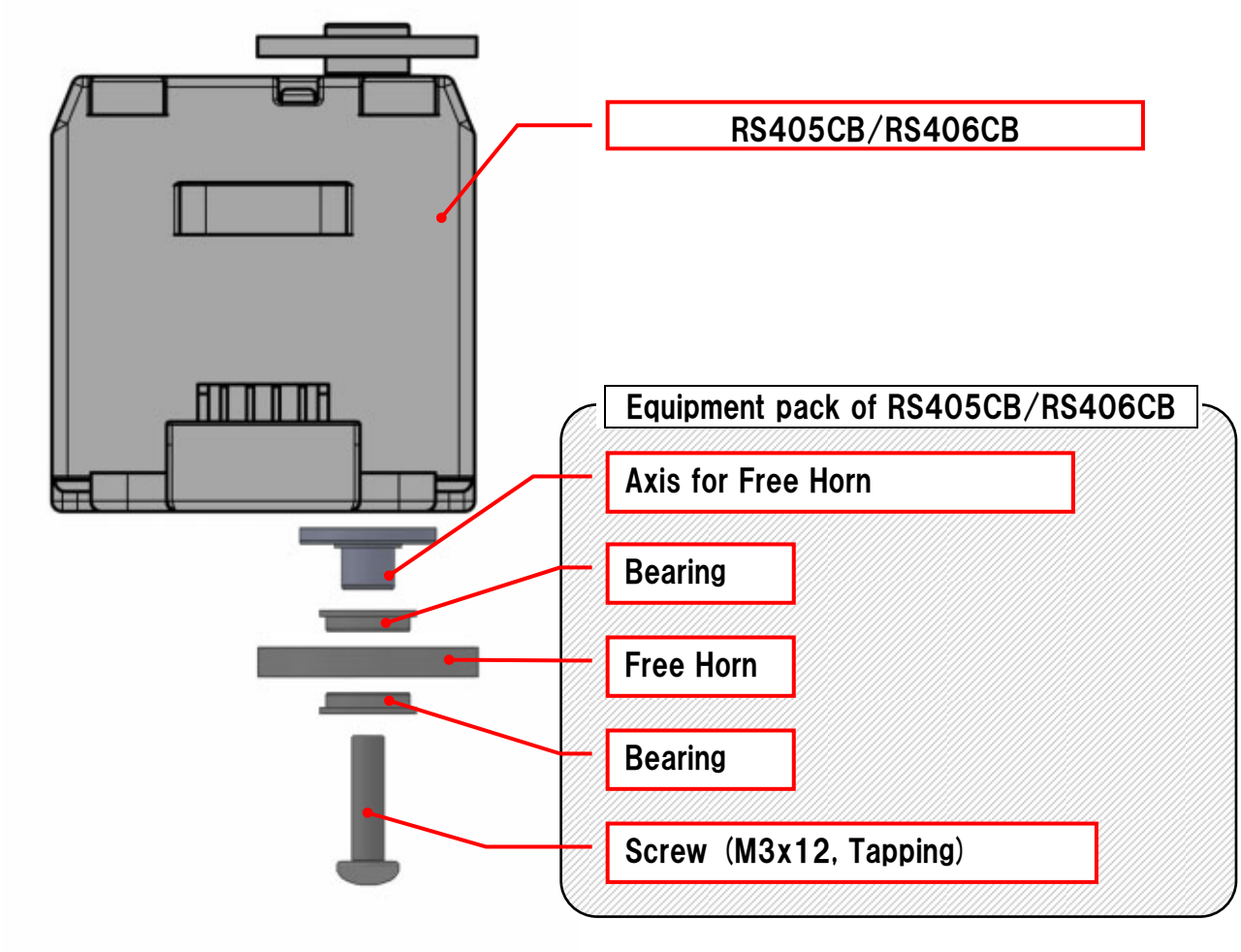


Fig. 2.2 How to fix Free Horn

● Daisy-Chain Connection

RS405CB/RS406CB has connectors on both sides, and is possible to be wired together in sequence or in a ring (see **Fig. 2.3**).

*Put cover to unused connector.

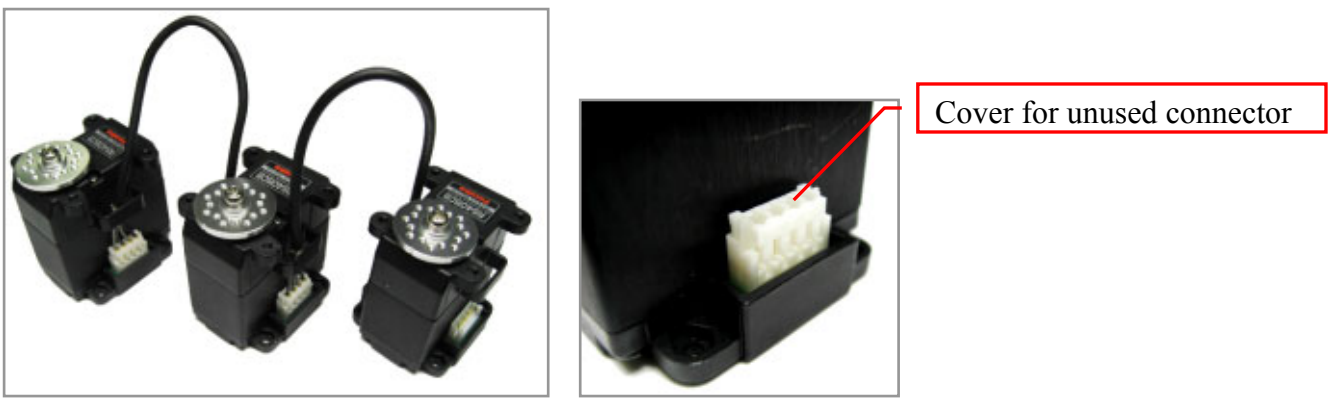


Fig. 2.3 (L) Daisy-Chain Connection (R)Covering an unused connector

● **Servo Horn made by aluminum with marks of standard position**

Servo Horn for RS405CB/RS406CB is made by aluminum to stand the large output power.

There are marks on the top of output axis and the top and side of the servo horn to show neutral position (0 degree).

