

Control_Table_example

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Control Table, Data, Address

Area (Flash, RAM)

Size

Access

Initial Value

Control Table of FLASH Area

Control Table of RAM Area

Control Table Description

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Model Information(2)

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Bus Watchdog (35) Example

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The Control Table is a structure of data implemented in the servo. Users can read data registers to get information about the status of the device with Read Instruction Packets, and modify data registers to control the device with Write Instruction Packets..

Control Table, Data, Address

The Control Table is a structure that consists of multiple Data fields to store status of the servo or to control the servo. Users can check current status of the servo by reading a specific Data from the Control Table with Read Instruction Packets. WRITE Instruction Packets enable users to control the servo by changing specific Data in the Control Table. The Address is a unique value when accessing a specific Data in the Control Table with Instruction Packets. In order to read or write data, users must designate a specific Address in the Instruction Packet.

• Area (Flash, RAM)

The Control Table is divided into 2 Areas. Data in the RAM Area is reset to initial values when the servo is turned on (Volatile). On the other hand, modified data in the FLASH Area keeps their values even when the servo is turned off (Non-Volatile). Data in the FLASH Area can only be changed or modified when the value of Torque Enable(32) is '0' and Servo is in idle state.

• Size

The Size of data is 1 or 2 bytes depend on their usage. Please check the size of data when updating the data with an Instruction Packet. 2 bytes data will be saved according to Little Endian. Two's complement is applied for the negative value

- **Access**

The Control Table has two different access properties. 'RW' property stands for read and write access permission while 'R' stands for read only access permission. Data with the read only property cannot be changed by the WRITE Instruction. Read only property('R') is generally used for measuring and monitoring purpose, and read write property('RW') is used for controlling servo.

- **Initial Value**

Each data in the Control Table is restored to initial values when the servo is turned on. Default values in the FLASH area are initial values of the servo (factory default settings). If any values in the FLASH area are modified by a user, modified values will be restored as initial values when the servo is turned on. Initial Values in the RAM area are restored when the servo is turned on.

- Control Table of FLASH Area

Address	Size (Byte)	Data Name	Access	Initial Value	Range	Unit
0	2	Model Number	R		-	-
2	4	Model Information	R	-	-	-
6	1	Firmware Version	R	-	-	-
7	1	ID	RW	1	0-253	-
8	1	Baud Rate	RW	2	0~7	-
9	1	Return Delay Time	RW	250	0-255	2 [us]
10	1	Drive Mode	RW	0	0~13	-
11	1	Operating Mode	RW	0	0~2	-
12	2	Homing Offset	RW	0	-4095~4095	-
14	2	PWM Limit	RW	3599	0~3599	0.028 [%]
16	2	Velocity Limit	RW	2000	0~32767	0.1 [rpm]
18	2	Min Position Limit	RW	0	0~4095	-
20	2	Max Position Limit	RW	4095	0~4095	-
22	2	Min Voltage Limit	RW	36	36~150	0.1 [V]
24	2	Max Voltage Limit	RW	120	36~150	0.1 [V]
26	2	Threshold of Overcurrent	RW	1500	0~32767	1 [mA]
28	1	Window of OCP Judgment	RW	20	0~255	100 [ms]
29	1	Temperature Limit	RW	140	0~255	(x-70) [°C]
30	1	Status Return Level	RW	2	0~2	-
31	1	Shutdown	RW	36	-	-
32	1	Position Error Margin	RW	0	0~255	-
33	1	Punch	RW	0	0~255	-

- **Control Table of RAM Area**

Address	Size (Byte)	Data Name	Access	Initial Value	Range	Unit
34	1	Torque Enable	RW	0	0~1	-
35	1	Bus Watchdog	RW	0	0~127	20 [ms]
36	2	Goal PWM	RW	-	-PWM Limit(14) ~ PWM Limit(14)	-
38	2	Goal Velocity	RW	-	-Velocity Limit(16) ~ Velocity Limit(16)	0.1 [rpm]
40	2	Profile Acceleration	RW	0	0~32767	100 [rev/m2]
42	2	Profile Velocity	RW	0	0~32767	0.1 [rpm]
44	2	Goal Position	RW	-	Min Position Limit(18) ~ Max Position Limit(20)	-
46	2	Present PWM	R	-	-	-
48	2	Present Velocity	R	-	-	0.1 [rpm]
50	2	Present Position	R	-	-	-
52	2	Velocity Trajectory	R	-	-	0.1 [rpm]
54	2	Position Trajectory	R	-	-	-
56	2	Present Current	R	-	-	1 [mA]
58	2	Present Voltage	R	-	-	0.1 V
60	1	Present Temperature	R	-	-	(x-70) [°C]
61	1	Registered	R	0	-	-

Control Table Description

- **Model Number(0)**

This address stores the model number of your servo.

