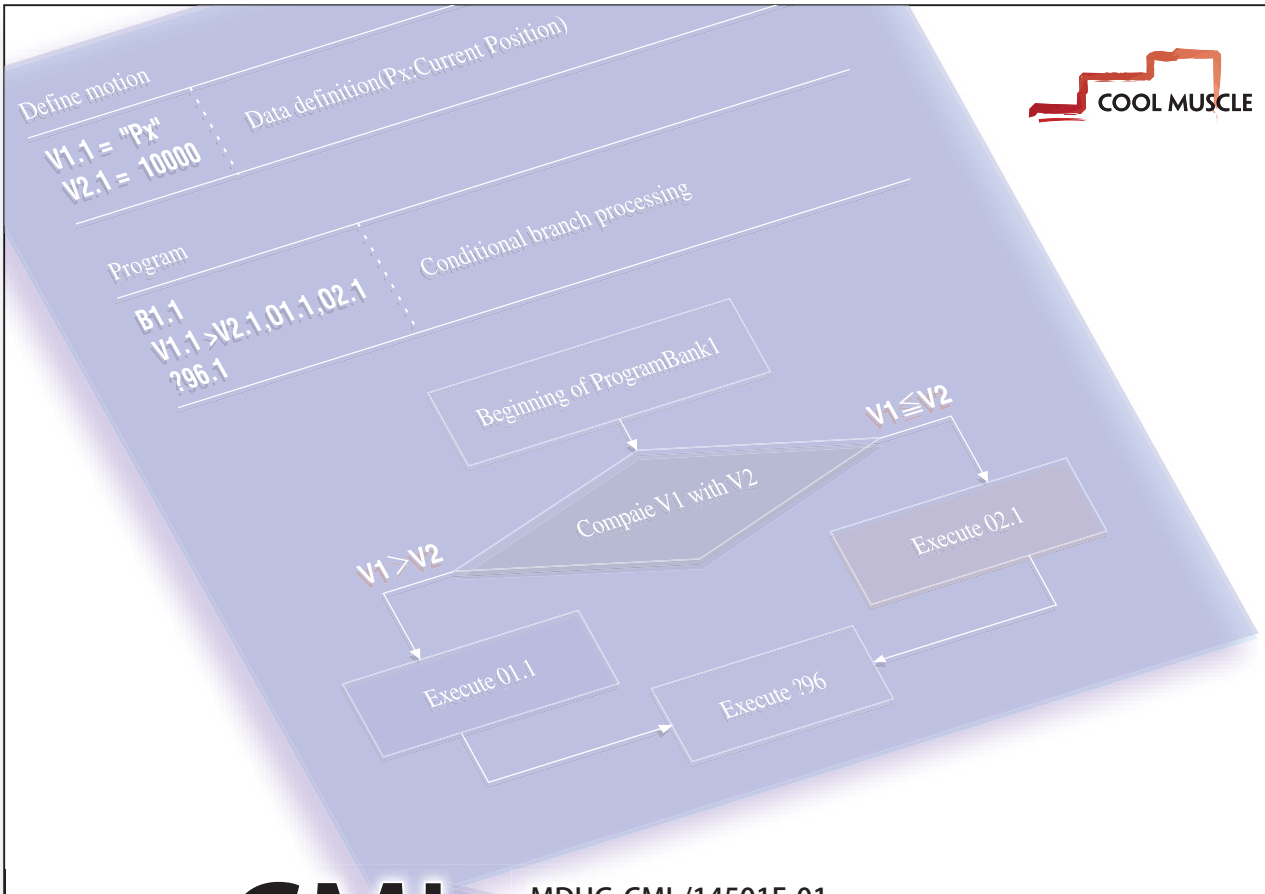
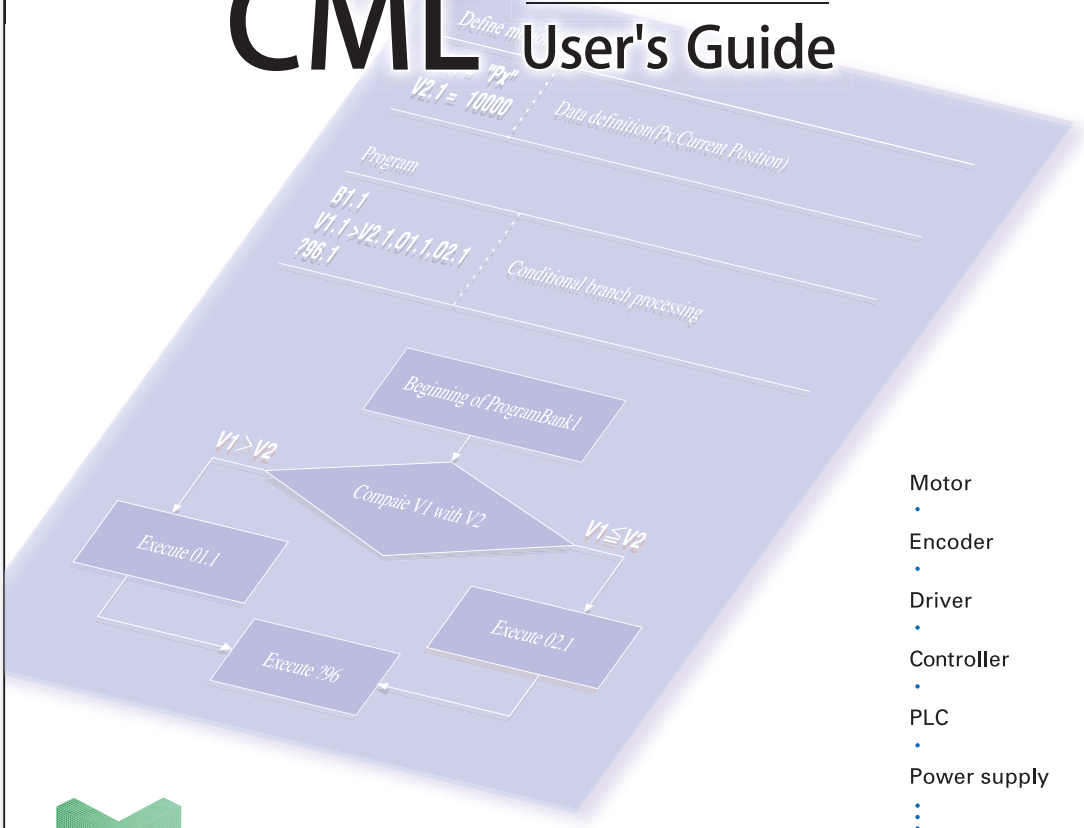


