1M23N04602

User's Manual ver.3.50

AJ9DA

Servo for UAS

Instruction Manual

Caution

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

For models/UAS

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

Warning

NEVER use this product for the devices that is directly related to human life such as below;

- Medical Devices
- Aerospace/ground manned vehicles
- Nucleus-related Devices

⚠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 use the servo underwater.
Protection level of the servo is IP64 (dust and drip proof).
Using the servo underwater may be cause of damage or crash.

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.

Do not add a strong shock or vibration to the servo.
Do not drop and/or throw the servo away.

Please use a power source with sufficient capacity of current.
When the servo is locked (fixed not to be able to move), a very large current flows.

Use the servo-horn specially designed for this servo.
Take a measure so that the servo horn does not loosen.
Ensure that there are no obstruction and/or bent between the device being controlled and the servo horn.

Design the location of the servo carefully about the temperature.
The case of the servo is designed as a heat sink, it will become high-temperature.

Locate the servo so that the cases of the servo will not touch other metal parts.
To touch metal parts will be cause of electrical noise and adversely affects communication .

Turn on the control signal for the servo before turning on the power on.
When using servos with Transmitter and Receiver, always make sure to turn the Transmitter power on first.

Turn off the servo before switching signals between PWM/S.BUS and RS485.
Switching between S.BUS/PWM and RS485 without turning off the power will be cause of breaking down of the servo.

Do NOT input “S.BUS” or “PWM” and “RS485” simultaneously.
Inputting S.BUS/PWM and RS485 will be cause of breaking down of the servo.

Connect the servo correctly with external equipment such as power supply and receiver.

Incorrect connection will be cause smoke, fire, or damage.

Locate the servo from the noise source.

Strong noise such as electromagnetic waves and static electricity from the external environment will be cause of malfunction or damage.

Do not connect or disconnect the servo connector while the power is ON.

When connecting and disconnecting the servo connector in a state of power-ON, the servo will mis-recognizes the control signal and might stop.

Use the servo and other devices within each range of operational voltage.

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

feature

AJ9DA series are servos for UAS (Unmanned Aerial System) etc..

The “Servo” here is a module that has a motor, gear-train, and control circuits, and can be controlled by an order from outside and can output data of its internal sensors.

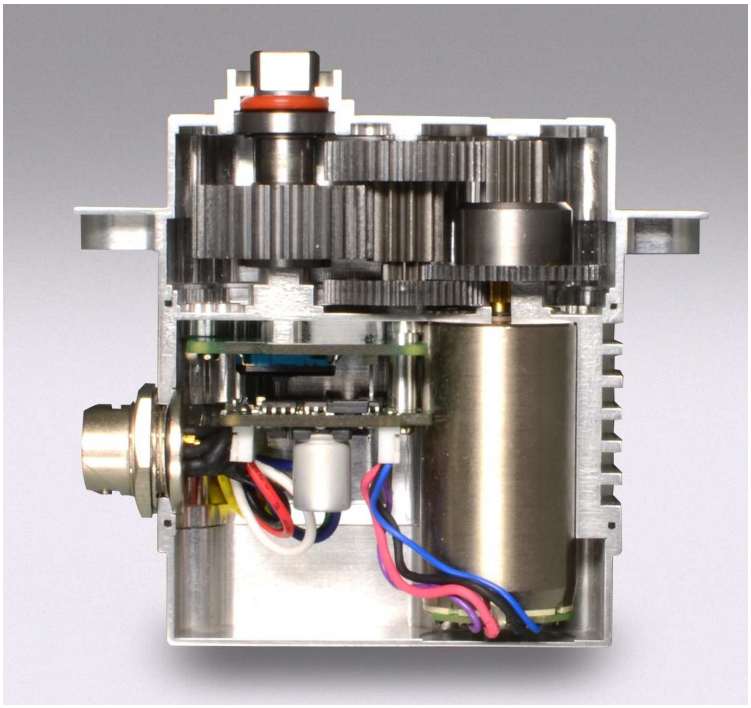


Fig. 2.1 Internal Structure of AJ9DA

Variations

"AJ9DA" series has several variations, and numbers of the model name end are different according to each specification such as Voltage, Cable Type, Gear Types..

Model	Voltage	Cable	Gear Type	Torque [ozf-inch] ([N-m])	Speed [s/60°] ([rpm])
AJ9DA**41**	11.1 [V]	Fixed	Torque	1166.5 (8.2)	0.27 (37.0)
AJ9DA**42**			Speed	902.7 (6.4)	0.21 (47.6)
AJ9DA**43**		Receptacle	Torque	1166.5 (8.2)	0.27 (37.0)
AJ9DA**44**			Speed	902.7 (6.4)	0.21 (47.6)
AJ9DA**51**	24.0 [V]	Fixed	Torque	1527.8 (10.8)	0.20 (50.0)
AJ9DA**52**			Speed	1208.3 (8.5)	0.16 (62.5)
AJ9DA**53**		Receptacle	Torque	1527.8(10.8)	0.20 (50.0)
AJ9DA**54**			Speed	1208.3(8.5)	0.16 (62.5)

● Cable Type

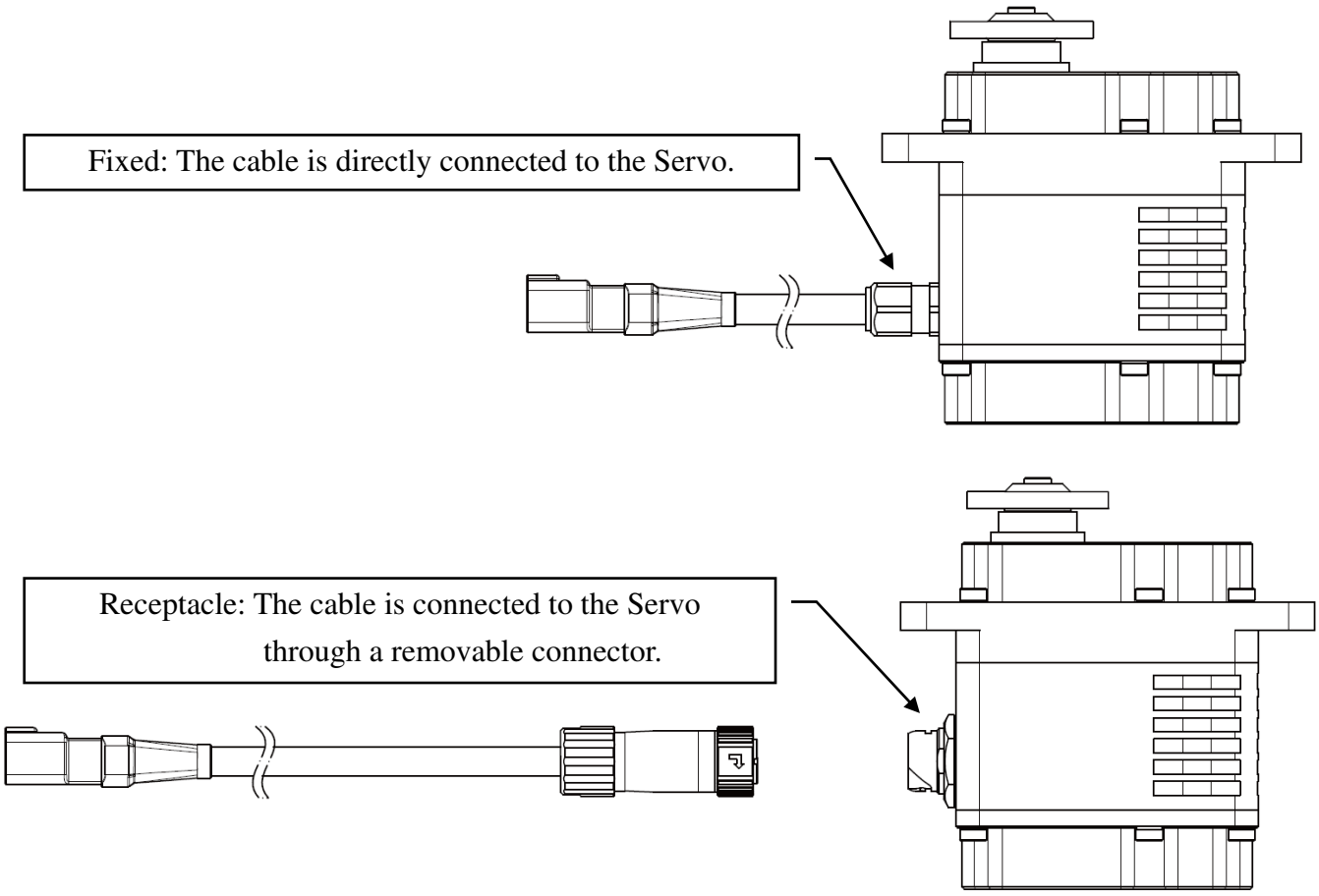


Fig. 2.2 Cable Type (Upper)Fixed (Lower)Receptacle

Components

The following parts are included in AJ9DA.

1) AJ9DA 1pcs

2) Servo Horn for AJ9DA 1pcs

3) Screw to fix Servo Horn(M3x8) 1pcs

*Servo Horn and Screw (2), 3)) are attached to the servo.