(L) Mark on the top of Output Axis

(R) Marks on the top and the side of Servo Horn

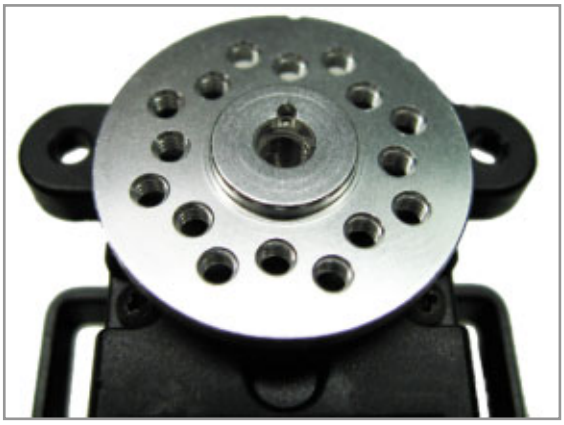


Fig. 2.4 Assembles at Neutral position

Part Names

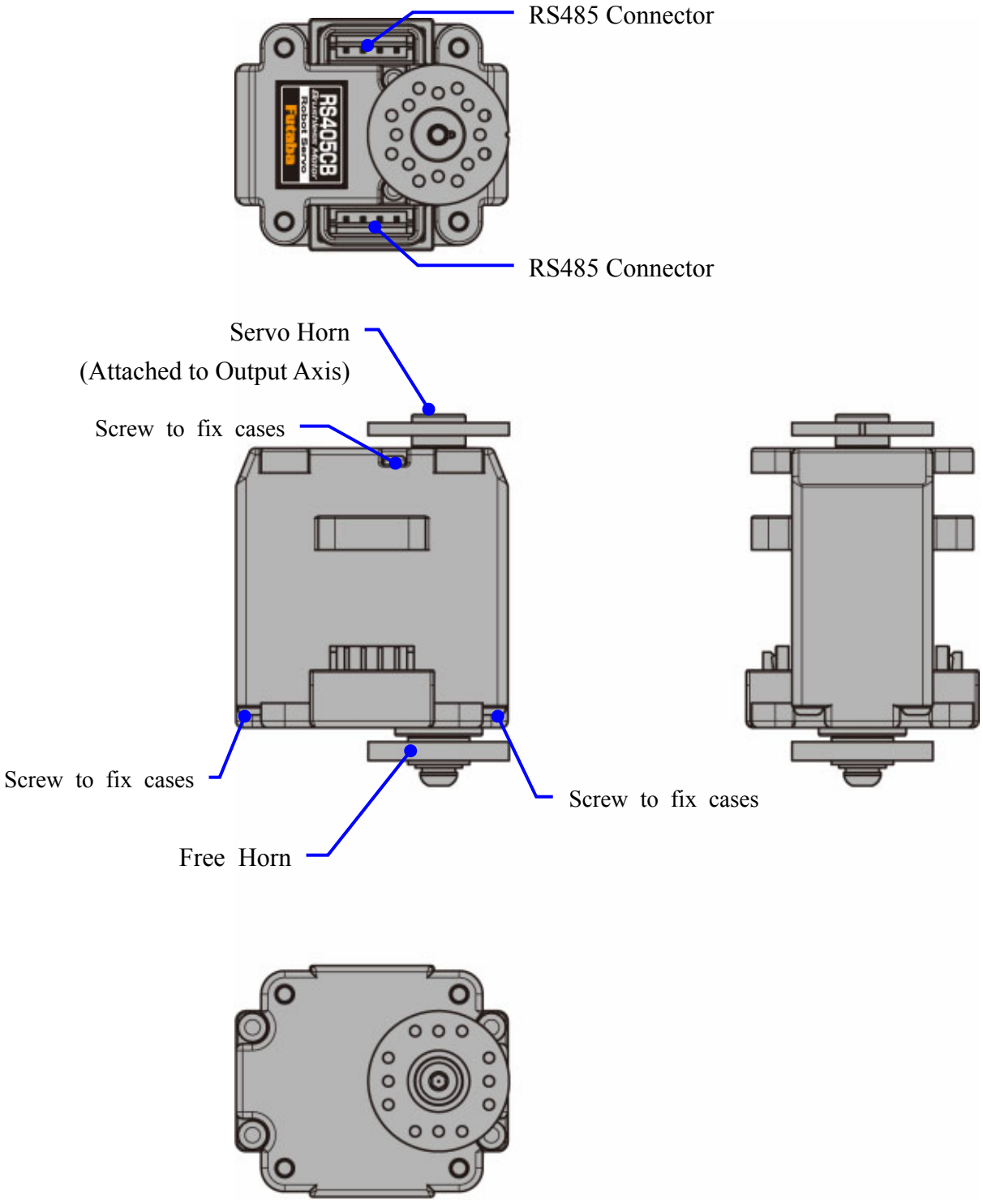


Fig. 2.5 Part Names

Caution

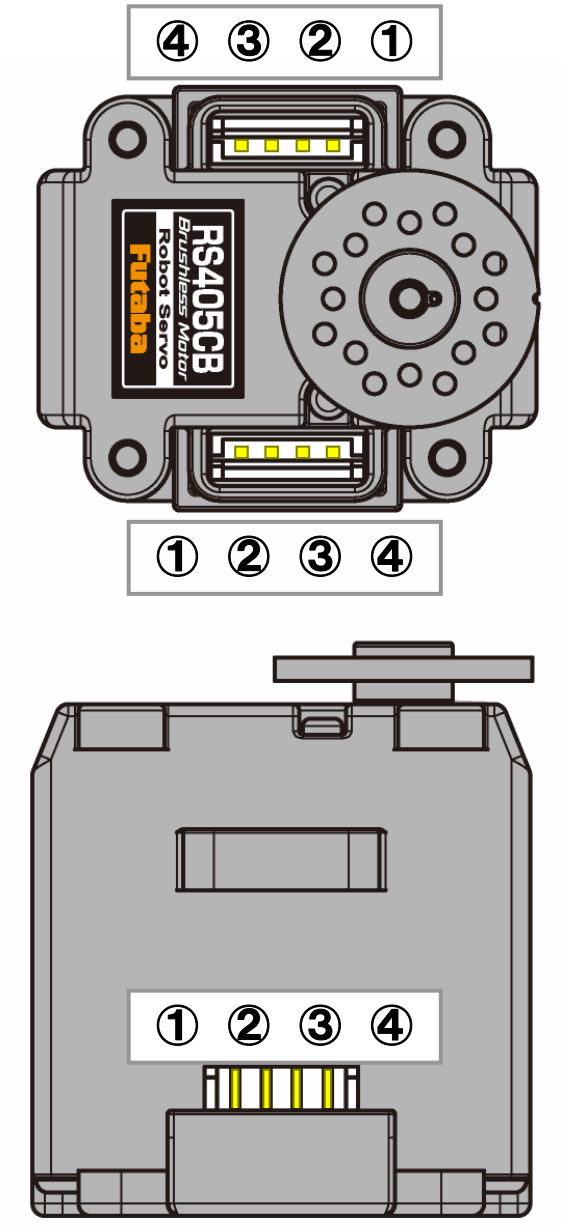
Do not remove screws to fix cases.

Removing the screws may damage the servo.

Pin Assignment

Pin Assignment of RS405CB/RS406CB is shown bellow;

● For RS485 Communication



① RS485 B (D−)
② RS485 A (D+)
③ Vcc (DC7.2V ～ 12.0V)
④ GND

[Connector]
JST Mfg. Co., Ltd. B4B-EH

Fig. 2.6 Pin Assignment for RS485 Communication

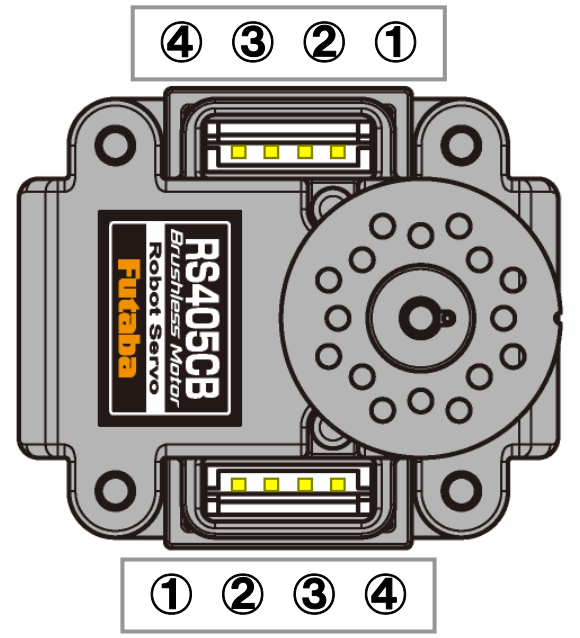
Connectors for RS405CB/RS406CB are "B4B-EH" (JST Mfg. Co., Ltd.).

● For PWM Communication

"CC-E3P3-300" is needed to input PWM Pulse to 405CB/RS406CB.

Please use only one of the connectors of the servo when the servo is controlled by PWM Pulse.

If PWM Pulse is input by both connectors simultaneously, the servo will not work normally.



① (NC)
② PWM
③ Vcc (DC7.2V ～ 12.0V)
④ GND

[Connector]
JST Mfg. Co., Ltd. B4B-EH

Fig. 2.7 Pin Assignment for PWM Pulse

Fig. 2.8 CC-E3P3-300

3. Connections

Systems

Systems of the robot with RS405CB/RS406CB are varies according to the control type.