Decimal Value	Hex Value	Model Name
12207	0x2FAF	C12204-003

• Model Information(2)

Model information used by manufacturer.

• Firmware Version(6)

This address stores the version number of the current firmware running on your servo.

• ID(7)

The ID assigned is a unique value used to identify a specific servo through the network. The numbers 0-253 (0xFD) can be assigned as an ID, with 254 (0xFE) reserved for use as the Broadcast ID that can send an Instruction Packet to all connected servos simultaneously.

NOTE : Please avoid using an identical ID for multiple SERVOS. You may face communication failure or may not be able to detect Servos with an identical ID.

NOTE : If an Instruction Packet ID is set to the Broadcast ID(0xFE), Status Packets will not be returned for READ or WRITE Instructions regardless of the configured Status Return Level (26).

• Baud Rate (8)

The Baud Rate(8) determines serial communication speed between a controller and servos.

Value	Baud Rate	Margin of Error
7	4.5M [bps]	0.000 [%]
6	4M [bps]	0.000 [%]
5	3M [bps]	0.000 [%]
4	2M [bps]	0.000 [%]
3	1M [bps]	0.000 [%]
2(Default)	115,200 [bps]	0.000 [%]
1	61,600 [bps]	0.000 [%]
0	9,600 [bps]	0.000 [%]

NOTE : Less than 3% of the baud rate error margin will not affect to UART communication.

• Return Delay Time (9)

When a servo receives an Instruction Packet, it will return a Status Packet response after the configured Return Delay Time(9) has passed. The range of configurable values for this setting is 0 to 254 (0xFE) in units of 2 [μ sec]. For instance, if the Return Delay Time(9) is set to '10', a Status Packet will be returned 20[μ sec] after an Instruction Packet is received.

Unit	Value Range	Description
2[μ sec]	0 ~ 255	Default value '250'(500[μ sec]) Maximum value: '510'[μ sec]

• Drive Mode(10)

Drive Mode contains several settings for adjusting the operating behavior of servos, including automatic torque on, reverse movement, and movement profiles.

Bit	Item	Description
Bit 7(0x80)	-	Unused, always '0'
Bit 6(0x40)	-	Unused, always '0'
Bit 5(0x20)	-	Unused, always '0'
Bit 4(0x10)	-	Unused, always '0'
Bit 3(0x08)	Torque On by Goal Update	[0] Movements will only be executed if Torque Enable(32) is set to '1' [1] Movements will be executed regardless of the value of Torque Enable(32). If the value of Torque Enable(32) is '0' and a command is given, Torque Enable(32) will be updated to '1'.
Bit 2(0x04)	Profile Configuration	[0] Velocity-based Profile: Create Profiles based on movement Velocity [1] Time-based Profile: Create Profiles based on time steps.
Bit 1(0x02)	-	Unused, always '0'
Bit 0(0x01)	Normal/Reverse Mode	[0] Normal Mode: CCW(Positive), CW(Negative) [1] Reverse Mode: CCW(Negative), CW(Positive)

NOTE : If the value of Bit 0(Normal/Reverse Mode) of Drive Mode(10) is set to **1** , rotational direction is inverted. Thus, **Goal Position**, **Present Position** will also have inverted directions. This feature can be very useful when configuring symmetrical joints, or similar mirrored servo installations.

• Operating Mode(11)

Value	Operating Mode	Description
0(Default)	Position Control Mode	This mode controls position. This mode is identical to the Joint Mode of servo. Operating position range is limited by the Max Position Limit(20) and the Min Position Limit(18). This mode is ideal for articulated robots that each joint rotates less than 360 degrees.
1	Velocity Control Mode	This mode controls velocity. This mode behaves similarly to a standard DC motor, and is best suited to applications like drive wheels.
2	PWM Control Mode (Voltage Control Mode)	This mode directly controls PWM output. (Voltage Control Mode)

• Homing Offset(12)

Homing Offset(12) allows users to adjust the servo's home position by adding the offset value is to the reported Present Position(48).

Present Position(48) = Actual Position + Homing Offset(12)

Unit	Value Range
about 0.088 [°]	-4,095 ~ 4095

NOTE : any invalid Homing Offset(12) values will be ignored(valid range : -4,095 ~ 4,095).

WARNING : Even if Drive Mode(10) is set to Reverse Mode, the sign of the Homing Offset(12) value is not reversed.