Equipment Parts

4) AJ9DA Cable (*Only for AJ9DA43,44,53,54) 1pcs

5) Cable with connector for AJ9DA 1pcs

6) Usage Precautions 1pcs

Fig. 2.3 (L) AJ9DA41,42,51,52 (R) AJ9DA43,44,53,54

Fig. 2.4 (L) (4) AJ9DA Cable (for AJ9DA 43,44,53,54) (R) (5)Cable with connector for AJ9DA

Part and Names

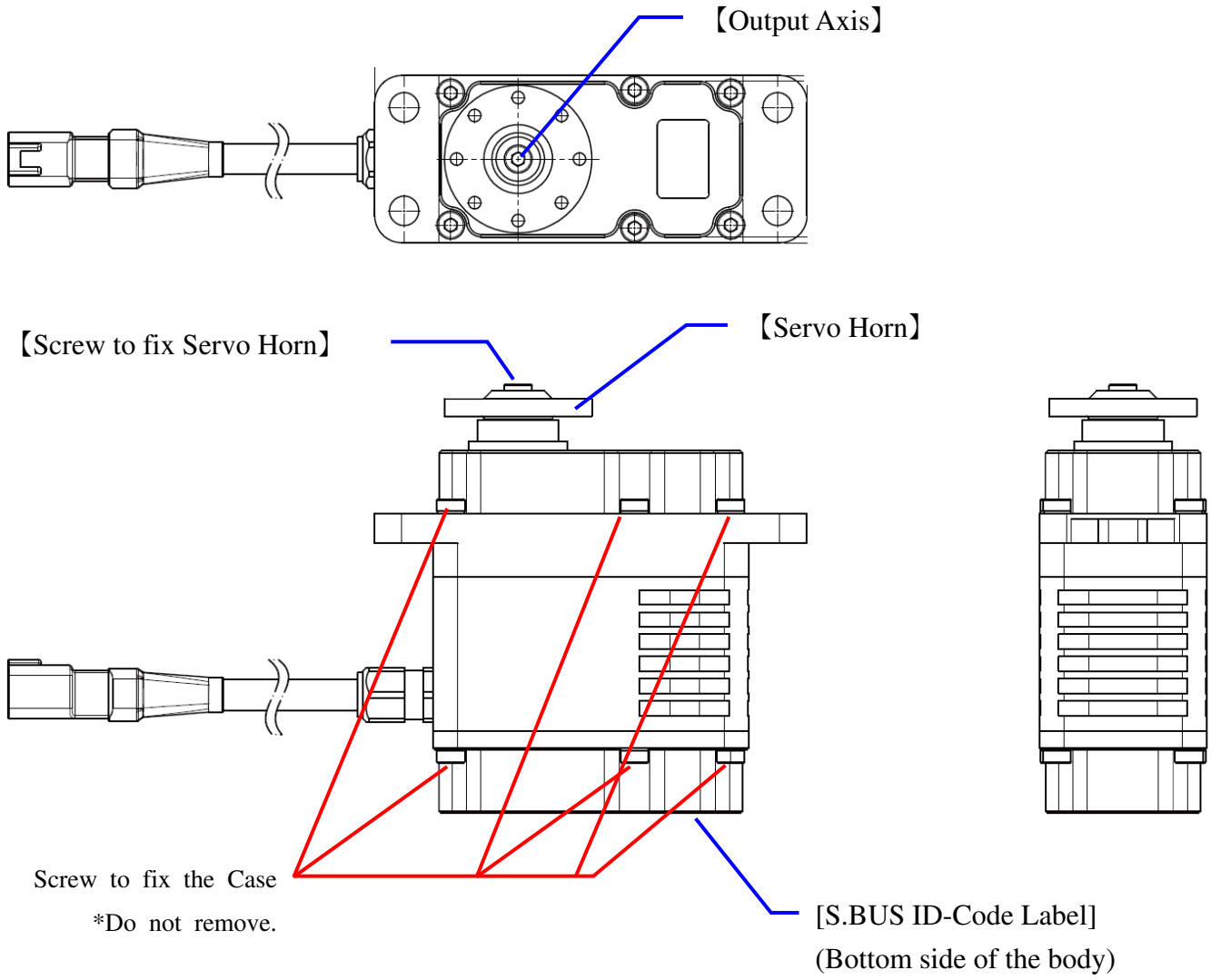


Fig. 2.5 Part and Names

Caution

Do not remove the screws to fix the case.

Removing the screws to fix cases may damage the servo.

Angle of the Servo

The angle of the servo is defined as shown in Fig. 3.2.
(Clock Wise Direction is “+”, Counter Clock Wise direction is “-”.)
This definition is common in all control methods and angle feedback.

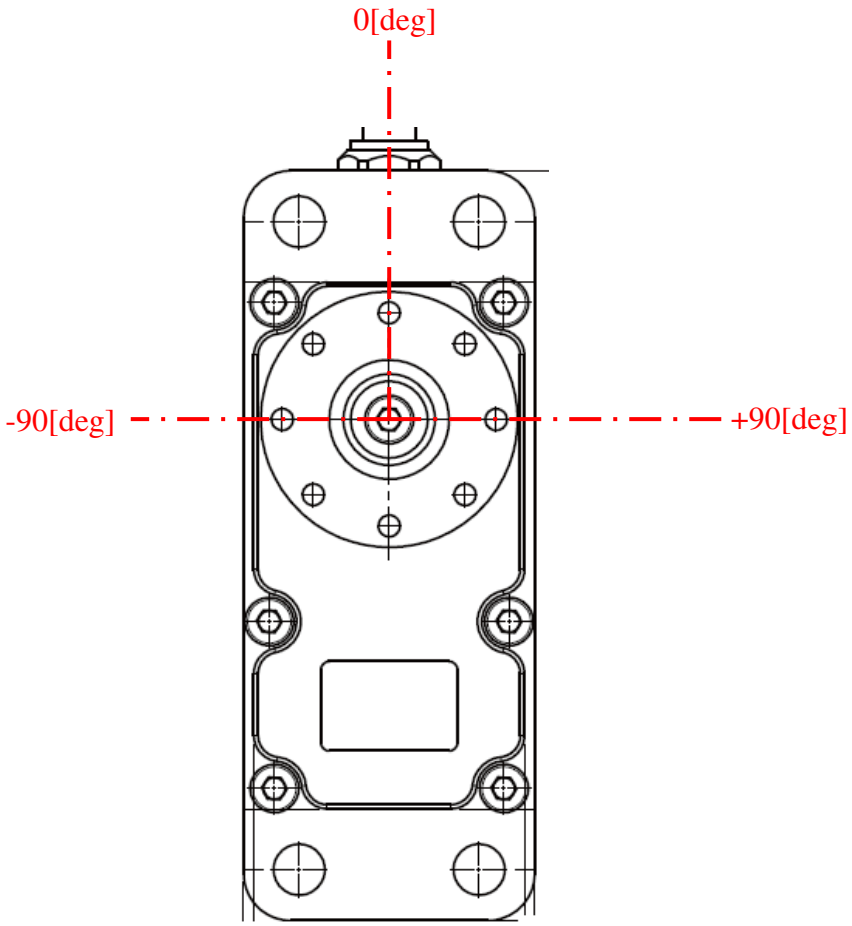
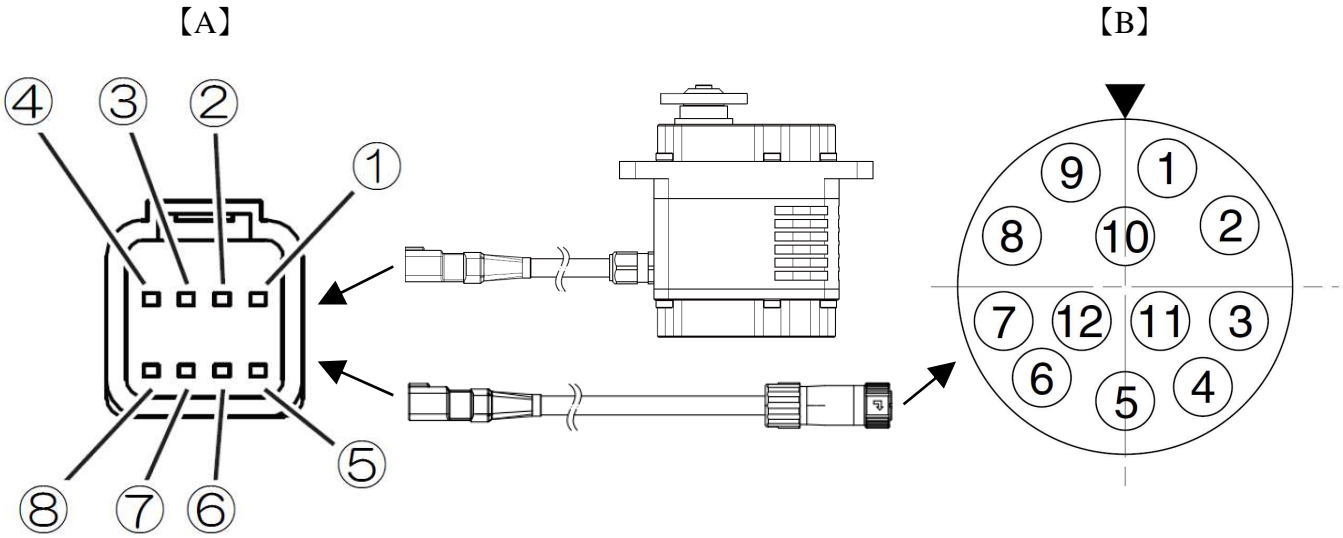


Fig. 2.6 definition of the Angle

3. Connection/Control

Pin Assignment

Pin Assignment of AJ9DA is shown below;



	【A】 *Tip of the Cable			【B】 Basal of the Cable *only AJ9DA43,44	
Manufacture	J.S.T. Mfg. Co., Ltd			HIROSE ELECTRIC CO., LTD	
Type	08T-JWPF-VSLE-D			LF10WBP-12S(31)	
Mating	08R-JWPF-VSLE-D etc.			LF10BRB-12P	
Pin Assignment	1	Brown	Position Feedback (+)	1	RS485 B(D-)
	2	Yellow	Position Feedback (-)	2	RS485 A(D+)
	3	Green	RS485 A(D+)	3	Position Feedback (-)
	4	Blue	RS485 B(D-)	4	Position Feedback (+)
	5	White	S.BUS / PWM	5	Battery (-)
	6	Red	Battery (+)	6	(NC)
	7	Black	Battery (-)	7	Battery (+)
	8	Grey	Case Shield Line	8	(NC)
				9	S.BUS / PWM
				10	(NC)
				11	(NC)
				12	(NC)

Fig. 3.1 Pin Assignment

Control method

AJ9DA series can be controlled by “S.BUS”, “PWM” and “RS485 Command”, and has a “Position Feedback” function.

⚠Caution

Do NOT input “S.BUS” or “PWM” and “RS485” simultaneously.