● Systems as Command-Type Servo

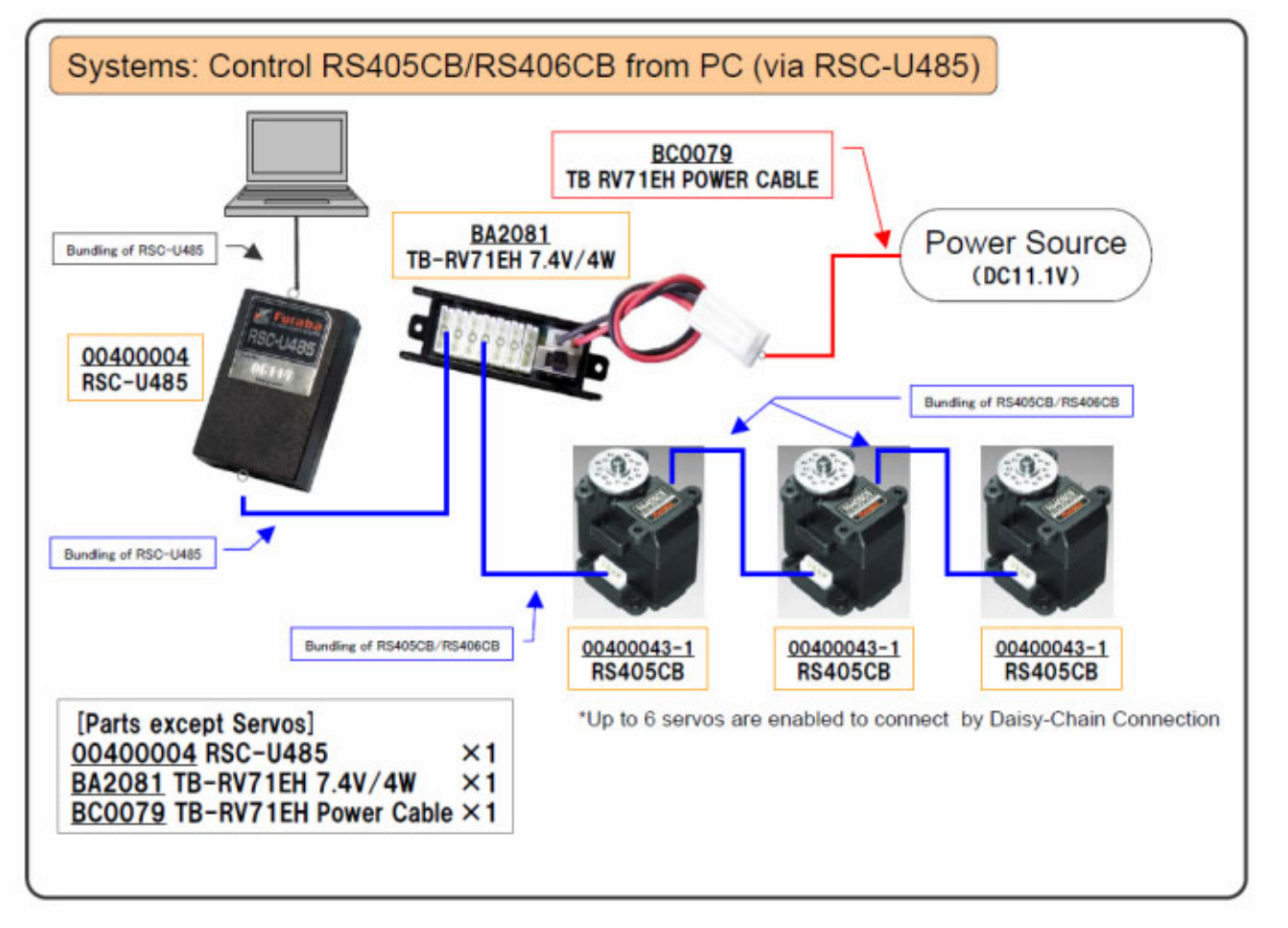


Fig. 3.1 Systems with Command-Type Servo

Use USB-RS485 Converter “RSC-U485” to control RS405CB/RS406CB from PC.

Communication Settings for PC is;

Baud Rate	:	115.2	[kbps](9.6[kbps]～460.8[kbps], see P.26 for more details)
Data bit	:	8	[bit]
Parity	:	none	
Stop Bit	:	1	[bit]
Flow Control	:	none	

● Cautions of connection

The maximum number of the connectable servo in 1 Daisy-Chain Connection is 6.

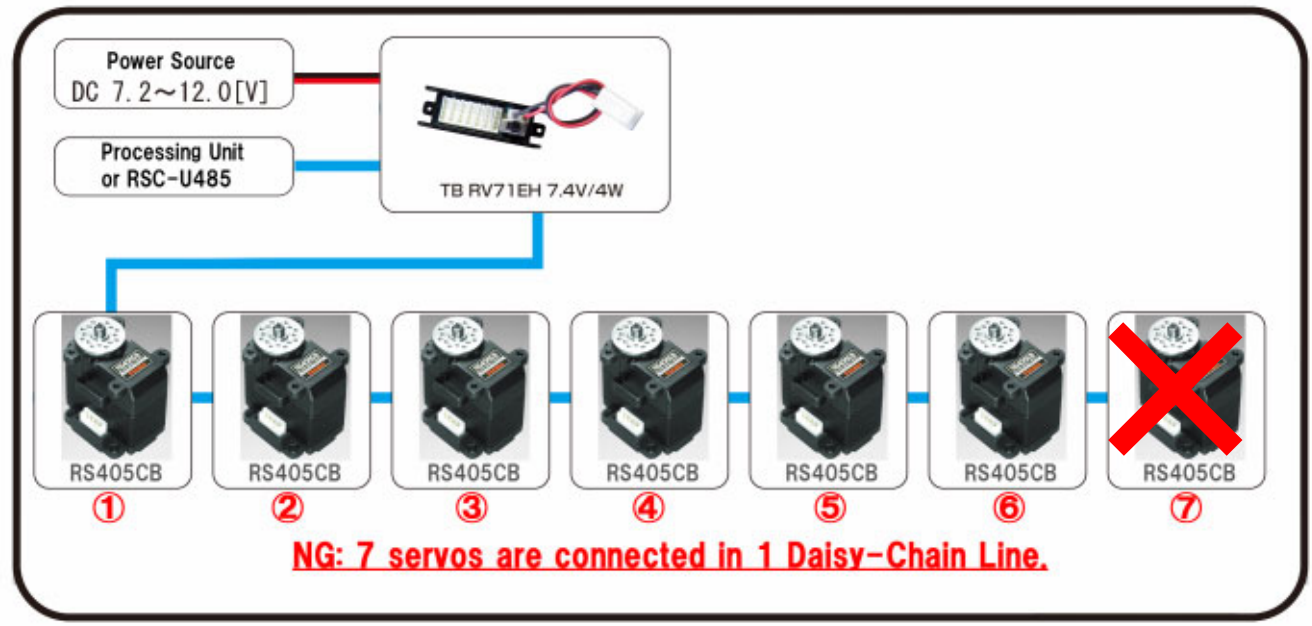


Fig. 3.2 NG: More than 6 servos are connected in 1 Daisy-Chain Line.

⚠Caution

Electric current capacity of the connector is 2A (continuous)

In **Fig. 3.3**, output torque of ① is the usually highest and that of ⑥ is the weakest because the output becomes weak as a far-off servo from a power supply.

Then adding the new power line like **Fig. 3.3** enables the output torque more equally

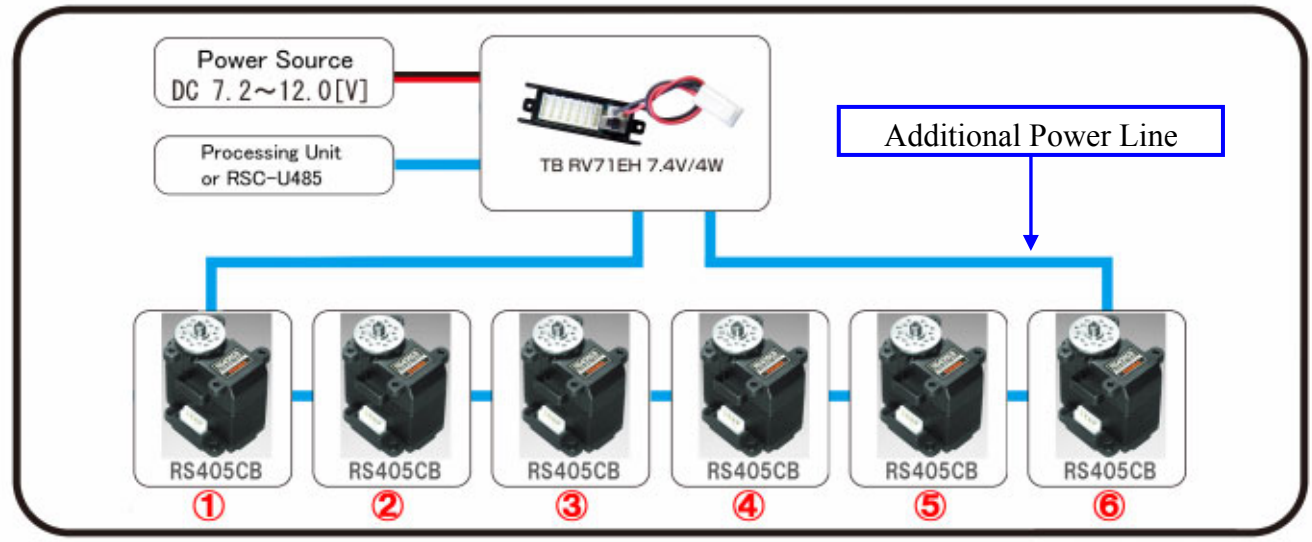


Fig. 3.3 Addition of Power Line

4. Control

Abstract

● Switch of Command-Type and PWM-Type

RS405CB/RS406CB can be controlled either as the Command-Type Servo of PWM-Type Servo.
Which Type will be applied is automatically decided by the first signal sent after the power is turned on. The Type once decided never changes until the power is turned off.

When RS405CB/RS406CB is controlled with a Robot Processing Unit "RPU-10" or USB-RS485 Converter "RSC-U485", they are operated as Command Type Servo. When RS405CB/RS406CB is used by connecting to a radio control receiver or a controller for PWM-Type Servo, they are controlled as PWM-Type Servo.

● Communication Protocol (RS485 Command-Type)

The communication protocol used for RS485 Command Type Servo is asynchronous half-duplex communication. The signal line can be switched alternately for transmission or reception of data.
Normally, RS405CB/RS406CB stands by in a receiving mode. When they receive commands from RPU-10 etc. to get the data of or the status of servos, the mode changes to a transmitting mode. After sending the data, they stand by again in a receiving mode.

● Control as PWM-Type Servo

To control RS405CB/RS406CB as a PWM-Type Servo, they are operated by changing the pulse width of the constant-frequency pulse (4ms-50ms). There is no direct relationship between the frequency, the torque, and the speed.
The relations between the pulse width and angles (positions) are as follows.

Table 4.1 Pulse Width and Angles

Pulse Width	Angle(degrees)
560 μs	+144
1520 μs	0
2480 μs	-144

If there is no input for more than 80ms or an invalid value, less than 500μs or more than 2550μs, is input, the RS405CB/RS406CB will deactivate (see p.28).