COOL MUSCLE

CML User's Guide

MDUG-CML/14501E-01



Motor
•
Encoder
•
Driver
•
Controller
•
PLC
•
Power supply

All in **ONE** Solution

MUSCLE CORPORATION

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●Before reading CML User's Guide, please read “CM2 User's Guide” for installation or operation of Cool Muscle and “COOL WORKS LITE USER'S MANUAL” for the usage of “COOL WORKS LITE”, Cool Muscle operation software.

INDEX

Chapter 5

Chapter 6

Explanation of icon

Icons used in this User's Guide.


Warnings and notices


Important points


Supplemental explanations

Chapter 1

CML Overview

1.1. What is CML?

CML is a short form of "Cool Muscle Language", which is a collection of commands used to control the motion of Cool Muscle. CML consists of the following commands.

● Parameters

Parameters set Cool Muscle's operating conditions. Do not change parameters while the motor is in motion. Please refer to the Chapter 3.

● Data Commands

Data commands define the data for Cool Muscle's motion and support various kind of motion. Please refer to the section 2.1.1 and 2.2.1.

● Bank Commands

Bank Commands define motion logic. Program Banks are executed by the Execution commands. Please refer to the section 2.2.2 and 2.2.3.

● Execution Commands

Execution commands execute or stop motion of Cool Muscle. Please refer to the section 2.1.2.

● Query

Query commands confirm Cool Muscle's current status (defined value as position, speed etc). Please refer to the section 6.6.

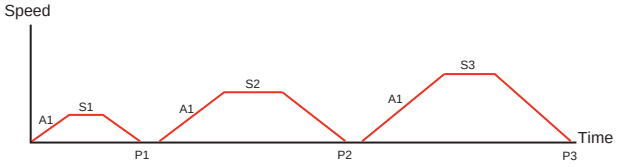
● Operator (Arithmetic / Logical / Comparison)

By using both data and bank commands, more complex motions are possible. Please refer to the section 6.7, 6.8 and 6.9 for more detailed information.

Please use 1 byte character fonts only.
CML does not distinguish between upper case and lower case characters.

The following motion can be created by CML

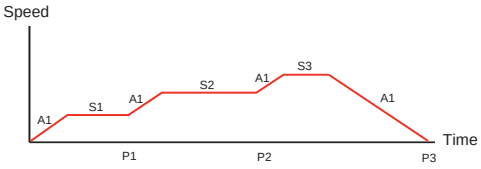
● PTP motion with different speeds



Example:

From the origin, the motor accelerates/decelerates using A1. Move with stops at each point (P1,P2,P3) changing the speed (S1, S2, S3).

● Merged Motion



Example:

From the origin, the motor moves to P3 with the acceleration/deceleration A1, changing speeds (S1,S2,S3) at each point (P1, P2) without stop.

● Motion Control for Multiple motors

By specifying the Motor ID, up to 15 motors can be controlled on a single network. 3 Dimensional motions can be accomplished on a single network for X, Y, Z applications.

● Circular / Linear Interpolation

Using the new interpolation commands, 2 axis systems can be coordinated and trace arcs and lines. Ovals are also possible.

● Conditional Branching

Using New logical operators, branching by multiple input or motor status is possible. It supports various branching as motion branching and conditional branching.

1.2. Motion Mode

There are 2 modes of operation in the Cool Muscle.

● Direct Mode

Like chatting online, you can control the Cool Muscle directly. Direct Mode is useful for an instant control, debugging, or the interrupt handling in a program (ex. forced termination). Direct Mode is available in all types of Cool Muscle.

● Program Mode

By using Bank commands, Cool Muscle executes motion according to the block of predefined motion logic (Bank command). There are Program Bank and Ladder Logic Bank as a block of motion logic. They can be stored in Cool Muscle's memory and executed by execution command or digital signal.