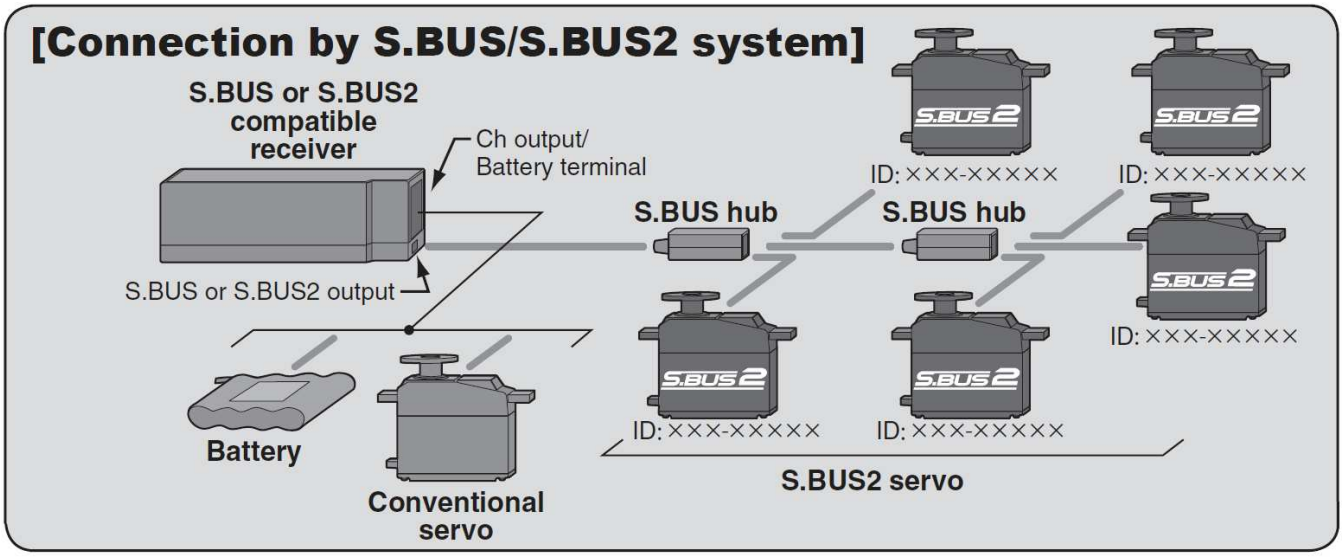
Inputting S.BUS/PWM and RS485 will be cause of breaking down of the servo.

Connector Pin for S.BUS and PWM is same, and the servo will change the control mode automatically according to the input signal (S.BUS or PWM).
When you change the control mode, you will have to reboot the Servo.
After the reboot, the servo stays in force-OFF (No output force) until the servo receives S.BUS or PWM (p.15) is input.

3.1. S.BUS (Input)

“S.BUS” is Futaba’s original protocol for Hobby R/C, and is used to be controlled by Receivers with “S.BUS Port” or to change the parameters from PC with “S-Link” via USB adapter “CIU-2”.

The data of S.BUS includes commands to multiple servos such as “move the channel 3 servo to 15 degrees, move the channel 5 servo to 30 degrees”, and the S.BUS servos execute only the part of the command that the ID is equal to its ID.
For this, it can be used by connecting multiple servos to the same signal line.



● S.BUS2

S.BUS2 is advanced protocol of S.BUS that enables bi-directional communication and used for S.BUS servos and telemetry sensors.

AJ9DA is connectable with the both of S.BUS and S.BUS2.

● S-Link

”S-Link” is FREE software for S.BUS Servos and can be downloaded from Futaba’s Website.

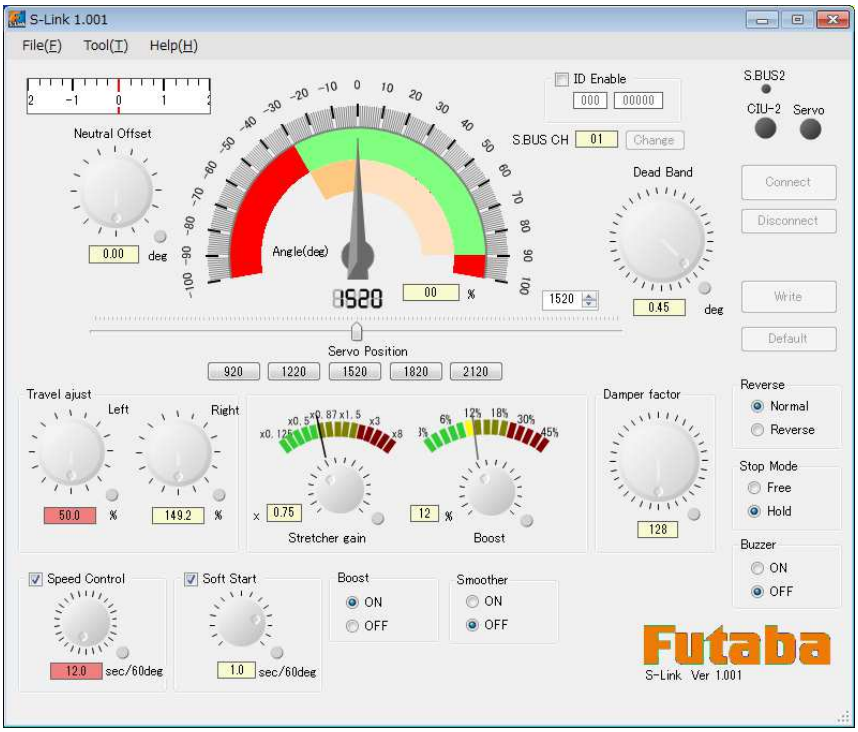
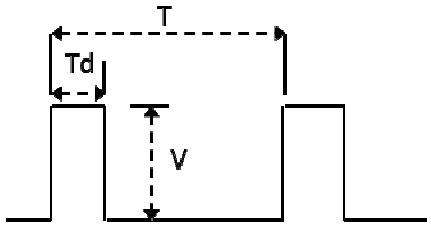


Fig. 3.2 S-Link

3.2. PWM (Input)

PWM for conventional hobby R/C servomotors is useful for the control of the servo.
The angle of output axis is determined by the pulse-width ("Td" in the table below)

Table 3.1 PWM Specification

Model		AJ9DA 41～44	AJ9DA 51～54
Signal Voltage: V	HIGH	min. 2.0V, max. Vcc	min. 3.0V, max. 16.8V
	LOW	min. 0.0V , max.0.45V	
Frame Rate: T	3.0～30ms (Default 14.25ms)		
Goal Angle: Td	920 ～ 2120 (Center:1520) μs （Resolution recommends less than 1 μ s.）		
			

● Goal Position (PWM)

The settable range of "Td" is 920 to 2120 [μs].

After power-on, the servo stays in torque-OFF (No output torque) until the servo receives PWM that "Td" is in the settable range.
When "Td" go out of settable range in PWM-Mode, the servo will hold the angle just before being out of the range.

● Maximum Operating Angle(PWM/S.BUS)

The target angle of "Td"=920μs (2120μs) is -60 deg. (+60 deg.).
The settable range of these angles (Maximum Angle) is 50% to 150% (30deg. to 90deg.）.

● Soft Start Delay(PWM/S.BUS)

To avoid servo's sudden movement, the movement of the servo to the first target angle is slow.
When the actual angle approaches enough to the target angle, or the target angle is changed, the servomotor works with the original speed.

3.3. RS485 Command (Input/Output)

RS485 Command is interactive serial communication protocol for Futaba's Servos for Robots, and to be used for sending target angle or getting data of internal sensors such as Angle, Temperature, Load(Current)and Voltage.

Table 3.2 Specifications of RS485 Command

Bit/s:		**115.2**	**[kbps]（selectable from 9.6[kbps] to 460.8[kbps])**
Data bit	**8**	**[bit]**	
Parity		**None**	
Stop bit	**1**	**[bit]**	
Flow Control		**None**	

3.4. Position Feedback (Output)

The voltage between Position Feedback (+) and Position Feedback (-) increases and decreases according to the angle of the output axis (refer Fig. 3.1 in p.12).
This output will go on as long as the power is supplied to the servo.

The output voltage can be expressed from the angle of the output axis as follows, but use it only as a reference value.
When using the output voltage, please understand the actual relationship between the angle of the output axis and the output voltage.

Ex.
Output Voltage = 1.53 – Angle × 0.0116 [V]

Angle of the Output axis	Output Voltage
-60 [deg.]	2.23 [V]
0 [deg.]	1.53 [V]
+ 60 [deg.]	0.83 [V]

3.5. Protection Function (Temperature-Limit)

AJ9DA Series has a protection function (temperature limit function) to prevent the damage caused by the heat of the motor.
The behavior of the servo when the protection function acted and method to reboot is determined by its control method.

● PWM/S.BUS

The output torque gradually decreases when the sensed temperatures of the internal sensor exceed 90 degrees Celsius, and becomes 0(Torque OFF) when it exceeds 95 degrees Celsius.

The output torque gradually increases when it falls less than 95 degrees Celsius, and becomes 100% when it falls less than 90 degrees Celsius.

● RS485

The servo will be Torque-OFF when the Present Temperature exceeds temperature Limit.

To turn on the torque again, turn off-and-on the power (or) and send Torque-ON command after the temperature becomes less than temperature limit.

4. RS485 Command

Features

● Communication Protocol

The protocol of “RS485 Command” is Asynchronous Half-Duplex communication and the signal line can be switched alternately for transmission or reception of data.
Normally, AJ9DA stands by in a Receiving-Mode. When they receive commands to get the data, they changes to Transmitting-Mode. After sending the data, they stand by again in a Receiving-Mode

● Memory Map

AJ9DA has its own memory area to store data necessary for its movement. This memory area is called “Memory Map”.
“Memory Map” is divided into two groups. One is “RAM Area” in which data will be erased when the power is turned off, and the other is “ROM Area” in which data will be held even after the power is turned off.

● 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 the Servo.
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.

● Return Packet

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

Format of the Packet

● 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 4.1 bit of Flag

Bit	function
7	(Reserved)
6	Write Flash ROM
5	Reboot Servo
4	Initialize Memory Map
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:01)

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.

Turning off the servo will cause the damage of the servo.

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:01)

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 “Memory Map of ROM Area” (p.28) for more details.