● Memory Map

RS405CB/RS406CB has its own memory area to store data necessary for its movement. This memory area is called “Memory Map”.
This memory map is divided into two groups. One is “RAM area” in which data will be erased when the power is turned off. The other one is “ROM area” in which data is held even after the power is turned off.

In “ROM area”, there are three different types of parameters; parameters used only for Command Type, parameters used only for PWM Type and those used for both Types. When these parameters are required to be rewritten, even parameters used only for PWM Type Servo, it is required to transfer the data as a Command Type Servo after connecting the servos to the PC with USB-RS485 converter (RSC-U485) etc.

While the servos are operated as PWM Type Servo, rewriting the parameters cannot be executed. Therefore, the servos are operated with the prewritten parameters.

● Servo ID

“ID” is used to identify servos during communication.

The default number of every servo is set to “1”.
When you use plural servos in a single communication network, give them different “ID” numbers.

● Packet

“Packet” is a block that is used for sending a command to or receiving data from RS405CB/RS406CB. Packets are divided into the following three groups, having different formats.

Short Packet

Short Packets are used for sending the data in the memory map toward a single servo.

Long Packet

Long Packets are used for sending the data in the memory map toward multiple servos simultaneously.

Return Packet

Return Packet is a packet that is sent from a servo when a return packet is requested.

Format of Packets

● Short Packet

Short Packet is used for sending the data in the memory map to a single servo.

Structure

Header	ID	Flag	Address	Length	Count	Data	Sum

Header

This is a line head of a packet. Set “FA AF” for short packets.

ID

Set “ID” of the servo to be sent the packet.
By setting “FF” (=255), commands are commonly effective to all servos,

Flag

“Flag” shows reaction of the servo such as sending Return Packet or write ROM Area and so on.
For details, refer subsequent pages.

Address

Set the starting address of Memory Map to be changed.

Length

“Length” is the length of the data. Set the number of bytes of “Data”.

Count

“Count” is the number of servos to be sent “Data”. Set “1” for a short packet.

Data

“Data” to be written in the memory map of the servo.

Sum

“Sum” is the value obtained from XOR operation on all bytes from ID through Data in a packet by a unit of a byte.

Ex.)”Sum” of following packet is “1C”.

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1E	02	01	00 00	1C

01H XOR **00H** XOR **1EH** XOR **02H** XOR **01H** XOR **00H** XOR **00H** = **1C**

Details of Flag

Each bit has the following meaning.

Table 4.2 bit of Flag

Bit	Function
7	(Reserved)
6	Write Flash ROM
5	Reboot Servo
4	Initialize memory map data
3	Direct Address of Return Packet
2	Direct Address of Return Packet
1	Direct Address of Return Packet
0	Direct Address of Return Packet

Bit 7 : Reserved

Set “0” to this bit always.

Bit 6 : Write Flash ROM

By setting this bit to “1” (Flags=40H) and sending a packet of address = FFH, Length = 00H, Count = 00H to a servo, data of the memory map from No.4 to No.29 is written in Flash ROM.

ex)Write Flash ROM of the servo (ID: 1)

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	40	FF	00	00	BE

The servo’s memory should be renewed with the data you want to write into the Flash ROM by transferring the data beforehand.
The servo ID becomes effective only after receiving a packet. The ID returns to the previous number on the next boot up unless the ID is written into the Flash ROM.

Caution

Never turn off the power while the Flash ROM is being written.

Bit 5 : Reboot Servo

Setting this bit to “1” (Flags=20H), and sending a packet with Address = FFH, Length = 00H, Count = 00H to a servo will reboot a servo.

Ex) Reboot servo (ID: 1)

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	20	FF	00	00	DE

A packet for “Write Flash ROM” and a packet for “Reboot Servo” have to be sent separately.
“Reboot Servo” packet must be sent after finishing “Write Flash ROM”.

Bit 4 : Initialize the memory map from No.4 to No.29

Setting this bit to “1” (Flags=10H), and sending a packet with Address = FFH, Length = 00H, Count = 00H and data = FFH to a servo will initialize the memory map from No.4 to No.29 to their default value. Please refer to default value in the “Variable ROM Area” for more details.

Ex) Initialize the memory map of the servo (ID: 1)

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	10	FF	FF	00	11

Caution

After initializing the servo, “ID” of the servo becomes “1”.

Bit 3～0 : Direct Address of Return Packet

(1) Direct Area of Memory Map

Setting Bit 3 to Bit 0 of a Short Packet as **Table 4.3**, you can receive return data of the specified area of servo's memory map.
The RS485 half duplex communication does not allow addressing more than one servo that can send a return packet. After requesting a return packet, do not send next data until completing receiving of the return packet.

Table 4.3 Direct Area of memory map

Bit	3	2	1	0	Function
	0	0	0	0	No return Packet
	0	0	0	1	Return ACK/NACK Packet
	0	0	1	1	Return the data of memory map No.00～No.29
	0	1	0	1	Return the data of memory map No.30～No.59
	0	1	1	1	Return the data of memory map No.20～No.29
	1	0	0	1	Return the data of memory map No.42～No.59
	1	0	1	1	Return the data of memory map No.30～No.41
	1	1	1	1	Return the specified number of bytes of data starting from the specified address

(2) Direct specified address

Setting the Bit 3 to Bit 0 to "1" and sending a short command with the starting address whose data you want to receive, the length of data and the count=00H makes it possible to return the specified number of bytes of the data starting from the specified address.
Available addresses in the memory map are from No.00 to No.139 (00H~8BH).

Ex)Return the data of addresses from No.42 (2AH) through No.43 (2BH) of the servo(ID:1).

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	0F	2A	02	00	26

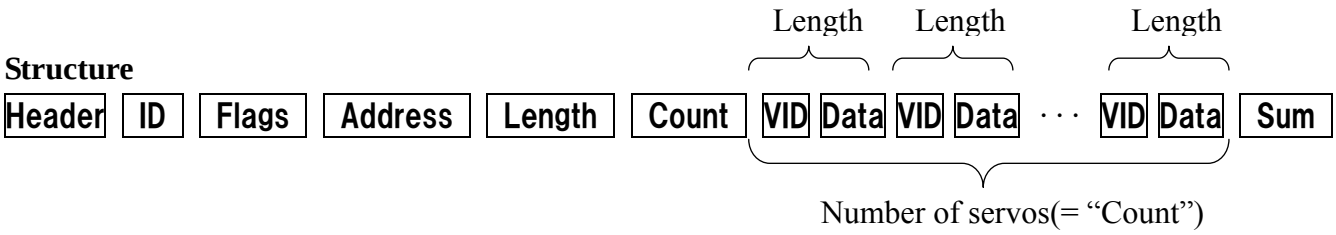
(3) ACK/NACK Packet

By sending a Short Packet with the Bit 0=1, Bit1=0, Bit2=0, Bit3=0, the servo will return ACK/NACK packet.
ACK/NACK Packet is only 1 byte of data that is **07H** = "ACK" or **08H** = "NACK".

● Long Packet

"Long Packet" is used to send the data to multiple servos.
("Address" and "Length" are the same to all servos.)

Structure



Header

This notation indicates the front of a packet. Set "FA AF" for Long Packet.

ID

Set "0" for Long Packet always.

Flags

Set "0" for Long Packet always.

Address

Set the starting address of Memory Map to be changed.

Length

"Length" is the length of the data for each servo.
Length = "the number of bytes of the data for each servos" + 1(byte of VID)

Count

"Count" is the number of servos to be sent "Data".

VID

"VID" is the ID of each servo

Data

"Data" to be written in the memory map of each servo.

Sum

"Sum" is the value obtained from XOR operation on all bytes from ID through Data in a packet by a unit of a byte.

Ex)Set angle to 10 degrees to the Servos (ID:1 and ID:2) and 50 degrees to the servo (ID:5).

Hdr	ID	Flg	Adr	Len	Cnt	VID	Dat	VID	Dat	VID	Dat	Sum
FA AF	00	00	1E	03	03	01	64 00	02	64 00	05	F4 01	ED

The check sum of the send data above is:

00H XOR **00H** XOR **1EH** XOR **03H** XOR **03H** XOR **01H** XOR **64H** XOR **00H** XOR **02H** XOR **64H** XOR **00H** XOR **05H** XOR **F4H** XOR **01H** = **ED**

● Return Packet

"Return Packet" is the packet returned from the servo when the Flag field requests a servo to send a return packet.

Structure

Header	ID	Flags	Address	Length	Count	Data	Sum

Header

This notation indicates the front of a packet. "FD DF" is set to Return Packet.

ID

This is the "ID" of the servo that sent Return Packet.

Flags

"Flags" of the Return Packet shows conditions of the servo.

Table 4.4 Flags of Return Packet

Bit	Value	Meanings
7	0: Normal / 1: Error	Temperature Limit (Torque OFF)
6	0	(Reserved)
5	0: Normal / 1: Error	Temperature Alarm
4	0	(Reserved)
3	0: Normal / 1: Error	Write Flash ROM Error
2	0	(Reserved)
1	0: Normal / 1: Error	Received Packet Error
0	0	(Reserved)

Address

"Address" shows starting address of the data of return packet.