Program bank is useful for repetitive motion applications.

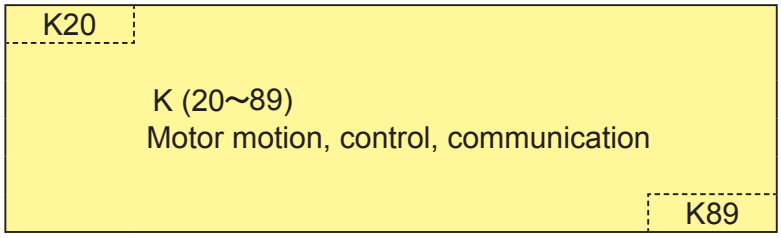
The process depending on input or motor status is described in Ladder Logic Bank. Ladder Logic Bank is scanned continuously in the background per set time by a parameter. It works as a simple sequencer or PLC.

*Program mode is not available with the P type.

1.3. Memory Map

By parameter commands, specified numbers of pre-set value can be stored in the Memory of Cool Muscle. Indicate a memory number following parameter commands to read or save the pre-set value. The following diagram outlines the memory composition.

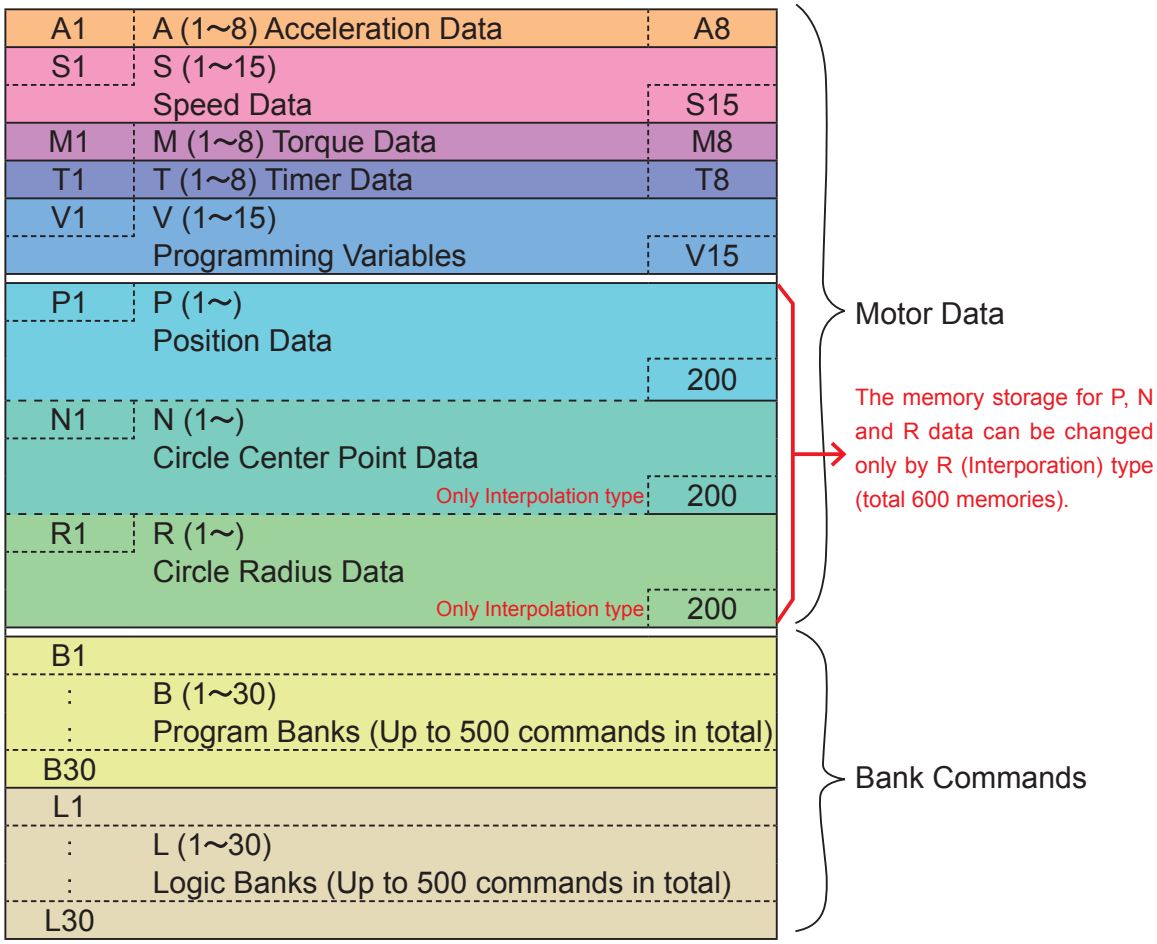
【Parameters】



【Direct Mode】

The memory number is not specified.

【Program Mode】



Chapter 2

Operation by CML

2.1. Direct Mode

In Direct Motion, Position, Speed and Acceleration need to be predefined. Motion based on these predefined data is executed by execution command.

(n: Motor ID, ↵ : Enter Key input)

S.n= Value↵ …Define speed

A.n= Value↵ … Define Acceleration

P.n= Value ↵… Define Target Position

M.n= Value↵ … Define Torque Limit

^.n …Execute action based on the above values

[Operation Example]

Let's operate Cool Muscle

First of all, define the data by entering numbers as below.