Ex)Initialize the memory map of the servo (ID:01)

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 to 0 : Direct Address of Return Packet

(1) Direct Area of Memory Map

Setting Bit 3 to Bit 0 of a Short Packet as Table 4.2, 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 4.2 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 to No.29
	0	1	0	1	Return the data of memory map No.30 to No.59
	0	1	1	1	Return the data of memory map No.20 to No.29
	1	0	0	1	Return the data of memory map No.42 to No.59
	1	0	1	1	Return the data of memory map No.30 to 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 Packet 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

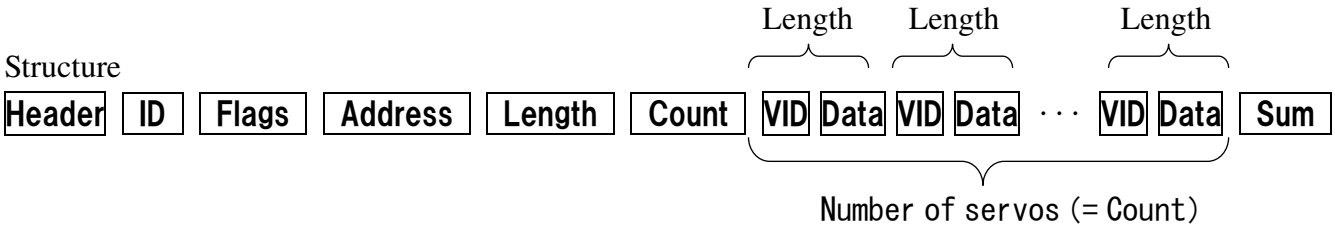
(3) ACK/NACK Packet

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"

● 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 servo + 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 4.3 Flags of Return Packet

Bit	Value	Function
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	Not Defined	(Reserved)
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. "1" is set 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.

● Storing 2-Byte date

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

Memory Map

4.1. Invariable ROM Area

Table 4.4 Memory Map (Invariable ROM Area)

Area	Address DEC	Address HEX	Initial	Name	R/W
Invariable	00	00H	N/D	Model Number L	R
	01	01H	N/D	Model Number H	R
	02	02H	N/D	Firmware Version	R
	03	03H	00H	Reserved	-

*N/D; Not Defined, or the value is defined according to each models.

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

The relations of Model Name and Model Number are shown below;

Table 4.5 Model Name and Model Number

Model Name	Model Number L	Model Number H
AJ9DA**41**	10H	70H
AJ9DA**42**	20H	70H
AJ9DA**43**	10H	70H
AJ9DA**44**	20H	70H
AJ9DA**51**	30H	70H
AJ9DA**52**	40H	70H
AJ9DA**53**	30H	70H
AJ9DA**54**	40H	70H

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

It is the version of the servo's firmware.

Its value is depending on the version at production (0x01 in the example below).

Firmware Version = 01H

4.2. Variable ROM Area

Table 4.6 Variable ROM Area

Area	Address DEC	HEX	Initial	Name	R/W
Variable	04	04H	01H	Servo ID	RW
	05	05H	00H	Reverse	RW
	06	06H	07H	Baud Rate	RW
	07	07H	00H	Return Delay Time	RW
	08	08H	E8H	CW Angle Limit L	RW
	09	09H	03H	CW Angle Limit H	RW
	10	0AH	18H	CCW Angle Limit L	RW
	11	0BH	FCH	CCW Angle Limit H	RW
	12	0CH	00H	Reserved	-
	13	0DH	00H	Reserved	-
	14	0EH	55H	Temp Limit L	R
	15	0FH	00H	Temp Limit H	R
	16	10H	00H	Reserved	-
	17	11H	00H	Reserved	-
	18	12H	00H	Reserved	-
	19	13H	00H	Reserved	-
	20	14H	00H	Reserved	-
	21	15H	00H	Reserved	-
	22	16H	00H	Reserved	-
	23	17H	00H	Reserved	-
	24	18H	01H	CW Compliance Margin	RW
	25	19H	01H	CCW Compliance Margin	RW
	26	1AH	01H	CW Compliance Slope	RW
	27	1BH	01H	CCW Compliance Slope	RW
	28	1CH	00H	Punch L	RW
	29	1DH	00H	Punch H	RW

● No.4 Servo ID (1Byte, 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, 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.
When it is set to 01H (reverse rotation), the Angle Limit is also reversed.

● No.6 Baud Rate (1Byte, 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	Value	Baud Rate
00H	9,600bps	04H	38,400bps	08H	153,600bps
01H	14,400bps	05H	57,600bps	09H	230,400bps
02H	19,200bps	06H	76,800bps	0AH	460,800bps
03H	28,800bps	07H	115,200bps		

(Data 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, 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

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

“Return Delay Time” is the time before sending Return Packet after receiving a packet requiring Return Packet.
The unit is 1[ms] and the initial value is 0(00H).

Ex) Set Return Delay Time of the servo (ID:01) to 1[ms].

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	07	01	01	01	07

No.8/ No.9/ No.10/ No.11 Angle Limit(2 Byte, 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	100[deg.] (03E8H)	0[deg.] (0000H) to +100[deg.] (03E8H)
CCW	-100[deg.] (FC18H)	0[deg.] (0000H) to -100[deg.] (FC18H)

Initial value is the maximum value and Do NOT set a value bigger than this because it will be cause of damage of the servo.

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	0A	02	01	18 FC	EC

● No.14/ No.15 Temperature Limit(2 Byte, 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.
"Temperature Limit" is not changeable.

Temperature limit behavior varies depending on the communication mode. For details, refer to "Protection Function (Temperature-Limit)" (p.17).

⚠Caution

Do not continue using in the high temperature by repeating reboot before the temperature of the servo decreases enough because it will cause the trouble of the servo.

● No.24 / No.25 Compliance Margin (1 Byte, 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 01H (0.1[deg.]) and the settable range is 0～25.5[deg.] (00H to FFH) for both directions.
In most case, the initial value is the most suitable value and changing it is not recommended.

● No.26 / No.27 Compliance Slope (1 Byte, 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 0.1 degree, initial value is 0.1[deg.](01H) and the settable range is 0～25.5[deg.](00H~FFH) for each directions.

● No.28 / No.29 Punch(2 Byte, 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 0.00208%, initial value is 0000H(0%) and the settable range is 0000H to 7FFFH(68.2%).

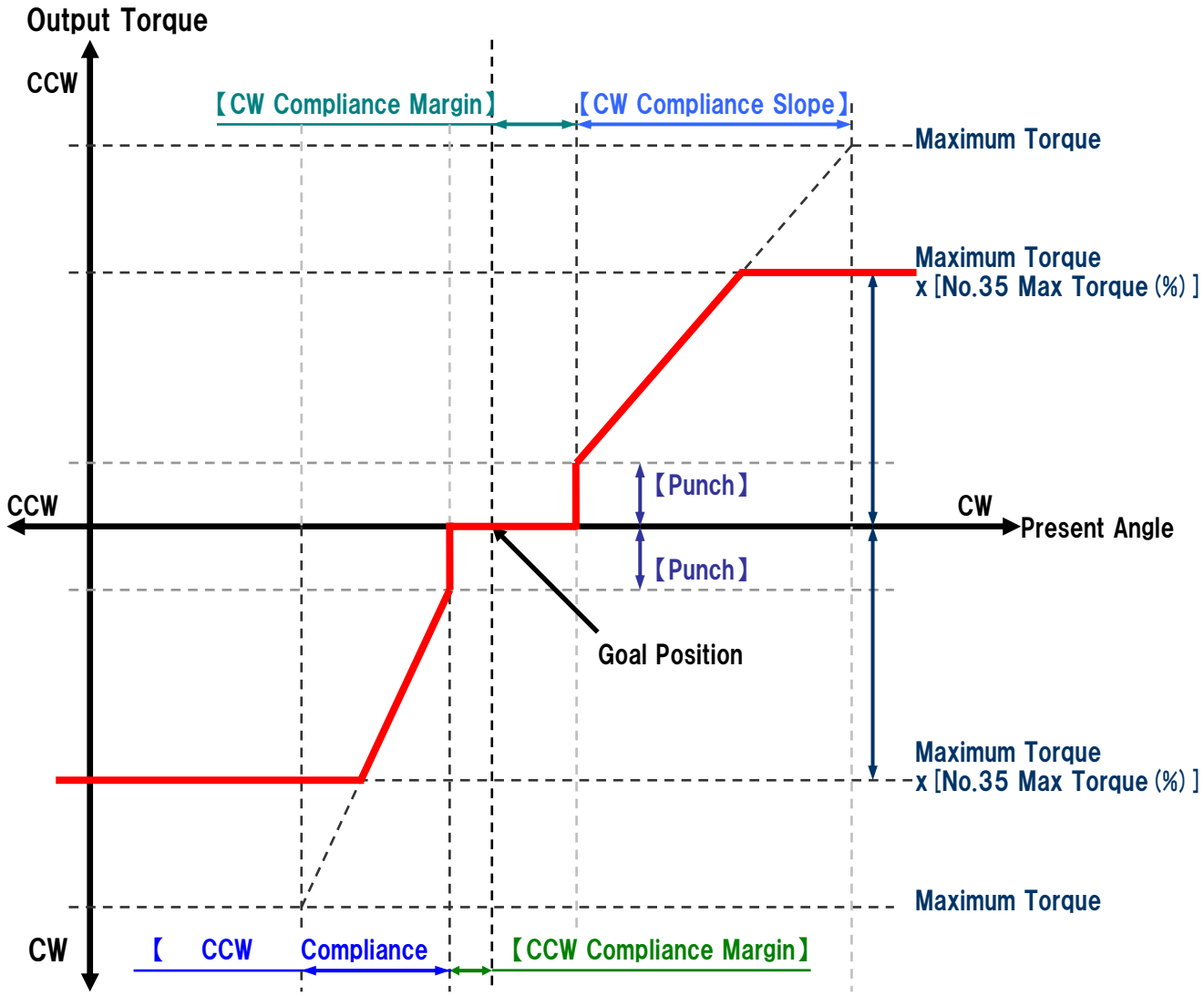


Fig. 4.1 The relationship of Output Torque, Angle and Compliance settings.

Ex.1) Set Punch of the servo (ID:01) to 0120H.