Length

"Length" shows the number of bytes of "Data".

Count

"Count" Shows the number of servos. It is set to "1" for Return Packet.

Sum

"Sum" shows check sum of the Return Packet, and its value is the XOR from "ID" to the end of "Data" in byte units.

Memory Map

4.1. Invariable ROM Area

Table 4.5 Invariable ROM Area

Area	Address No. DEC	HEX	Initial	Name	R/W
Invariable	00	00H	50H(60H)	Model Number L	R
	01	01H	40H	Model Number H	R
	02	02H	03H	Firmware Version	R
	03	03H	--	Reserved	-

*(*) for RS406CB

● No.0/No.1 Model Number(2 Byte, Hex, Read)

It is the Model Number(name of the servo).

“40 50” means RS”405”CB, and “40 50” means RS”405”CB.

	RS405CB	RS406CB
Model Number L	50H	60H
Model Number H	40H	40H

● No.2 Firmware Version(1Byte, Hex, Read)

It is the version of the servo’s firmware.

Its value is depending on the version at production (0x03 in the example below).

Firmware Version = 03H

*Saving 2-Byte data

Two-byte data is stored to the memory map in two individual 8-bit bytes of H (High byte) and L (Low byte).

Ex) Set Angle to 29.2 degrees to servo (ID: 23)

Target angle is stored in “Goal Position” (Address 30/31) with unit of 0.1 degrees.

(29.2 [degrees] = 292 [0.1degrees, DEC] = 0124[0.1degrees, HEX])

Stored data is bellow:

Goal Position (L) = 24H

Goal Position (H) = 01H

4.2. Variable ROM Area

Table 4.6 Variable ROM Area

Area	Address DEC	Address HEX	Initial	Name	R/W
Variable ROM Area	04	04H	01H	Servo ID	RW
	05	05H	00H	Reverse	RW
	06	06H	07H	Baud Rate	RW
	07	07H	00H	Return Delay	RW
	08	08H	DCH	CW Angle Limit L	RW
	09	09H	05H	CW Angle Limit H	RW
	10	0AH	24H	CCW Angle Limit L	RW
	11	0BH	FAH	CCW Angle Limit H	RW
	12	0CH	00H	Reserved	-
	13	0DH	00H	Reserved	-
	14	0EH	69H	Temperature Limit L	R
	15	0FH	00H	Temperature Limit H	R
	16	10H	00H	Reserved	-
	17	11H	00H	Reserved	-
	18	12H	00H	Reserved	-
	19	13H	00H	Reserved	-
	20	14H	10H	Damper	RW
	21	15H	00H	Reserved	-
	22	16H	00H	Torque in Silence	RW
	23	17H	C8H	Warm-up Time	RW
	24	18H	01H	CW Compliance Margin	RW
	25	19H	01H	CCW Compliance Margin	RW
	26	1AH	04H	CW Compliance Slope	RW
	27	1BH	04H	CCW Compliance Slope	RW
	28	1CH	14H	Punch L	RW
	29	1DH	05H	Punch H	RW

*C: Effective only for Command-Type Control

*P: Effective only for PWM-Type Control

● No.4 Servo ID (1 Byte, Hex, Read/Write)

It is the “ID” of the servo.

Its Initial value is 01H and the settable range is from 1 to 127 (01H to 7FH).

Ex)Set ID to “5” to the servo (ID:1).

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	04	01	01	05	00

The servo begins to operate under the new ID as soon as the ID rewrite packet is received.

Note that the ID returns to previous ID if it was not written to the Flash ROM before turning off the power.

● No.5 Servo Reverse (1 Byte, Hex, Read/Write)

It is the direction of rotation of the servo.

Its initial value is 00H that means the normal rotation, and the value of 01H means reverse rotation.

If it is set to 01H (reverse rotation), the Angle Limit is also reversed.

Ex) Reverse the servo (ID:1):

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	05	01	01	01	05

● No.6 Baud Rate (1 Byte, Hex, Read/Write)

It is the baud-rate of communication.

Initial value is 07H (115,200bps) and the settable range is from 0 to 10 (00H to 0AH)

The values and baud rate is assigned as shown in Table 4.7.

Table 4.7 Baud Rate

Value	Baud Rate	Value	Baud Rate
00H	9,600bps	06H	76,800bps
01H	14,400bps	07H	115,200bps
02H	19,200bps	08H	153,600bps
03H	28,800bps	09H	230,400bps
04H	38,400bps	0AH	460,800bps
05H	57,600bps	---	---

(Date Bits : 8 bit、Stop Bit :1 bit、Parity : None、Flow Control : None)

Even after the value is rewritten, the servos are operated at the previous baud rate.

In order to operate under the new baud rate, it is required to write Flash ROM and Reboot Servo.

Ex) Set baud rate as 38,400 bps to the servo (ID:1)

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	06	01	01	04	03

After sending above packet, "Write Flash ROM" packet and "Reboot Servo" packet must be sent.

● No.7 Return Delay (1 Byte, Hex, Read/Write)

It is the delay time for reply when the Return Packet is required.

The servo sends the return packet in 100μs after receiving data with the setting of 0.
The parameters of No.7 are in units of 001H = 50μs.
If you want to set the delay time for reply to 1ms, write 18 (12H). (1ms=100μs+18x50μs)

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	60	07	01	01	12	74

● No.8/No.9/No.10/No.11 Angle Limit (2 Byte, Hex, Read/Write)

It is the maximum operating angle based on 0 degree (units: 0.1 degree).
No.8 and No.9 are used for CW (clockwise) direction and No.10 and No.11 are for CCW (counterclockwise) direction.

When the set angle is larger than the set Angle Limit, the servo rotates to the maximum operating angle.
Initial value and settable range is;

Direction	Initial	range
CW	+150(05DCH)	0 (0000H) ～ +150 (05DCH)
CCW	-150(FA24H)	0 (0000H) ～ -150 (FA24H)

Ex. 1) Set the CW Angle Limit of servo (ID: 1) to 100.0 degrees.
Since the angle is set in 0.1 degree units, 100.0 degrees = 1000(03E8H) is set.
CW Angle Limit L = E8H, CW Angle Limit H = 03H

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	08	02	01	E8 03	E1

Ex. 2) Set the CCW Angle Limit of servo (ID: 1) to -100.0 degrees.
-100.0 degrees = -1000(FC18H).
CCW Angle Limit L = 18H, CCW Angle Limit H = FCH

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	10	02	01	18 FC	F6

● No.14/ No.15 Temperature Limit(2 Byte, Hex, Read)

It is the limit value of the internal temperature of the servo.

When the internal temperature is increased by the heat of the motor, etc. and exceeds the set value, the servo will automatically turns off its torque to avoid troubles.
To turn on the torque again, cool the servo and reboot it.
*Note that rewriting this value will null and void the product warranty.

● No.20 Damper (1 Byte, Hex, Read/Write)

It is a damping-down of the movement of the servo.

It is used to reduce overshoot movement by an inertial force when the servo moves a heavy thing.
When hunting (convulsions) occur by a large load, please set a value bigger than an initial value.

The initial value is 16(10H) and the settable range is 0~255(00H~FFH).

● No.22 Torque in Silence(1 Byte, Hex, Read/Write, for PWM)

It is the condition of the servo's output torque.
When there is no input for more than 80ms or continuous invalid input that the pulse width is less than 0.5ms or more than 2.55ms, the servos' torque condition changes to the specified condition.

The initial value is 0(00H) and the relationship between the set value and the condition is shown as below;

Table 4.8 Torque Conditions

Value	Condition
0(00H)	Torque OFF
1(01H)	Torque ON and keep the same angle*
2(02H)	Brake mode (refer p.33)

*The servo continues maintain the angle directed just before the losing input or invalid input is started.

● No.23 Preparation Time (1 Byte, Hex, Read/Write, for PWM)

It is the time of the first movement after the power is turned on.
Setting this parameter enables the servo to avoid moving suddenly just after turning on the power.

Its unit is 10ms and the settable range is 0~255 (00H~FFH).
The Initial value is 200(C8H).

● No.24 / No.25 Compliance Margin (1 Byte, Hex, Read/Write)

It is the allowable range of the angle around the goal angle.
If the error between the present angle and the goal position is in the set range, the servo recognized itself to be in the goal position and stop moving.

No.24 is for CW and No.25 is for CCW.
The unit is 0.1 degree, initial value is 1(01H) and the settable range is 0~255(00H~FFH) for both directions.

● No.26 / No.27 Compliance Slope (1 Byte, Hex, Read/Write)

It is the range that output torque of the servo increases in proportion to the error between the present angle and aim angle. The flexibility of the servo increases in proportion to this value.

No.26 is for CW and No.27 is for CCW.
The unit is 1.0 degree, initial value is 4(04H) and the settable range is 0~255(00H~FFH) for each directions.

● No.28 / No.29 Punch (2 Byte, Hex, Read/Write)

It is the minimum torque (electric current) that is generated when present angle of the servo exceeds the range of Compliance Margin.

The unit is 0.01% of the maximum torque and the settable range is 0~10,000(00H~2710H)
The initial value is 0514H (13%).