S.1=100

A.1=100

P.1=10000

M.1=100

Defined data can be confirmed by sending the query “?.1”

?.1 sent command to Cool Muscle

P.1=10000, S.1=100, A.1=100, M.1=100 replied data from Cool Muscle

Cool Muscle's default setting is Resolution 1000[ppr], Speed Unit 100[pps], so that the example above should be

Speed = S.1 value x Speed Unit = 100 x 100[pps] = 10000[pps]

Acceleration = A.1 value = 100[kpps^2]

Target Position = P.1 value = 10000[pulse]

Torque Limit = M.1 value = 100[%].

Then operate Cool Muscle by entering the command as below.

^.1

Cool Muscle moves to the target position 10000[pulse] with the set speed and acceleration. After completion of positioning, Cool Muscle replies Ux.1=8 that means in-position status.

Current position can be confirmed by the query command ?96.1.

?96.1 sent command to Cool Muscle

Px.1=10000 replied data from Cool Muscle

2.1.1. Data Commands in Direct Mode

Motion commands are explained in the format below.

Data Defining Commands	Functions
Unit	Description
Example	Description of example

P	Position Data Definition
Unit: pulse	This command defines Target Position. The value can be defined as relative against current position by using += or -=. If the value is set to 1000000000, the motor will run continuously. Min -1000000000 Max 1000000000 *The setting range depends on K37.
P.1=10000	Set Target Position to 10000 pulses for Motor 1.
P.1=-5000	Set Target Position to -5000 pulses for Motor 1.
P.1+=100	Add 100 pulses to the current position and set it as Target Position for Motor 1.
P.1-=200	Deduct 200 pulses from the current position and set it as Target Position for Motor 1.
P.1=1000000000	Set endless position as target position for Motor 1.

S	Speed Data Definition
Unit: 100pps or 10pps or 1pps (Set by K37)	This command sets the motor Speed as an absolute value. As example, value is treated as +100 even if -100 is set. Only when the motor is running continuously, set Speed to a positive number for CW direction motion, and set Speed to a negative number for CCW direction motion. Min -32767 Max 32767
S.1=250	Set Motor 1 Speed to 25000/2500/250pps.

A	Acceleration Data Definition
Unit : kpps²	This command sets Acceleration. Min 1 Max 32767
A.1=100	Set Motor 1 Acceleration to 100 kpps².

M	Torque Limit Data Definition
Unit : %	This command sets Torque Limit using a percentage (0-100%) of the maximum motor torque. Soon after setting M data, the motor torque should be limited by M data. Min 0 Max 100
M.1=50	Set Motor 1 Torque Limit to 50% of the maximum motor torque.

N	Center Point Data of Circle Definition
Unit: pulse	Only interpolation type can be used. This command defines Center of an arc (circles, ovals, arcs) with 2 axes. Min -1000000000 Max 1000000000 *The setting range depends on K37.
N.1=50, N.2=30	Set Center of a circle to 50pulses for Motor 1 (X axis), and 30 for Motor 2 (Y axis)

R	Radius Data of Circle Definition
Unit: pulse	Only interpolation type can be used. This command defines Radius for an arc (circles, ovals, arcs) with 2 axes. When R values for both 2 axes are set to equal, then it will draw a circle. When they are different, it will draw an oval. When R is set to a positive number, a longer arc will be drawn. When it is set to a negative number, a shorter arc will be drawn. When it is set to 0, line will be drawn. Min -1000000000 Max 1000000000 *The setting range depends on K37.
R.1=80, R.2=80	Set Radius to 80 pulses for Motor 1 (X axis) and Motor 2 (Y axis).

2.1.2. Execution Commands in Direct Mode

Execution commands are explained in the format below.

Command	Function
Description	
Example	Explanation of Example

^	Execute the Direct Command Motion
This command executes motion using predefined Data Commands (S,A,P,M).	
S.1=250 A.1=100 P.1=10000 ^.1	Motor 1 moves to position 10000 with the speed 250 and acceleration 100kpps².

|	Origin Search
This command makes the motor search an Origin based on Origin Search Parameters K42,43,45,46. *This is a bar not the letter I.	
|.1	Motor 1 starts to search Origin.

|1	Move to Position 0
This command makes the motor move to an Origin (Position 0). Acceleration and deceleration are set by Parameters K42,43.	
|1.2	Motor 2 moves to Origin.

|2	Assign Current Position to 0
This command sets the current position to Origin (Position 0). *No motion.	
|2.3	Set Motor 3's current potion to Origin

(	Enable Motor
This command enables Motor.	
(.1	Enable Motor 1.

)	Motor Free
This command makes the motor “Motor Free”.	
).1	Make Motor 1 Motor Free.

O	Output Signal ON
This command turns the output on. Parameter K34 needs to be set to 4 (General). Format: O#.n (# = Output No., n = Motor ID)	
O2.1	Output 2 on Motor 1 is set to on.

F	Output Signal OFF
This command turns the output off. Parameter K34 needs to be set to 4 (General). Format: F#.n (# = Output No., n = Motor ID)	
F2.1	Output 2 on Motor 1 is set to off.