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	1C	02	01	20 01	3F

Ex.2) Set the servo (ID:01) as shown below;

CW Compliance Margin	=	01H
CCW Compliance Margin	=	01H
CW Compliance Slope	=	10H
CCW Compliance Slope	=	10H
Punch	=	0120H

Hdr	ID	Flg	Adr	Len	Cnt	Dat	Sum
FA AF	01	00	18	06	01	01 01 10 10 20 01	3F

4.3. Variable RAM Area

Table 4.8 Variable RAM Area

Area	Address DEC	HEX	Initial	Name	R/W
Variable RAM	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	Maximum Torque	RW
	36	24H	00H	Torque Enable	RW
	37	25H	01H	Reserved	-
	38	26H	64H	Reserved	-
	39	27H	00H	Reserved	-
	40	28H	00H	Reserved	-
	41	29H	00H	Reserved	-
	42	2AH	00H	Present Position L	R
	43	2BH	00H	Present Position H	R
	44	2CH	00H	Present Time L	R
	45	2DH	00H	Present Time H	R
	46	2EH	00H	Reserved	-
	47	2FH	00H	Reserved	-
	48	30H	00H	Present Load L	R
	49	31H	00H	Present Load H	R
	50	32H	00H	Present Temperature L	R
	51	33H	00H	Present Temperature H	R
	52	34H	00H	Present Voltage L	-
	53	35H	00H	Present Voltage H	-
	54	36H	00H	Reserved	-
	55	37H	00H	Reserved	-
	56	38H	00H	Reserved	-
	57	39H	00H	Reserved	-
	58	3AH	00H	Reserved	-
	59	3BH	FFH	Reserved	-

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

“Goal Position” is the target angle of the servo.
Definition of the angle and its range is shown in Fig. 2.6 (p.11)
The unit is 0.1 [deg.] and initial value is “0[deg.]” (0000H). For example, “900(0384H)” means 90[deg.]

When “Torque-ON Command” (No.36 Torque Enable = 01H) is received, the value of Goal Position changes to the value of Present Position (p.37).
If the value is larger than the Angle Limit (p.30) set for No. 8 to 11, the servo moves to the Angle Limit and the value is changed to the value of Angle Limit automatically.

Ex.1) Move the servo (ID:01) to 90[deg.] (900=0384H).

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

Ex.2) Move the servo (ID:01) to -90[deg.] (-900=FC7CH).

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, Read/Write)

“Goal Time” is the time to move to “Goal Position”. The unit is 10[ms] and initial value is 0(0000H).
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.
When external force is applied, it may not be able to operate at the specified time.

Ex.1) Move the servo (ID: 1) to 90.0[deg.] in 5[s]. (90.0[deg.]=900(0384H), 5[s]=500(01F4H))

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

When an external force is applied, operation may be switched to the maximum speed after the set travel time has elapsed.

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

“Maximum Torque” is a ratio of real output for the maximum torque of the servo (shown in p42).
The unit is 1[%], initial value is 100(64H) and the settable range is 0 to 100(00H to 64H).
If the value is larger than 100(64H), the value changes to 100(64H) automatically.

Ex) Set maximum Torque of the servo (ID:01) to 80%(50H).

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

● No.36 Toque Enable (1Byte. Read/Write)

"Torque Enable" is the condition of the servo's torque.
The initial value is 0(00H) and settable range is 0 to 2(00H to 02H).

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

In "Brake mode",. The servo does not have output torque, but weak resistance torque occurs when it is turned from the outside.

Ex.1) Torque ON the servo (ID:01)

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

Ex.2) Torque OFF the servo (ID:01)

FA AF	01	00	24	01	01	00	25

Ex.3) Set the servo (ID:01) to "Brake Mode"

FA AF	01	00	24	01	01	02	27

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

“Present Position” is the real angle of the servo’s output shaft.
The unit is 0.1[deg.] and the detectable range is -1000 to 1000(FC18H to 03E8).

Ex) Read “Present Position” of the servo (ID:01)
To get Memory Map No.42 to 59 as a Return Packet, a Short Packet with “Flag”:bit3=1, bit2=0, bit1=0 and bit0=1 is required to be sent.

The packet to require Return Packet with Memory Map No.42 to 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	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

*Data and Sum are according to the real condition.

Top 2 bytes of Data shows No.42 and No.43 of Memory Map.
In the example above, it means 0384H=90.0[deg.].

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

“Present Time” is the elapsed time after the servo receives a packet to move.
The unit is 10[ms]. When movement is finished, the value will be “0”.

Ex) Read “Present Time” of the servo (ID:01).
To get Memory Map No.42 to 59 as a Return Packet, a Short Packet with “Flag”:bit3=1, bit2=0, bit1=0 and bit0=1 is required to be sent.

The packet to require Return Packet with Memory Map No.42 to 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	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

*Data and Sum are according to the real condition.

3rd and 4th value of Data shows No.44 and No.45 of Memory Map
In the example above, it means 0237H=5670ms.

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

“Present Load” shows detected electric current of the servo. The unit is 10[mA].
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:01)
To get Memory Map No.42 to 59 as a Return Packet, a Short Packet with “Flag”:bit3=1, bit2=0, bit1=0 and bit0=1 is required to be sent.

The packet to require Return Packet with Memory Map No.42 to 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	···		···	48	49	···		···		58	59	Sum
FD DF	01	00	2A	12	01	4E FB 00 00 00 00					00	06	00 BA 03 00		00 00 00 00 00 00				32

*Data and Sum are according to the real condition.

7th and 8th value of Data shows No.48 and No.49 of Memory Map
In the example above, it shows 0600H=1,536[mA].

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

“Present Temperature” is detected temperature on the circuit board in the servo.
The unit is 1 [degrees Celsius].
The sensor has individual difference about up to ±8 degrees Celsius.

When “Present Temperature” becomes 10 degrees Celsius lower than “Temperature Limit” (p.31) , “Temperature Alarm” (Bit 5 of Flag of Return Packet) becomes “1”.

When “Present Temperature” exceeds “Temperature Limit” (p.31) , “Temperature Limit” (Bit 7 of Flag of Return Packet) becomes “1” and the servo will turn off its torque (“Torque Enable” becomes “0”).

Once the temperature exceeds “Temperature Limit”, 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 Limit”, temperature around the motor of the servo reaches 120 to 140 degrees Celsius. Please be careful about burns and use the servo after the temperature fell enough.

Ex) Read “Present Temperature” of the servo (ID:01)
To get Memory Map No.42 to 59 as a Return Packet, a Short Packet with “Flag”:bit3=1, bit2=0, bit1=0 and bit0=1 is required to be sent.

The packet to require Return Packet with Memory Map No.42 to 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 00 00 00 00				32

*Data and Sum are according to the real condition.

9th and 10th value of Data shows No.50 and No.51 of Memory Map
In the example above, it shows 002DH=45[degrees Celsius].

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

“Present Voltage” shows detected voltage of the power applied to the servo.
The unit is 10[mV].
The sensors has individual difference about up to ±0.3[V].

Ex) Read “Present Voltage” of the servo (ID:01)
To get Memory Map No.42 to 59 as a Return Packet, a Short Packet with “Flag”:bit3=1, bit2=0, bit1=0 and bit0=1 is required to be sent.

The packet to require Return Packet with Memory Map No.42 to 59 is;

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

An example of Return Packet is;

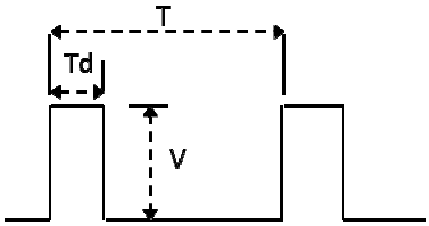
						Data																
Hdr	ID	Flg	Adr	Len	Cnt	42	43	・・・	・・・	52	53	・・・	・・・	58	59	Sum
FD DF	01	00	2A	12	01	4E FB 00 00 00 00 06 00 2D 00				56	04	00 00 00 00 00 00				F4

*Data and Sum are according to the real condition.

11th and 12th value of Data shows No.52 and No.53 of Memory Map
In the example above, it shows 0456H=11.1[V].

5. References

Specs

<table>
<tr><th></th><th>Item</th><th colspan="3">Specification</th><th colspan="3">Remark</th></tr>
<tr><td rowspan="6">1</td><td rowspan="6">Communication
Interface *2</td><td colspan="3" rowspan="6">PWM</td><td>V (Signal Voltage)</td><td>AJ9DA4x
HIGH :
min. 2.0V
max.Vcc
LOW : min. 0.0V , max.0.45V</td><td>AJ9DA5x
HIGH :
min. 3.0V
max. 16.8V</td></tr>
<tr><td>T (Frame Rate)</td><td colspan="2">3.0～30ms (Default 14.25ms)</td></tr>
<tr><td>Td (Pulse Width)</td><td colspan="2">2220 / 1520 / 820 μs
Left / Center / Right
(Resolution recommends less than 1 μs.)</td></tr>
<tr><td colspan="3"> 
</td></tr>
<tr><td colspan="3">S.BUS</td><td colspan="3">Futaba Serial Protocol</td></tr>
<tr><td colspan="3">RS485</td><td colspan="3">Half-duplex communication</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Rated Voltage</td><td>Model</td><td colspan="2">value</td><td colspan="3"></td></tr>
<tr><td>AJ9DA4x</td><td colspan="2">11.1～14.8V</td><td colspan="3"></td></tr>
<tr><td>AJ9DA5x</td><td colspan="2">24.0V</td><td colspan="3"></td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Operation Voltage</td><td>Model</td><td colspan="2">value</td><td colspan="3"></td></tr>
<tr><td>AJ9DA4x</td><td colspan="2">9.0～16.8V</td><td colspan="3"></td></tr>
<tr><td>AJ9DA5x</td><td colspan="2">20.0～30.0V</td><td colspan="3"></td></tr>
<tr><td>4</td><td>Stand-by Current</td><td colspan="3">≤ 60mA</td><td colspan="3">AJ9DA4x : at 11.1V
AJ9DA5x : at 24.0V</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">Consumption Current</td><td>Model</td><td colspan="2">Value</td><td colspan="3" rowspan="4">with No-Load</td></tr>
<tr><td rowspan="2">AJ9DA4x</td><td>160 mA</td><td>at 11.1V</td></tr>
<tr><td>180 mA</td><td>at 14.8V</td></tr>
<tr><td>AJ9DA5x</td><td>120 mA</td><td>at 24.0V</td></tr>
</table>