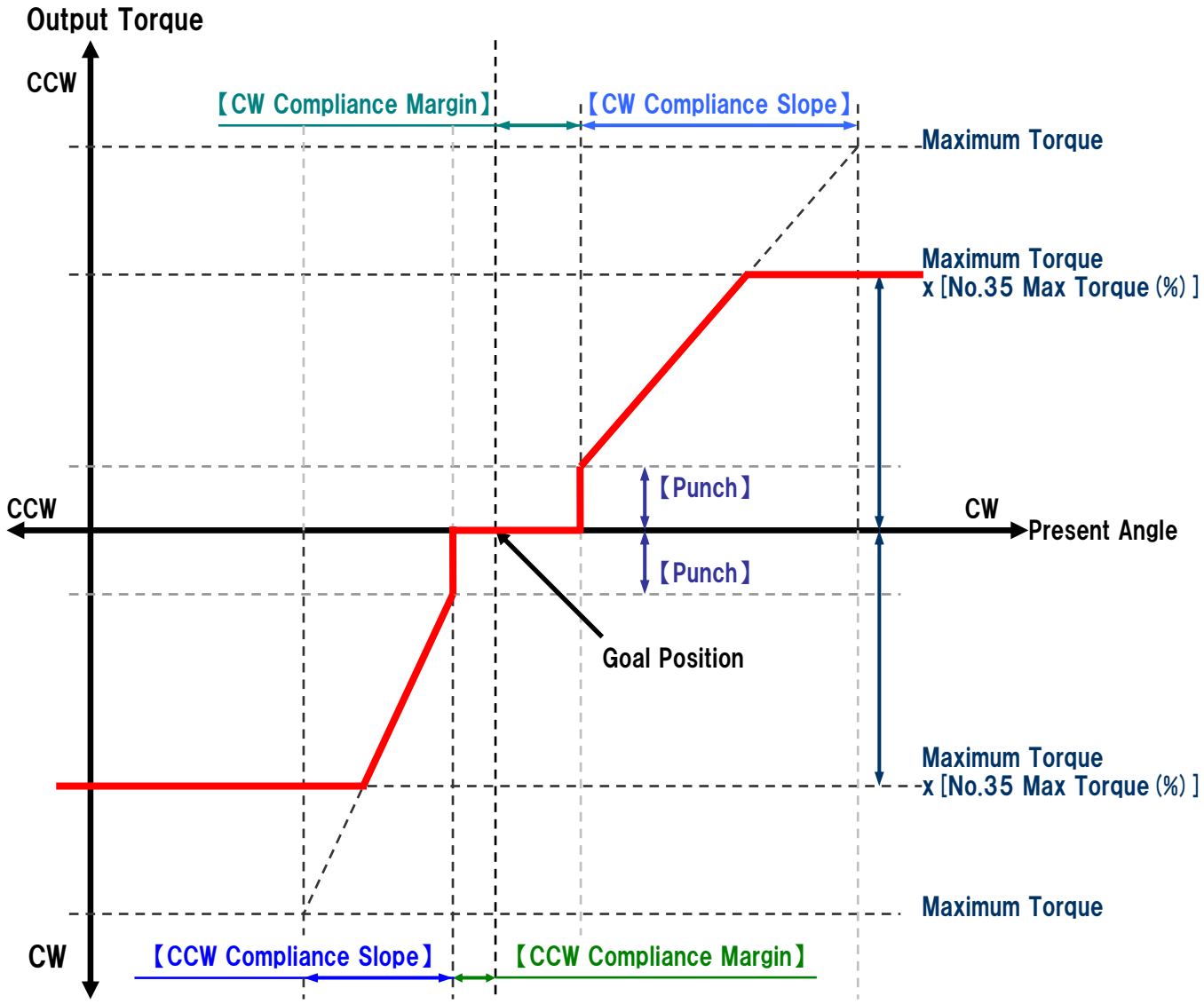


Fig. 4.1 The relationship of Output Torque, Angle and Compliance settings.

Ex.1) Set Punch of the servo (ID: 1) to 1[%](= 100(0064H)).

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1C	02	01	64 00	7A

Ex.2) Set the servo (ID: 1) as shown below;

CW Compliance Margin	=	03H
CCW Compliance Margin	=	03H
CW Compliance Slope	=	14H
CCW Compliance Slope	=	14H
Punch	=	0064H

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	18	06	01	03 03 14 14 64 00	7A

4.3. Variable RAM Area

Table 4.9 Variable RAM Area

Area	Address DEC	Address HEX	Initial	Name	R/W
Variable RAM Area	30	1EH	00H	Goal Position L	RW
	31	1FH	00H	Goal Position H	RW
	32	20H	00H	Goal Time L	RW
	33	21H	00H	Goal Time H	RW
	34	22H	00H	Reserved	-
	35	23H	64H	Max Torque	RW
	36	24H	00H	Torque Enable	RW
	37	25H	00H	Reserved	-
	38	26H	00H	Reserved	-
	39	27H	00H	Reserved	-
	40	28H	00H	Reserved	-
	41	29H	00H	Reserved	-
	42	2AH	00H	Present Posion L	R
	43	2BH	00H	Present Posion H	R
	44	2CH	00H	Present Time L	R
	45	2DH	00H	Present Time H	R
	46	2EH	00H	Present Speed L	R
	47	2FH	00H	Present Speed H	R
	48	30H	00H	Present Current L	R
	49	31H	00H	Present Current H	R
	50	32H	00H	Present Temperature L	R
	51	33H	00H	Present Temperature H	R
	52	34H	00H	Present Volts L	R
	53	35H	00H	Present Volts H	R
	54	36H	00H	Reserved	-
	55	37H	00H	Reserved	-
	56	38H	00H	Reserved	-
	57	39H	00H	Reserved	-
	58	3AH	--	Reserved	-
	59	3BH	--	Reserved	-

● No.30 / No.31 Goal Position (2 Byte, Hex, Read/Write

This parameter is the target angle of the servo.

Center of the movable range is 0 degrees and CW direction is "+" and CCW direction is "-" from the top of the servo (nameplate side). Unit of Goal Position is 0.1 degree and its settable range is -1500~+1500.

If the set value is out of the range specified by the No.8~No.11 ("Angle Limit"), the servo moves to the set maximum or minimum angle.
When No.36 "Torque Enable" is set from 0 (Torque OFF) to 1 (Torque ON), "Goal Position" is automatically rewrite to the value of Present Position.
When a packet that direct Torque ON and set Goal Position in 1 packet (packet to write No.30~36 at once) is received, the servo turns on its torque but not moves.

Ex.1) Move servo (ID: 1) to 90.0 degree.

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1E	02	01	84 03	9B

Ex.2) Move servo (ID: 1) to -90.0 degree

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1E	02	01	7C FC	9C

● No.32 / No.33 Goal Time (2 Byte, Hex, Read/Write)

This parameter is the time to move to "Goal Position".

The unit is 10ms and the settable range is 0~16,383(3FFFH), but note that error occurs about up to 5% when the set value is too big.
In the case that the speed required by "Goal Position" and "Goal Time" is faster than the maximum speed of the servo, the servo moves with its maximum speed.

Ex.1) Move the servo (ID: 1) to 90.0 degree in 5 sec.
90.0 degree = 900(0384H), 5 sec = 500 (01F4H)

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1E	04	01	84 03 F4 01	68

Ex.2) Move the servo (ID: 1) to -120.0 degree in 10 sec.
-120.0 degree = -12000(FB50H) , 10 sec = 1000(03E8H)

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1E	04	01	50 FB E8 03	5A

● No.35 Maximum Torque (1 Byte, Hex, Read/Write)

This parameter set the maximum torque of the servo.
In PWM-Type Control, the servo always moves with initial value (100%) regardless of set value.

The unit is 1 % with the torque described in this manual (p.40) as 100%.
The initial value is 100(64H) and the settable range is 0~100(00H~64H)

Ex) Set Maximum Torque of the servo (ID: 1) to 80%(=50H).

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	23	01	01	50	72

● No.36 Torque Enable (1 Byte, Hex, Read/Write)

It is the condition of the servo's torque.
The relationship of the value and the condition is shown as below;

Value	Condition
0(00H)	Disable (Torque OFF)
1(01H)	Enable (Torque ON)
2(02H)	Brake mode

The initial value is 0(00H) when the power is turned on.
In "Brake mode", the servo does not have output torque, but weak resistance torque occurs when it is turned from the outside.

Ex.1) Turn on the torque of the servo (ID: 1).

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	24	01	01	01	24

Ex.2) Turn off the torque of the servo (ID: 1)

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	24	01	01	00	25

Ex.3) Set the servo (ID: 1) to "Brake mode "

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	24	01	01	02	27

● No.42 / No.43 Present Position (2 Byte, Hex, Read)

It is the angle of the servo.

Center of the movable range is 0 degrees and CW direction is “+” and CCW direction is “-” from the top of the servo (nameplate side).Unit of Goal Position is 0.1 degree and its range is -1500~+1500.