$	Save Data
This command saves Parameters, Data Commands, Program Banks and Ladder Logic Banks into Cool Muscle's Memory. When data is saved, a message “saved. Motor ID” is returned. Once saved, the data is kept after the motor is powered off.	
$.1	Save Motor 1's Data like Program Banks.

?	Query
This command shows Parameters, Data Commands, Program Banks and Ladder Logic Banks stored in Cool Muscle's Memory.	
?.1	Display the predefined data of Direct mode of Motor 1

#	Capture Position Data
This command sets the current position data to a specified memory.	
#2.1	Take the position memory No.2 from Motor 17s current position.

[	Execute Program Bank
This command executes predefined or restart paused Program Bank.	
[1.2	Execute Motor 2's Program Bank 1

]	Pause Program Bank
This command stops all motors and pauses Program Bank in operation. The “ [“ re-starts Program Bank in pause. When this command is entered twice, Program Bank is terminated and cannot be resumed.	
[1.1]]	 Stop all motors and pause Program bank 1. Program bank is terminated.

]1	Pause Specified Motor
This command specifies a motor on a daisy chain network to be paused.	
]1.3	Only Motor 3 pauses on a daisy chain network.

}	Stop after Completing Current Line
This command pauses the program bank after completing the current line in Program Bank. The " [" command re-starts the program bank in pause. When this command is entered twice, Program Bank is terminated and cannot be resumed.	
}.1	Motor 1 stops after completing the current line in Program Bank.

*	Emergency Stop
This command makes all motors stop with the maximum deceleration. This is used when emergency stop is required. To re-start the motion, you have to cancel Emergency Stop using *1 Command. The program is resumed with the next executable line. Program Bank stops when this command is transmitted twice, and Program Bank operates from the beginning with command [after canceling the emergency stop by command *1. This command can be assigned to inputs.	
*	Execute an emergency stop

*1	Cancel Emergency Stop
This command cancel Emergency Stop * and enable the motor.	
*1	Cancel an emergency stop

>	Execute Next Line
This command executes the next line of Program Bank in pause. After executing the last line of Program Bank, the motor executes no motion and reply "End.ID".	
>.1	Execute the next line of Program Bank of Motor 1 in pause

<	Execute Previous Line
This command executes the previous line in Program bank in pause. When execution is impossible, a message [Can't back!] is displayed.	
<.1	Execute the previous line of Program Bank of Motor 1 in pause

[L	Execute Ladder Logic Bank
This command executes the specified Ladder Logic Bank in the background. Format: [L#.n (#=Program Bank No., n=Motor ID)	
[L2.1	Motor 1 executes Ladder Logic Bank 2 in the background.

]L	Stop Ladder Logic Bank
This command stops Ladder Logic Bank running in the background.	
]L.1	Motor 1 stops Ladder Logic Bank running in the background.

@	Execute Circular and Linear Interpolation Motion
Only Interpolation type can be used. The starting point is the current position. Motors execute Circular or Linear Interpolation motion toward the set position based on set R or N data. Format: @#.n modifier <+/-> (#=P memory No., n=Motor ID) The modifier should be set to + for CW direction, and - for CCW direction.	
@.1+, @.2+	Motors execute Circular Interpolation motion for CW direction toward P positions of Motor 1 and Motor 2.
@3.1-, @4.2-	Motors execute Circular Interpolation motion for CCW direction toward P3 of Motor 1 and P4 of Motor 2.

\ (¥ or ₩)	Area division of Data Command
Only Interpolation type can be used. The Data Command of P, N, and R in total 600 are divided the area. The occupancy priority: P, N, R After allocation of P, N should be allocated within the rest area. The rest area after allocation of N should be allocated for R automatically. If the maximum number is allocated for P, N and R should be 0.	
\P300	300 pieces are allocated for P as a data definition area.
\N200	200 pieces are allocated for N as a data definition area.
	The definition area of R becomes "600 - Number of P - Number of N" without specification. (R area should be 100 pieces in example.)

2.2. Program Mode

In program mode, positions, speeds, accelerations need to be predefined. Using these predefined motion data, Program Banks can be created. Program Banks are executed by execution commands. Please refer to Chapter 4 for program examples for different applications.

In program mode, memory numbers should be specified after each command.

The following shows basic structure of CML in program mode.
(#=Memory No., n=Motor ID, ↵ =Enter Key input)

S#.n=Value
A#.n=Value
P#.n=Value
V#.n=Value

Define each data using Motion commands

B#.n
P#.n=V#.n
S#.n, A#.n, P#.n
P#.n
END

Define motion order using Bank Commands.
⇒Bank Commands are described after B command (starting with Command B).

Transfer the predefined text files to the motor or input data directly via COOL WORKS LITE or Hyper Terminal.

[#.n ↵ …The specified Program Bank (B#) is executed based on the above definition.

It is suggested to create, edit and save Program Bank data as text files because whole Program Bank data should be transferred even though there is a small change.
Please save the file as .txt.

[Operation Example]

Let's make a Program Bank, download it to Cool Muscle and execute it.

First of all, define the data that is necessary for Program Bank as below.