6	Max. Torque (Stall Torque)	Model	value	unit	
		AJ9DA 41/43	84.0	kgf-cm	at 11.1V
			8.2	N-m	
			1166.5	ozf-in	
			110.0	kgf-cm	at 14.8V
			10.8	N-m	
			1527.6	ozf-in	
		AJ9DA 42/44	65	kgf-cm	at 11.1V
			6.4	N-m	
			902.7	ozf-in	
			87.0	kgf-cm	at 14.8V
			8.5	N-m	
			1208.2	ozf-in	
		AJ9DA 51/53	110.0	kgf-cm	at 24.0V
			10.8	N-m	
			1527.6	ozf-in	
		AJ9DA 52/54	87.0	kgf-cm	at 24.0V
			8.5	N-m	
			1208.2	ozf-in	
7	Rated Torque	Model	value	unit	
		AJ9DA 41/43	16.8	kgf-cm	at 11.1V （20% of Max. Torque）
			1.65	N-m	
			233.3	ozf-in	
		AJ9DA 42/44	13	kgf-cm	
			1.27	N-m	
			180.5	ozf-in	
		AJ9DA 51/53	22.0	kgf-cm	at 24.0V （20% of Max. Torque）
			2.16	N-m	
			305.5	ozf-in	
		AJ9DA 52/54	17.4	kgf-cm	
			1.70	N-m	
			241.6	ozf-in	

		Model	Value	unit	
8	Rated Torque	AJ9DA 41/43	0.27	s/60°	at 11.1V
			222.2	°/s	
			37	rpm	
			0.20	s/60°	at 14.8V
			300.0	°/s	
			50.0	rpm	
		AJ9DA 42/44	0.21	s/60°	at 11.1V
			285.7	°/s	
			47.6	rpm	
			0.16	s/60°	at 14.8V
			375.0	°/s	
			62.5	rpm	
		AJ9DA 51/53	0.20	s/60°	at 24.0V
			300.0	°/s	
			50.0	rpm	
		AJ9DA 51/53	0.20	s/60°	at 24.0V
			375.0	°/s	
			62.5	rpm	

9	Travel Angle (Default)	CW 60° (920us) CCW 60° (2120us)			Absolute angle is within ± 5 ° (with No-Load)
10	Travel Angle (Max)	CW 90° (920us) CCW 90° (2120us)			Programing tool (CIU-2/CIU-3,S-Link) required for S.BUS/PWM input.
11	Back Lash	≤ 0.5°			—
12	Temperature Range (Operate)	-30～+70 -22～158		℃ °F	—
13	Temperature Range (Storage)	-40～+80 -40～176		℃ °F	
14	Humidity Range (Operate)	≤ 90% RH			—
15	Humidity Range (Storage)	≤ 90%RH			—
16	Outer Dimensions	64.2 x 34.0 x 73.7 2.53 x 1.34 x 2.90		mm inch	—
17	Weight	Model	value	unit	Including Cables.
		AJ9DA 41,42,51,52	337 11.89	g oz	
		AJ9DA 43,44,53,54	355 15.52	g oz	
18	Material for cases	Upper : AL / Middle : AL / Bottom : AL			—
19	Material for Gears	Metal			—
20	Cables	Shielded Cable			Length: 400mm
21	Connector	Manufacture	J.S.T. Mfg. Co., Ltd		
		Type	08T-JWPF-VSLE-D		
		Mating	08R-JWPF-VSLE-D etc.		

*1 ALL Specifications are subject to change without prior notice.

*2 Note that the signal voltage range of the communication Interface is different from the operating voltage range.

T-N/T-I Curve

The following graphs show the relationship of speed, load and current of the servo.

“Speed” and “Load” shown in the graph are measurements of the servo's output axis and are not the spec of the internal motors.

In addition, these are reference contents based on the actual values in us and are not guaranteed specs.