Ex) Get “Present Position” of the servo (ID: 1)
To get the value of “Present Position”(No.42 and No.43 of the Memory Map) as a Return Packet, a Short Packet (“Flag”:bit3=1, bit2=0, bit1=0, bit0=1,”Address”=0, “Length”=0, “Count”=1 and no ”Data”) is required to be sent.

A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

						Data								
Hdr	ID	Flg	Adr	Len	Cnt	42	43	···			···	58	59	Sum
FD DF	01	00	2A	12	01	84	03	00 00 00 00 06 00	···00 00 00 00 00 00					B9

2 Byte from the top of “Data” is “Present Position” (No.42 and No.43 of Memory Map), then “Present Position” is 0384H=900= 90.0degrees.
*The value of "Data" varies according to the conditions of the real servo.

● No.44/No.45 Present Time (2 Byte, Hex., Read)

It is an elapsed time after a servo receives a packet to move.

When movement is completed, it maintains the last value.
If the “Goal Time” of the movement is “0(00H)”, “Present Time” will not be rewritten (maintain last value).

Ex) Get “Present Time” of the servo (ID: 1)
A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is the same as the previous paragraph.

A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

						Data									
Hdr	ID	Flg	Adr	Len	Cnt	42	43	44	45	···	···	58	59	Sum
FD DF	01	00	2A	12	01	5C FF	37	02	00 00 07 00	· · ·	00 00 00 00 00 00			A9

The 3rd and 4th Byte of the “Data” is “Present Time”(No.44 and No.45 of Memory Map), then “Present Time” is 0237H=567=5670msec.

*The value of "Data" varies according to the conditions of the real servo.

● No.46/No.47 Present Speed (2 Byte, Hex, Read)

It is the rotational speed and its unit is deg/sec.

Ex) Get “Present Speed” of the servo (ID: 1)

A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is the same as the previous paragraphs.

A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

						Data											
Hdr	ID	Flg	Adr	Len	Cnt	42	43	44	45	46	47	···	···	58	59	Sum
FD DF	01	00	2A	12	01	5C	FF	37	02	2C	01	07	00 ・・・	00	00	84

2 Byte as No.46 and No.47 of “Data” is the “Present Speed”, then “Present Speed” is 012CH=300 deg/sec.

*The value of "Data" varies according to the conditions of the real servo.

● No.48/No.49 Present Current (2 Byte, Hex, Read)

It is the electric current of the servo and its unit is 1mA.

It is almost proportional to output torque, but does not become 0 even in the condition of Torque-OFF.

Ex) Get “Present Current” of the servo (ID: 1)

A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is the same as the previous paragraphs.

A Short Packet to require Return Packet with Memory Map No.42 ~ No.49 is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

						Data													
Hdr	ID	Flg	Adr	Len	Cnt	42	43	···		···	48	49	···		···	58	59	Sum
FD DF	01	00	2A	12	01	4E FB 00 00 00 06 00 00 BA 03 00 00 00 00 00 00 00 00												32

2 Byte as No.48 and No.49 of “Data” is the “Present Current”, then “Present Current” is 0006H=6mA.

*The value of "Data" varies according to the conditions of the real servo.

● No.50/No.51 Present Temperature (2 Byte, Hex, Read)

It is the temperature of the board in the servo.
The sensor has individual difference about up to ±3 degrees Celsius.

When “Present Temperature” reaches low temperature 10 degrees Celsius than a “Temperature Limit” (No.14 and No.15 of Memory Map), “Temperature Alarm” (Bit 5 of Flag of Return Packet) becomes “1”.
When “Present Temperature” Exceeds “Temperature Limit”, “Temperature Limit” (Bit 7 of Flag of Return Packet) becomes “1” and the servo will be “Brake mode”(No.36 of Memory Map becomes to “2”) automatically.

<u>*) If the electric current was suddenly increased, it may become "Brake mode" before the temperature reaches the "Temperature Limit",</u>

The temperature reaches “Temperature Limit” once, the servo will not accept Torque-ON command until it is rebooted or is turned off-and-on the power again.

When “Present Temperature” reaches “Temperature Limits”, temperature around the motor of the servo reaches to 120~140 degrees Celsius. Please be careful about burns and use the servo after the temperature fell enough.

Ex) Get “Present Temperature” of the servo (ID: 1)
A Short Packet to require Return Packet with Memory Map from No.42 and No.59 is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

						Data														
Hdr	ID	Flg	Adr	Len	Cnt	42	43	・・・			・・・	50	51	・・・			・・・	58	59	Sum
FD DF	01	00	2A	12	01	4E	FB	00	00	00	00	06	00	2D	00	00	00	00	00	A6

2 Byte as No.50 and No.51 of “Data” is the “Present Temperature”, then the value is 002DH=45degrees Celsius.
*The value of "Data" varies according to the conditions of the real servo.

● No.52/No.53 Present Voltage (2 Byte, Hex, Read)

It is the voltage of the power applied to the servo and its unit is 10mV.
The sensor has individual difference about up to ±0.3V.

Ex) Get “Present Voltage” of the servo (ID: 1)
A Short Packet to require Return Packet with Memory Map from No.42 and No.59 is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

Hdr	ID	Flg	Adr	Len	Cnt	Sum
FA AF	01	09	00	00	01	09

An example of Return Packet is;

						Data														
Hdr	ID	Flg	Adr	Len	Cnt	42	43	・・・	・・・	52	53	・・・	・・・	58	59	Sum
FD DF	01	00	2A	12	01	4E FB 00 00 00 00 06 00 2D 00				56	04	00 00 00 00 00 00				F4

2 Byte as No.52 and No.53 of “Data” is the “Present Voltage”, then the value is 0456H=11.1V.
*The value of "Data" varies according to the conditions of the real servo.

5. References

Specs

Application	Actuators for Robots				
Dimensions	40.5 x 21.0 x 41.8 [mm] (except for flange part and connectors) *Refer next page for more details.				
Weight		67	[g]		
Consumption Current (Room Temperature, No Load)		(in suspension) (in operation)	30 210	[mA] [mA]	
Output Torque (at 11.1V)		RS405CB RS406CB	48.0 28.0	[kgf·cm] [kgf·cm]	
Maximum Speed (at 11.1V, No Load)		RS405CB RS406CB	0.21 0.11	[sec/60 degree] [sec/60 degree]	
Direction	CW CCW	Present Position < Goal Position Present Position > Goal Position			
Angle Range	CW CCW	150[degree] (Command-Type) / 144 [degree] (PWM-Type) 150[degree] (Command-Type) / 144 [degree] (PWM-Type)			
Supply Voltage		7.2	~	11.1	[V]
Temperature Range		(to operate) (to store)	0 -20	~ ~	+40[degrees Celsius] +60[degrees Celsius]
Power Source	DC Power Supply / Batteries				
Communication	Baud Rate Protocol	Maximum 460.8kbps Data bit: 8bit , Stop bit: 1, None Parity, Asynchronous			