S1.1=100

A1.1=100

P1.1=10000

P2.1=0

T1.1=1000

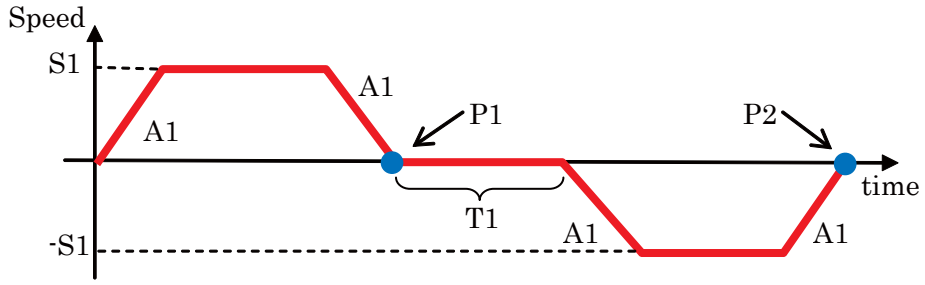
Then define the Program Bank as below.

B1.1	Start of Program Bank definition
S1.1, A1.1, P1.1	Move to P1 with speed S1 and acceleration A1
T1.1	Timer for T1
P2.1	Move to P2 with the same speed and acceleration
END	The end of Program Bank definition

After defining all data, execute the Program Bank 1 by entering a command as below.

[1.1

The motion in the diagram is executed as defined in Program Bank.



2.2.1. Data Commands in Program Mode

Data Commands can define multiple motion patterns. Each Data Command requires a memory number. The capacity of available memory space depends on the command.

Data Commands are explained in the format below.

Motion Commands	Function	Available memory space
Unit	Description	
Example	Explanation of Example	

P	Position Data Definition	1 ~ 200
Unit: pulse	This command defines Target Position. The value can be defined as relative against set position by using += or -=. If the value is set to 1000000000, the motor will run continuously. It can be defined up to 600 including Data Command N and R. (Interpolation type)	Min -1000000000 Max 1000000000 *The setting range depends on K37.
P2.1=10000	Save the value of 10000 to Motor 1's P memory 2.	
P2.1=-5000	Save the value of -5000 to Motor 1's P memory 2.	
P2.1+=1000	Save the value of 1000 as the relative one to Motor 1's P memory 2.	

S	Speed Data Definition	1 ~ 15
Unit: 100pps or 10pps or 1pps (Set by K37)	This command sets the motor Speed as an absolute value. As example, value is treated as +100 even if -100 is set. Only when the motor is running continuously, set Speed to a positive number for CW direction motion, and set Speed to a negative number for CCW direction motion.	Min -32767 Max 32767
S2.1=250	Save the value of 250 to Motor 1's S memory 2.	

A	Acceleration Data Definition	1 ~ 8
Unit: kpps²	This command defines Acceleration.	Min 1 Max 32767
A2.1=100	Save the value of 100 to Motor 1's A memory 2.	

T	Timer Data Definition	1 ~ 8
Unit: msec	This command defines Timer.	Min 0 Max 32767
T2.1=1000	Save the value of 1000 to Motor 1's T memory 2.	

M	Torque Limit Data Definition	1 ~ 8
Unit: %	This command sets Torque Limit using a percentage (0-100%) of the maximum motor torque. Soon after setting M data, the motor torque should be limited by M data.	Min 0 Max 100
M2.1=50	Save the value of 50 to Motor 1's M memory 2.	

V	Variable Data Definition	1 ~ 15
Unit: -	This command is for arithmetic operation or conditional branching by the value. General Data can be defined up to 4 digit numbers like 4 characters or motor's internal state value. Note that " (double quotation) is needed to use characters and motor's internal state value. Followings are motor internal state values. Px…Current Position Sx…Current Speed Ix…Current Iq Ux…Current Motor Status Pe…Position Error ADIN…Analog Input PT…Target Position ST…Target Speed	Min -1000000000 Max 1000000000
V2.1=12345678	Save 12345678 to Motor 1's V memory 2.	
V3.1=”abcd”	Save abcd to Motor 1's V memory 3.	
V4.1=”Px”	Save Px to Motor 1's V memory 4.	

N	Center Point Data of Circle Definition	1 ~ 200
Unit: Pulses	Only interpolation type can be used. This command defines Center Point of an arc (circles, ovals) using 2 axes. It can be defined up to 600.	Min -1000000000 Max 1000000000 *The setting range depends on K37.
N2.1=50,N2.2=30	Save the values of 50 for Motor 1 (X axis) and 30 for Motor 2 (Y axis) to N memory 2 of each motor.	

R	Radius Data of Circle Definition	1 ~ 200
Unit: Pulses	Only interpolation type can be used. This commands defines Radius of an arc (circles, ovals) using 2 axes. 0 must be set for Linear Interpolation. Only interpolation type can be used. It can be defined up to 600.	Min -1000000000 Max 1000000000 *The setting range depends on K37.
R2.1=80,R2.2=80	Save the values of 80 for Motor 1 (X axis) and Motor 2 (Y axis) to R memory 2 of each motor.	