• PWM Limit(14)

The PWM Limit(14) is used to configure the maximum allowable PWM output. Goal PWM(34) can't be set to a values exceeding the PWM Limit(14). Additionally, the PWM Limit(14) is used in all operating mode as an absolute limit to the motor's final output PWM. For more details, please refer to the Gain section of each operating mode.

Unit	Range
about 0.028 [%]	0(0 [%]) ~ 3599(100 [%])

• Velocity Limit(16)

The Velocity Limit(16) is used to limit the maximum acceptable value for the Goal Velocity(36). For more details, see Goal Velocity(36).

Unit	Value Range
0.1rpm	0 ~ 32767

• Min/Max Position Limit(18, 20)

The Min and Max Position Limit(18, 20) is used to configure the maximum movement range in Position Control Mode within a single rotation(0 ~ 4,095).

Provided Goal Position(42) values must be within the configured position limit range.

Unit	Value Range
about 0.088 [°]	0 ~ 4,095(1 rotation)

• Min/Max Voltage Limit(22, 24)

The Min Voltage Limit(22) and Max Voltage Limit(24) are used to configure the range of acceptable input voltages. When the Present Input Voltage(58) exits the range between Max Voltage Limit(24) and Min Voltage Limit(22), the Input Voltage error Bit(0x01) in the ERROR field of Status Packet will be set.

If the Input Voltage Error Bit(0x01) in the Shutdown(28) register is set, Torque Enable(32) will be set to '0'(Torque OFF).

For more details, please refer to Shutdown(28).

Unit	Value Range	Description
About 0.1 [V]	36 ~ 150	3.6 ~ 15.0 [V]

• Threshold of Overcurrent(26)

If the servo current consistently exceeds the Threshold of Overcurrent(26) and the time exceeds the Window of OCP Judgment(28), the Overcurrent Error bit of ERROR field will set as 1.

Unit	Value Range	Description
1 [mA]	50 ~ 5000	50 ~ 5000 [mA]

• Window of OCP Judgment(28)

If the servo current consistently exceeds the Threshold of Overcurrent(26) and the time exceeds the Window of OCP Judgment(28), the Overcurrent Error bit of ERROR field will set as 1.

Unit	Value Range	Description
100 [ms]	0~255	0 : No OCP 1~255 : 100~25500 ms

• Temperature Limit(29)

The Temperature Limit(29) is used to configure an upper limit on servo operating temperature.

When the Present Temperature(60) is greater than the Temperature Limit(29), the **Overheating Error Bit(0x04)** in the ERROR field of Status Pack will be set. If the Overheating Error Bit(0x04) is configured in Shutdown(31), Torque Enable(34) will be set to '0' (Torque OFF). See Shutdown(31) for more detailed information.

Unit	Value Range	Description
1°C	0 ~ 255	-70 ~ 185°

CAUTION : Do not set this value higher than it's default. In the case that a servo triggers a temperature shutdown alarm (Overheating Error Bit(0x04)), let it cool for some minutes or more before resuming use to prevent damage to the servo.

• Status Return Level(30)

The Status Return Level (30) is used to set the servo's response policy when an instruction packet is received.

Value	Responding Instructions	Description
0	PING Instruction	Returns a Status Packet for PING Instructions only
1	PING Instruction READ Instruction	Returns a Status Packet for PING and READ Instructions
2	All Instructions	Returns a Status Packet for all Instructions

NOTE : If the Instruction Packet ID is set to the Broadcast ID(0xFE), a Status Packet will not be returned for READ or WRITE Instructions regardless of Status Return Level (30).

• Shutdown(31)

servos can protect themselves by detecting dangerous situations that may occur during operation. This register allows user to configure which of these error states causes a safety shutdown. Each Bit is inclusively processed with 'OR' logic, allowing multiple options to be selected. For instance, when Shutdown(31) is set to '0x05' (binary : 00000101), the servo will shutdown in response to both both an Input Voltage Error(binary : 00000001) and Overheating Error(binary : 00000100). If those errors are detected, Torque Enable(34) is cleared to '0' and the motor's output will be set to 0 [%].