Dimensions

● RS405CB/RS406CB

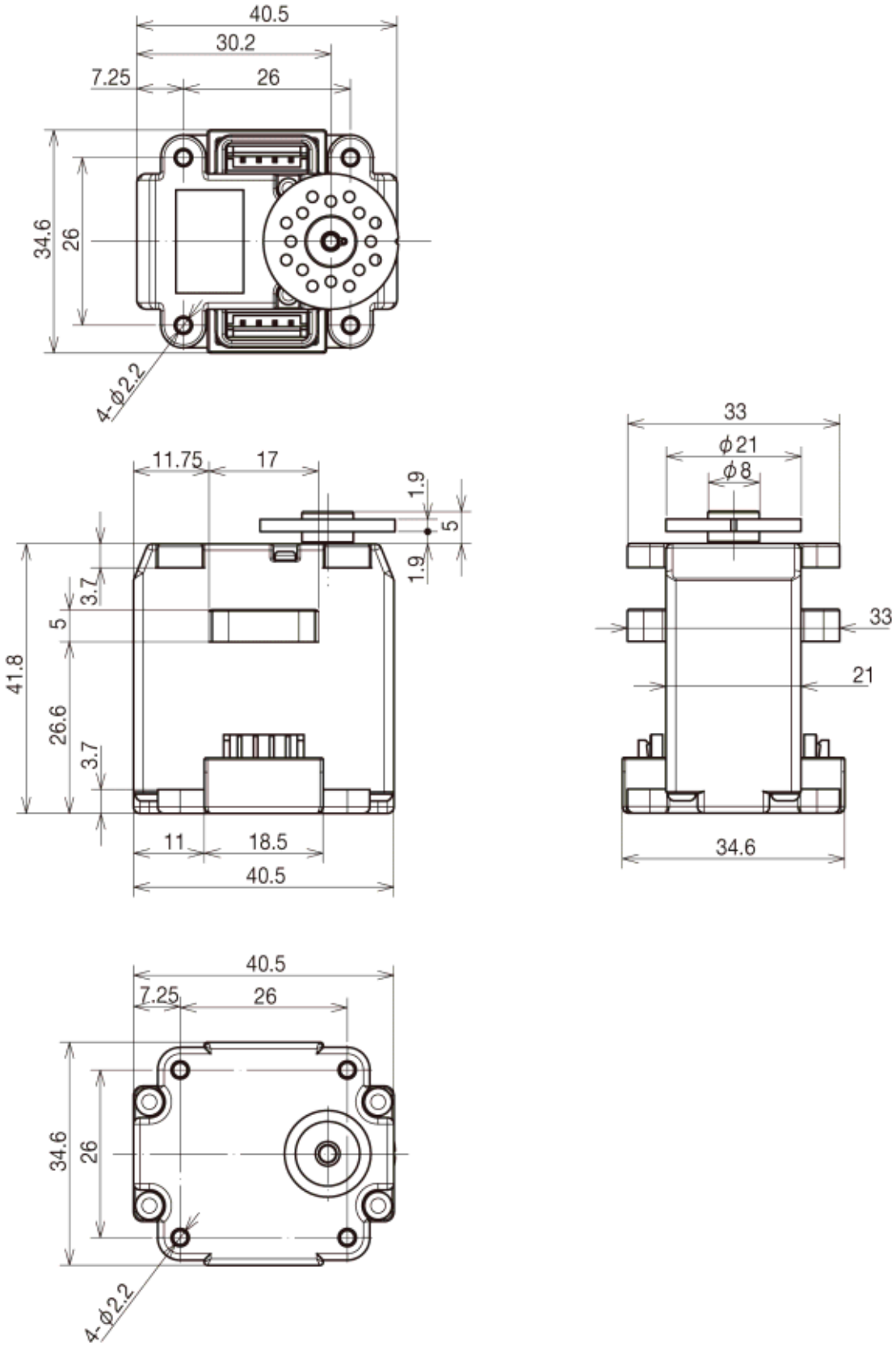


Fig. 5.1 RS405CB/RS406CB (unit: mm)

● RS405CB/RS406CB with Free Horn

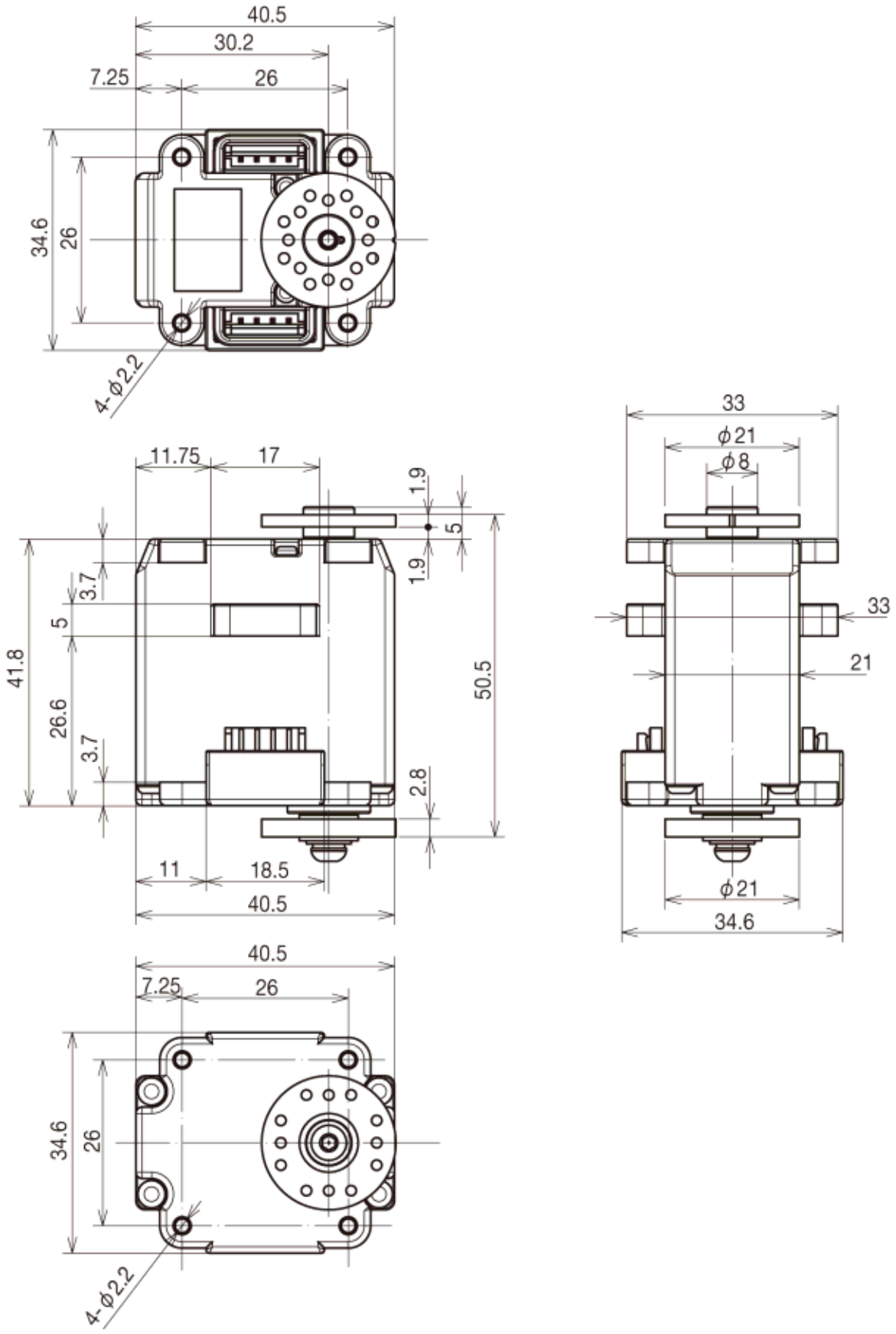


Fig. 5.2 RS405CB/RS406CB with Free Horn (unit: mm)

● RS405CB/RS406CB Servo Horn and Free Horn

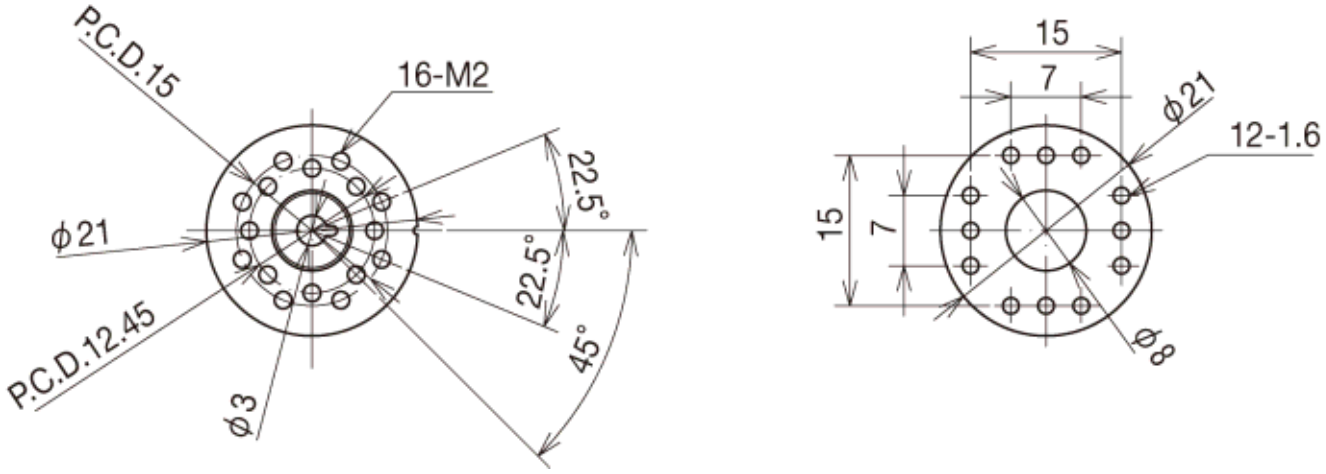


Fig. 5.3 (L)Servo Horn (R)Free Horn

Option Parts

Table 5.1 Option Parts for RS405CB/RS406CB

Name	
RS405CB SERVO HORN	Metal Servo Horn for RS405CB/RS406CB and Screw to fix it.
RS405CB FREE HORN SET	Free Horn Set for RS405CB/RS406CB (Free Horn, 2 Bearings, Axis for Free Horn)
RS405CB CASE SET	Cases for RS405CB/RS406CB (Heat Sink is **not** included)
RS405CB GEAR SET	Gears for RS405CB
RS406CB GEAR SET	Gears for RS406CB
CC-E4E4-150	RS485 Cable with EH-Connector(150mm)
CC-E3P3-300	Cable to connect TB22PP to other hubs, 300mm (Use for PWM Input to RS405CB/RS406CB)

*"RS405CB SERVO HORN", "RS405CB FREE HORN SET" and "RS405CB CASE SET" are commonly used for both RS405CB and RS406CB.

⚠Caution

Do not use "RS405CB GEAR SET" for RS406CB or use "RS406CB GEAR SET" to RS405CB.

If Gear Set for other servo is assembled, the servo will not move normally because several parameters are related to gear-ratio.

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