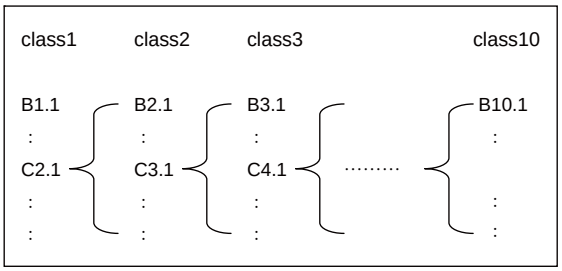
2.2.2. Program Bank Commands

Program Bank must start with the B command and end with End command. Program Bank is terminated also with the linefeed and without any command. Multiple commands in a single line are available and should be separated with commas. The maximum number of commands per motor is 500 commands in total.

Bank Commands are explained in the format below.

Program Commands	Function	Available memory space
Description		
Example	Explanation of Example	

B	Beginning of Program Bank	1 ~ 30
This command defines the beginning of Program Bank. Format: B#.n (# = Program Bank No., n = Motor ID)		
B2.1	Define the beginning of Motor 1's Program Bank 2.	

C	Call other Program Bank	1 ~ 30
This command calls and executes the specific Program Bank, and back to the original Program Bank line after completing the called Program Bank. C command can not be used to call the other ID's Program Bank. Program Bank where C command executes cannot be called again. The maximum layer (nesting) should be under 10.		
B1.1 C2.1	Motor 1's Program Bank1 calls and executes Motor 1's Program Bank 2.	

J	Jump to other Program Bank	1 ~ 30
This command jumps to and executes specific Program Bank. But different from C command, it will not go back to the original Program Bank. J command can be used to jump out of a looped program bank. J command can not be used to jump to the other ID's program bank.		
B1.1 J2.1	Motor 1's Program Bank 1 jumps to and executes Motor 1's Program Bank 2.	

S	Speed	1 ~ 15
This command defines Speed in S memory space. This command needs to be defined before motion commands (P, Q, Y, Z, @). If S command is not defined, the previously used value will be applied. The specified memory value can be changed by the value from Arithmetic Operator.		
S2.1, A2.1, P2.1	Use the value defined in Motor 1's S memory 2 as Speed when Motor 1 moves to P2.	
S3.1=S2.1+V2.1	Save the total value of the value defined in Motor 1's S memory 2 plus the value defined in Motor 1's V memory 2 to Motor 1's S memory 3.	

A	Acceleration	1 ~ 7
This command sets the acceleration value in a specified memory space. This command needs to be defined before motion commands (P, Q, Y, Z, @). If the A command is not defined, the previously used acceleration will be applied. The specified memory value can be changed by the value from Arithmetic Operator.		
S2.1, A2.1, P2.1	Use the acceleration value stored in Motor 1's memory 2, the motor moves to position 2.	
A3.1=A2.1+V2.1	Save the total acceleration value (acceleration value stored in motor1's acceleration memory position 2 plus the value stored in motor 1's general memory position 2) to motor 1's acceleration memory position 3.	

P	Position	1 ~ 200
This command saves the position value in a specified memory. Use + or - after Motor ID to make the value relative. This value can be added or subtracted from the current position. The specified memory value can be changed by the value from Arithmetic Operator.		
S2.1, A2.1, P2.1	Motor moves to P memory 2 with Acceleration memory 2 and Speed memory 2 respectively.	
P2.1+	Motor moves from the current position by the travel distance defined by position memory 2.	
P3.1=V1.1+V2.1	Save the total values stored general memory 1 and 2 to motor 1's position memory 3.	

Y	Execute next line without in-position queuing
Use this command instead of P to execute the next line of Program Bank without the in-position of Y command. Note that Program Bank may not be resumed after stop command during the operation of several Y commands.	
S2.1, A2.1, Y2.1	Motor 2 starts executing line 2 without waiting for Motor 1 to complete line 1.
S3.2, A3.2, P3.2	

Q	Push Motion
Use this command instead of P to execute push motion toward the target position. If the motor reaches the target position before completing push motion, an error occurs (message, Ux.n=256). To avoid this error, set the target position well behind the object that the motor pushes. Torque value and push time are defined by parameter K60 and K61.	
S2.1, A2.1, Q2.1	The motor performs push motion from the current position to P memory No.2.

Z	Execute next line without push motion completion
Use this command instead of Q to execute the next line of Program Bank without waiting for the completion of the push motion by Z command.	
S2.1, A2.1, Z2.1 S3.2, A3.2, P3.2	Motor 2 starts executing line 2 without waiting for Motor 1 to complete line 1.

M	Torque Limit	1 ~ 8
This command sets Torque Limit using a percentage (0-100%) of the maximum motor torque.		
M1.1=V5.1+V6.1	Set the operated value from V5.1+V6.1 as value for M1.1.	

I	Conditional Branching on Input Status	1 ~ 6
This command makes conditional branching based on the specified input status. Conditional branching is possible based on the status of all Motors' ID on daisy chain network. Use a logic operator when an action is based on the status of 2 inputs.		
I2.1, C3.1, C4.1 I1.2 && I2.3, C3.1, C4.1	If Motor 1's input 2 is on (true) then execute Program Bank No.3, if off (false) then call execute Program Bank No.4. If Motor 1's input 1 and Motor 3's input 2 are on (true) then execute Program Bank No.3, else execute Program Bank No.4.	