Bit	Item	Description
Bit 7	Encoder Error	Detects malfunction of the servo encoder
Bit 6	Instruction Error	Detects that undefined Instruction is transmitted or the ACTION command is delivered without the REG_WRITE command
Bit 5	Overcurrent Error	Detects that current above Threshold of Overcurrent exceeds time that Threshold of OCP Judgment
Bit 4	Checksum Error	Detects that the Checksum of the transmitted Instruction Packet is invalid
Bit 3	Range Error	Detects that the command is given beyond the range of usage
Bit 2	Overheating Error(default)	Detects that the internal temperature exceeds the set temperature
Bit 1	Angle Limit Error	Detects that Goal Position is written with the value that is not between Min Position Limit and Max Position Limit
Bit 0	Input Voltage Error	Detects that input voltage exceeds the configured operating voltage

• Position Error Margin (32)

It exists in all directions of CW/CCW and means the error between goal position and present position. The range of the value is 0~255, and the unit is the same as Goal Position(44). The greater the value, the more difference occurs.

• Punch(33)

Minimum output of pwm to drive motor. This value ranges from 0x0 to 0xFF.

• Torque Enable(34)

Torque Enable(34) is used to enable or disable the torque for the servo's internal motor. Setting Torque Enable(34) to '1' will enable output Torque and all Data in the FLASH area will be locked. Setting the value to '0' will disable torque and unlock the FLASH.

Value	Description
0(Default)	Torque Off, FLASH unlocked
1	Torque On, FLASH locked

• Bus Watchdog(35)

The Bus Watchdog(35) is a fail-safe system used to stop servo motion if communication between the controller and servo (RS-485, TTL) is disconnected.

	Values	Description
Range	0	Deactivate Bus Watchdog Function, Clear Bus Watchdog Error
Range	1 ~ 127	Activate Bus Watchdog (Unit: 20 [msec])
Range	-1	Bus Watchdog Error Active

The Bus Watchdog function monitors the interval of communications between the controller and servo when Torque Enable(34) is '1'(Torque ON).

If the measured communication interval is larger than the configured value of Bus Watchdog(35), the servo will stop. Then Bus Watchdog(35) will be changed to '-1'. When a Bus Watchdog Error screen is active, all Goal Values (Goal PWM(36), Goal Velocity(38), Goal Position(44)) will be changed to read-only-access until the error has been cleared. If the value of Bus Watchdog(35) is changed to '0', active Bus Watchdog Errors will be cleared.

– Bus Watchdog (35) Example

The following is an example of the operation of the Bus Watchdog failsafe.

After setting the Operating Mode(11) to speed control mode, change Torque Enable(34) to '1'.

If '50' is written to Goal Velocity(38), the servo will rotate in a CCW direction.

Change the value of Bus Watchdog(35) to '100' (2,000 [ms]) to activate the Bus Watchdog function.

If no instruction packet is received for 2,000 [ms], the servo will stop. When it stops, the Profile Acceleration(40) and Profile Velocity(42) are set to '0'.

The value of Bus Watchdog(35) changes to '-1' (Bus Watchdog Error). At this time, the access to Goal Values will be changed to read-only.

If '150' is written to Goal Velocity(38), a Data Range Error will be returned via Status Packet.

If the value of Bus Watchdog(35) is changed to '0', the Bus Watchdog Error will be cleared.

If "150" is written to Goal Velocity(38), the servo will rotate in a CCW direction.

• Goal PWM(36)

When the Operating Mode(11) is set to **PWM Control Mode**, Goal PWM(36) is used to directly control the supplied output voltage to the servo's motor. When set to a different Operating Mode(11), Goal PWM(36) is used as a final limiter on the output PWM value only.

Unit	Range
about 0.028 [%]	-PWM Limit(14)~ PWM Limit(14)

• Goal Velocity(38)

Goal Velocity(38) is used to set the target velocity when in the **Velocity Control Mode** Operating Mode(11). Goal Velocity(38) is not used to limit moving velocity in any operating modes.

Unit	Value Range
0.1 rpm	-Velocity Limit(16) ~ Velocity Limit(16)

NOTE : The maximum velocity and maximum torque of servo is affected by the supplied voltage. If the input voltage changes, so does the maximum velocity and torque. This manual assumes operation with the recommended input voltage.

NOTE : If Profile Acceleration(40) and Goal Velocity(38) are modified simultaneously, the newly modified Profile Acceleration(40) will be used to process the updated Goal Velocity(38).

• Profile Acceleration(40)

When the Drive Mode(10) is **Velocity-based Profile**, Profile Acceleration(38) sets the maximum allowable acceleration of the generated Profile.

When the Drive Mode(10) is **Time-based Profile**, Profile Acceleration(38) sets the allowed acceleration time of the generated Profile.

The Profile Acceleration(40) is used in all control modes except **PWM Control Mode**.