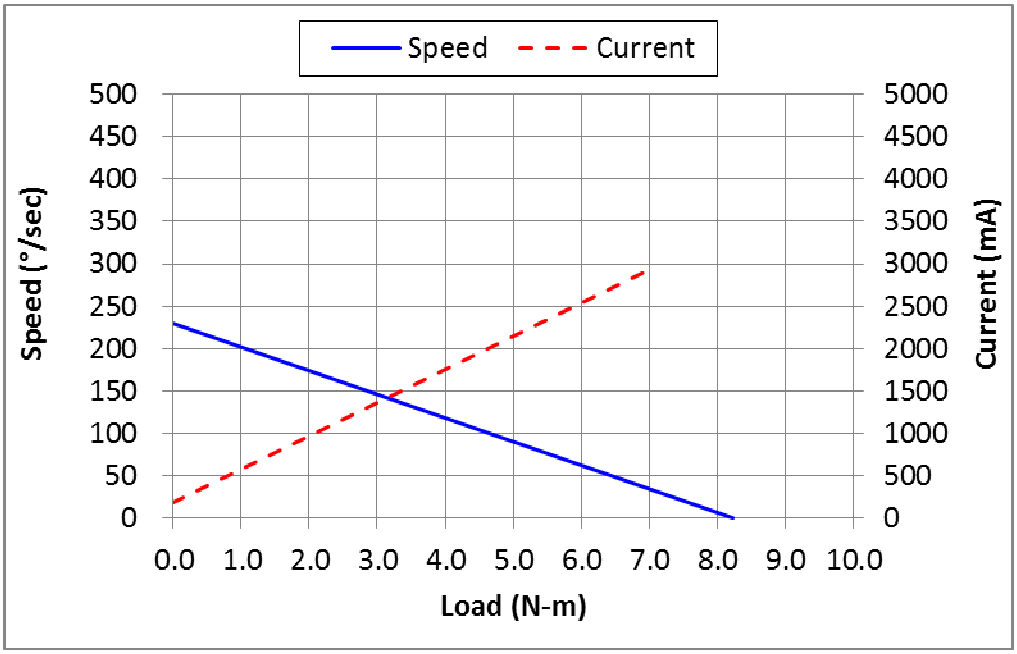


Fig. 5.1 AJ9DA41/43 at 11.1V

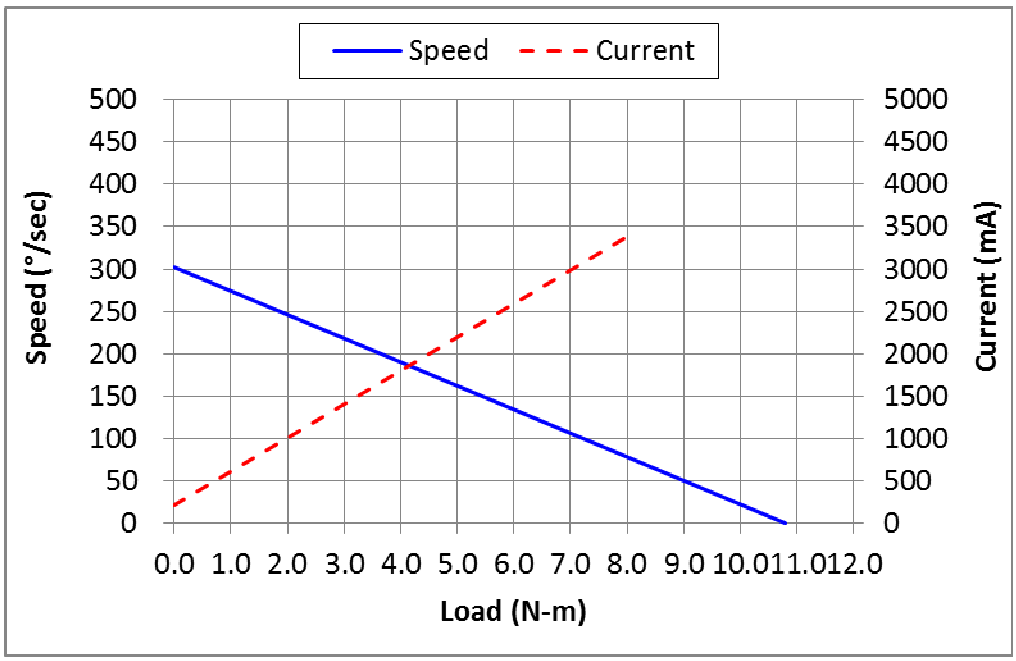


Fig. 5.2 AJ9DA41/43 at 14.8V

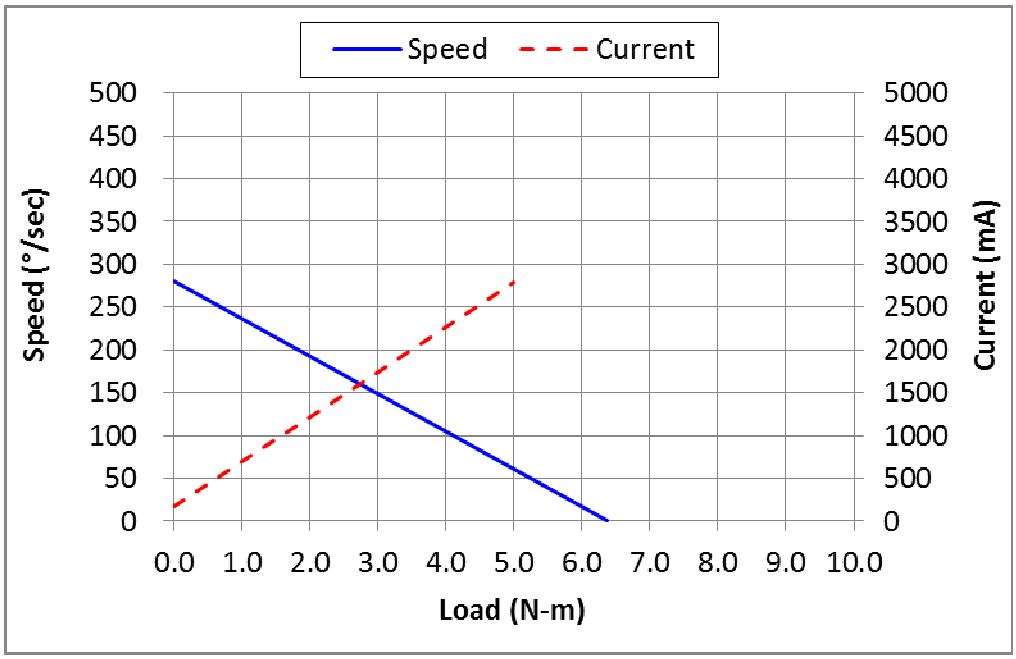


Fig. 5.3 AJ9DA42/44 at 11.1V

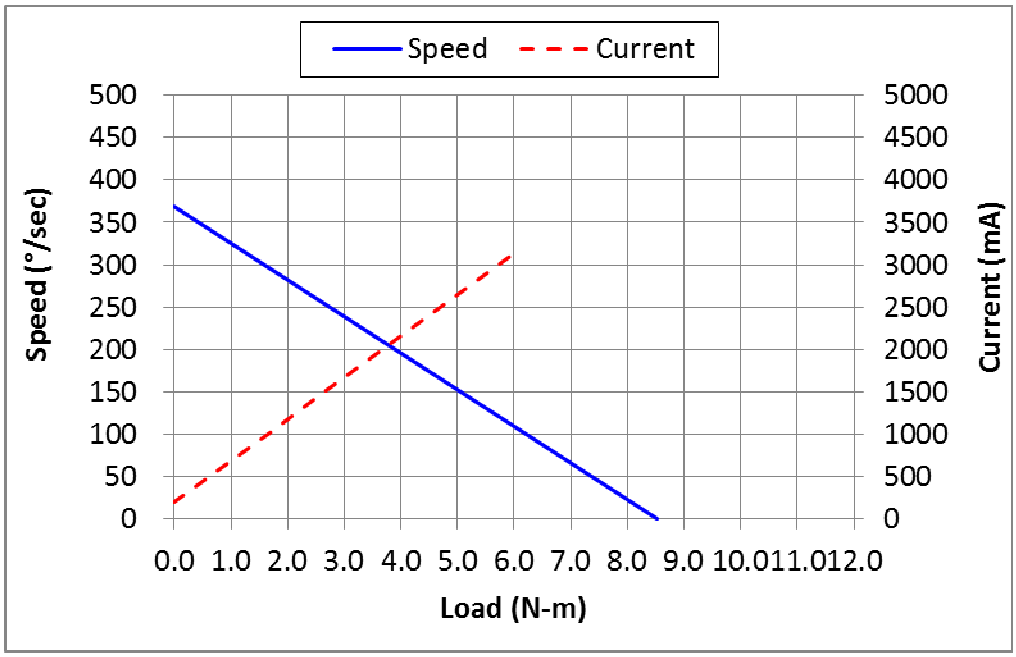


Fig. 5.4 AJ9DA42/44 at 14.8V

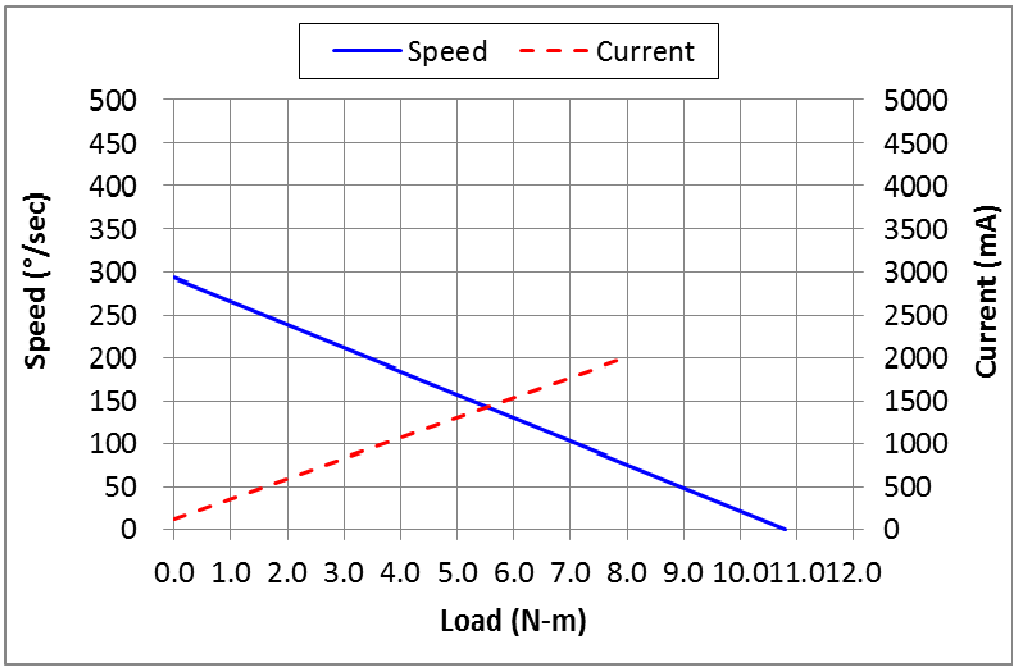


fig. 5.5 AJ9DA51/53 at 24.0V

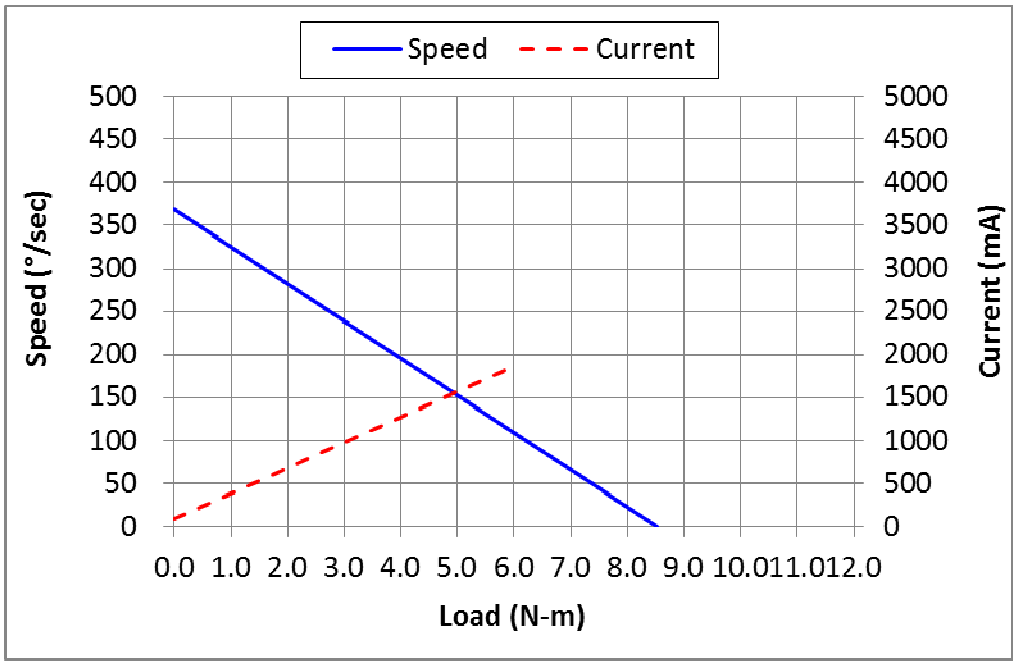


fig. 5.6 AJ9DA52/54 at 24.0V

Dimensions

● AJ9DA41,42,51,52

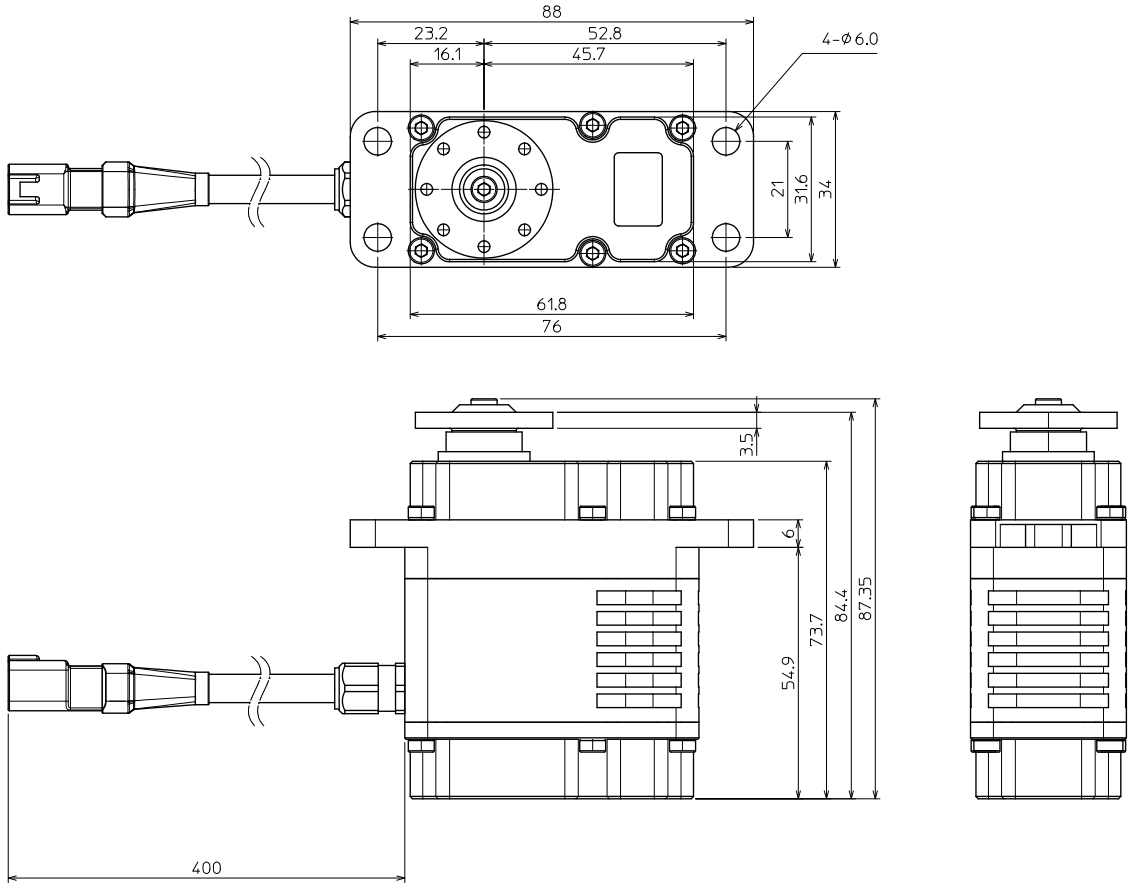


Fig. 5.7 AJ9DA41, 42, 51, 52 (unit: mm)