Velocity-based Profile	Values	Description
Unit	100 [rev/m2]	Sets maximum acceleration of the Profile
Range	0 ~ 32767	'0' represents an infinite maximum acceleration

Time-based Profile	Values	Description
Unit	1 [msec]	Sets allowed acceleration time of the Profile
Range	0 ~ 32767	'0' represents an infinite acceleration time('0 [msec]'). Profile Acceleration(38) can not exceed 50% of the configured Profile Velocity (40) value.

• Profile Velocity(42)

When the Drive Mode(10) is **Velocity-based Profile**, Profile Velocity(42) sets the maximum allowable velocity of the generated Profile.

When the Drive Mode(10) is **Time-based Profile**, Profile Velocity(42) sets the total execution time of the generated Profile. Profile Velocity(42) is only applied in the **Position Control Mode** Operating Mode(11).

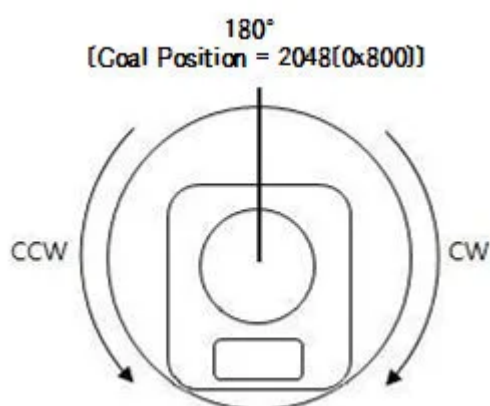
NOTE: Velocity Control Mode only uses Profile Acceleration(108)

Velocity-based Profile	Values	Description
Unit	0.1 [rpm]	Sets the maximum velocity of the Profile
Range	0 ~ 32767	'0' represents an infinite velocity

Time-based Profile	Values	Description
Unit	1 [msec]	Sets the time span for the Profile
Range	0 ~ 32767	'0' represents an infinite velocity. Profile Acceleration(38) can not exceed 50% of the configured Profile Velocity (40) value.

• Goal Position(44)

Goal Position(44) is used to set the actuator's desired output position.



Mode	Values	Description
Position Control Mode	Min Position Limit(18) ~ Max Position Limit(20)	Initial Value : 0 ~ 4,095

Unit	Description
about 0.088 [deg/pulse]	1[rev] : 0 ~ 4,095 (1 rotation (0 ~ 4,095, total 4,096 counts))

NOTE : Profile Velocity(42) and Profile Acceleration(40) are active under the following conditions:

- When the Operating Mode(11) is **Position Control Mode**, Profile Velocity(42) and Profile Acceleration(40) are used to create a new profile when the Goal Position(44) is updated.
- When the Operating Mode(11) is **Velocity Control Mode**, Profile Acceleration(40) is used to create a new profile when Goal Velocity(38) is updated.

• Present PWM(46)

This value indicates the present PWM duty being passed to the motor. For more details, please refer to Goal PWM(36).

• Present Velocity(48)

Present Velocity reports the current output speed of the actuator. For more details, please refer to Goal Velocity(38).

• Present Position(50)

The Present Position(50) indicates the present actuator Position. For more details, see Goal Position(44).

• Velocity Trajectory(52)

This register stores the current target velocity for the active trajectory created by the current Profile. The specific values and behavior of this register may change based on the active operating mode. For more details, please refer to Profile Velocity(42).

1. **Velocity Control Mode** : When the generated Profile reaches it's endpoint, Velocity Trajectory(52) becomes equal to Goal Velocity(38).
2. **Position Control Mode** : Velocity Trajectory is used to create the Position Trajectory(54) used for the movement. When the Profile reaches an endpoint, Velocity Trajectory(52) is set to '0'.

• Position Trajectory(54)

The Position Trajectory(54) is the desired movement trajectory created by the active Profile.

Position Trajectory(54) is used only when the Operating Mode(11) is **Position Control Mode**.

- **Present Current(56)**

The Present Current(56) reports the present current being supplied to the actuator. For more details, see the Threshold of Overcurrent(26).

- **Present Input Voltage(58)**

The Present Input Voltage(58) reports the present voltage level being supplied to the actuator. For more details, see the Min/Max Voltage Limit(22, 24).

- **Present Temperature(60)**

The Present Temperature(60) reports the present operating temperature of the actuator. For more details, see Temperature Limit (29).

- **Registered Instruction(61)**

Indicates whether an instruction has been registered by the Reg Write Instruction and is ready for execution. Following the execution of a registered action the Registered Instruction (61) value will automatically be updated to 0.

Value	Description
0	No instruction registered by REG_WRITE.
1	Instruction registered by REG_WRITE.