● AJ9DA43, 44, 53, 54

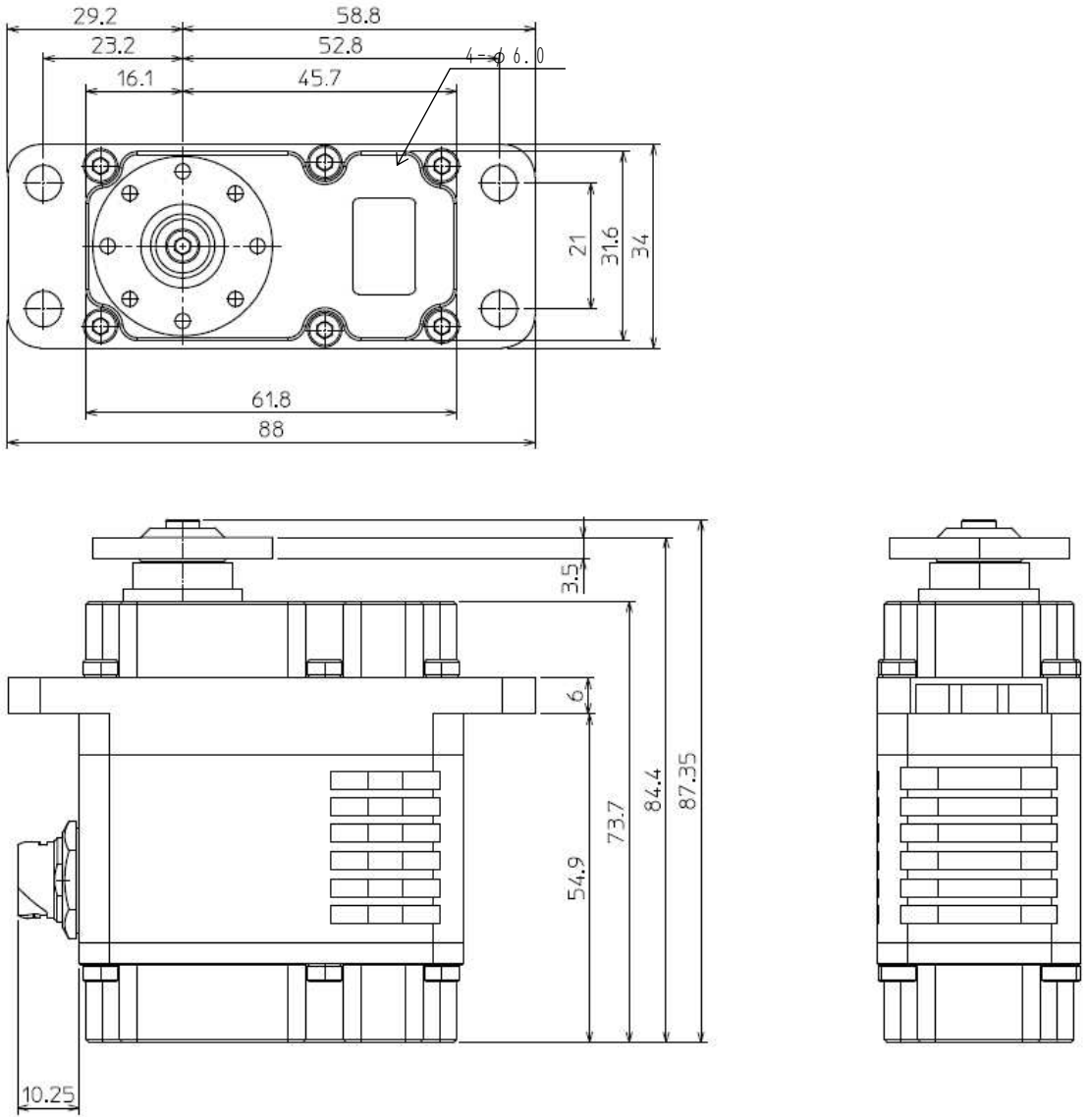


Fig. 5.8 AJ9DA43, 44 (unit: mm)

● AJ9DA Cable (for AJ9DA 43, 44, 53, 54)

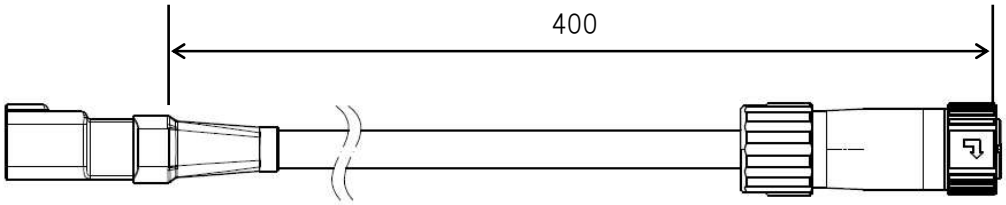


Fig. 5.9 AJ9DA Cable (AJ9DA 43, 44) (unit: mm)

● Attached equipment parts (SUS Servo Horn)

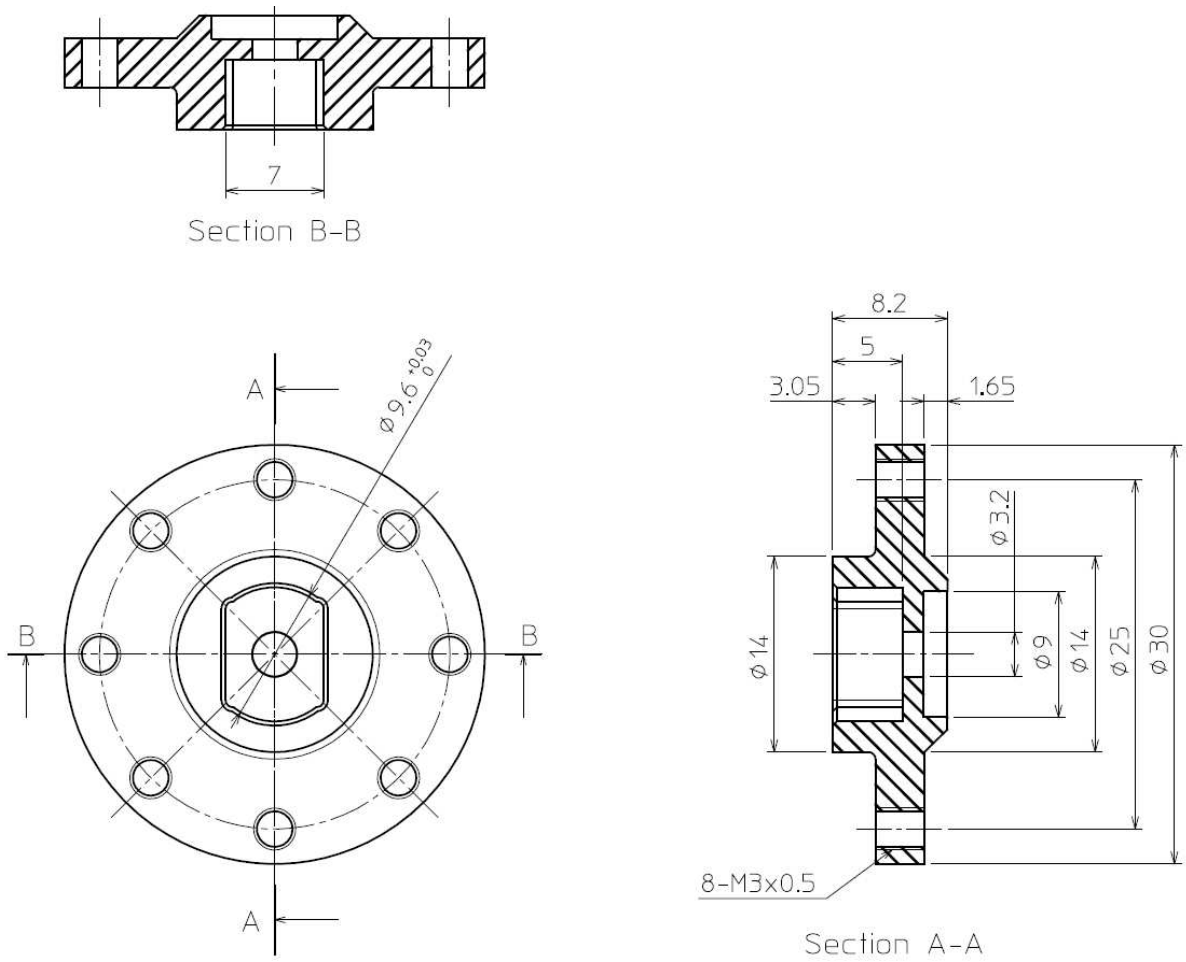


Fig. 5.10 SUS Servo Horn for AJ9DA (unit: mm)

● Cable with Connector for AJ9DA

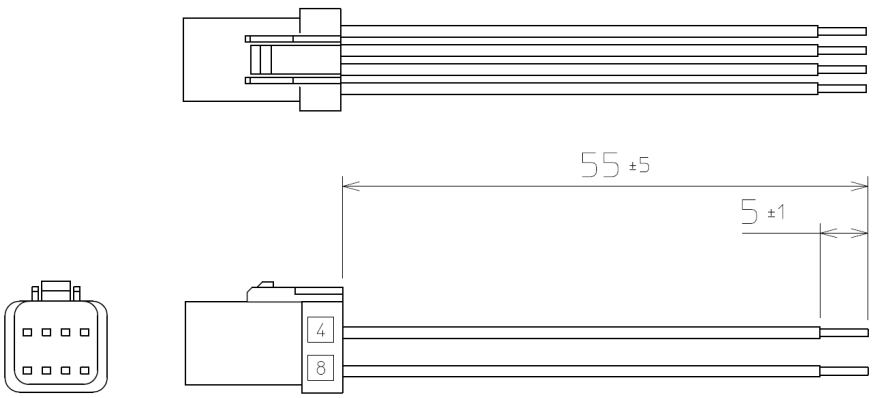


Fig. 5.11 Cable with Connector for AJ9DA (unit: mm)

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