T	Timer	0 ~ 8
This command sets the timer in timer memory locations. T0 means no action. * Please specify same Motor ID for T command and B command.		
T2.1	Motor 1 waits for the time defined by Timer memory No.2.	

W	Timer in Conditional Branching	0 ~ 8
Use this command instead of T to wait for the time defined by T command while the specified input status is true. If the input status changes while the motor is waiting, then it resumes motion. If it is set to 0 then the motor waits indefinitely. * Please specify same Motor ID for W command and B command.		
I2.1, W2.1, ?99.1 P2.1	If motor1's input 2 is on (true) then the motor waits for the time defined by T memory No.2. If the input status changes during the wait then the motor executes ?99 and the next line (move to P memory No.2).	

X	Looping	0 ~ 255

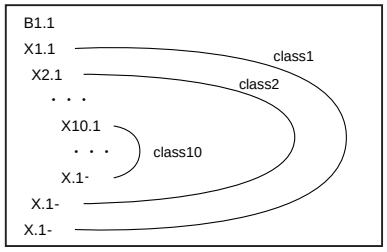
The program lines located between X and X- will be looped specified times.

The number of loops is defined between 0 and 255. When it is set to 0, it loops indefinitely.

The repeatable layer (nesting) is up to 10.

If the layer is over 10, the motion is not guranteed.

* Please specify same Motor ID for X command and B command.



X3.1 S2.1, A2.1, P2.1 X.1-	The lines between X and X- will be looped three times.

V	Conditional Branching, calculation and data display using variable data	1 ~ 15

1) Conditional branching can be executed using variable data.
Arithmetic or Logical operators can realize conditional branching with 2 variable data.

2) Arithmetic operator performs data calculations.

3) When this command is used alone, it displays the specified variable data.
This is used for a message sent to a host.

* Please specify same Motor ID for V command and B command.

B1.3
•
•
•
V1.3 > V2.3, ~ , ~

V2.1, ?99.1, ?98.1	If V2.1>0, then execute ?99.1. If not, execute ?98.1.
V2.1== V3.1, ?99.1, ?98.1	If V2.1 equals V3.1, then execute?99.1. if not, execute?98.1
P2.1= P3.1+ V2.1	Save the total value of P3 and V2 to Motor 1's position memory No.2.
V2.1	Display motor 1's general data value 2

N	Center Point of Circle	1 ~ 200

Only interpolation type can be used.

When this command is described before @ command, it defines the specified N memory values as the center of a circle.

N2.1, N2.2	Set the center values stored in motor 1 and 2's center memory No.2 as the center position of a circle.

R	Radius of Circle	1 ~ 200

Only interpolation type can be used.

When this command is described before @ command, it defines the specified R memory valuea as the radius of a circle.

The modifier after Motor ID, + or -, defines the arc size.

When R is set to a positive number, a major arc will be drawn and when it is set to a negative number, a minor arc will be drawn. If the values are set to 0, linear interpolation will be executed.

R2.1, R2.2	Set the values stored in Motor 1 and 2's Radius memory No.2 as the radius for a circle.

END	End of Program Bank
This command defines the end of each Program Bank.	
B1.1 S2.1, A2.1, P2.1 END	 End of Program Bank No.1

, (comma)	Command Concatenation / Merge Motion / Simultaneous Motion Execution
When multiple commands are listed in a single line, each command need to be separated by a comma. This allows for merge motion, instantaneous motion and dimultaneous motion by multiple axes.	
S2.1, A2.1, P2.1	Combining commands: move to P2 with Acceleration A2 and Speed S2.
A2.1, S2.1, P2.1, S3.1, P3.1 P2.1, P3.2	Merge motion: Move to P3 without stopping at P2. Speed changes to S3 when passing P2. Synchronous motion: Motor 1 moves to P2 and Motor 2 moves to P3 at the same time.

; (semi colon)	Command Concatenation in Multiple Lines
This allows for multiple commands to combine over multiple lines. This can be used for combining commands, Merge motion and Synchronous motion.	
S2.1, A2.1, P2.1; S3.1, P3.1	Merge motion: Motor 1 moves to P3 without stopping P2. Speed changes to S3 when passing P2. (same as in a single line with commas.)

: (colon)	Command Concatenation in Branching
This command can realize to execute multiple commands in conditional branching.	
V1.1> V2.1, ?99.1: O1.1, ?96.1: F1.1	If V1.1>V2.1, then execute ?99.1 and O1.1. If V1.1≦V2.1, then execute ?96.1 and F1.1.

//	Comment
This command allows you to write comments in Program Bank files. The description between this command and CRLF is not recognized as commands. Comments are not stored into Cool Muscle memory. Comments must be entered by English one byte character.	
// Comments here	Comments

Execute Commands	Execute commands within Program Bank
Various commands for Direct Mode are available in Program Bank. Please refer to 2.1.2.]1, [L,]L, >, <, }, $ commands can not be used.	

2.2.3. Ladder Logic Bank Commands

Ladder Logic Bank is independent from Program Bank and can be executed in the background. Therefore Cool Muscle can execute PLC functions in standalone mode, because they can execute the operations with defined data like Positions, Speeds and Accelerations. Ladder logic Bank execution cycle time is set by K63.
Ladder Logic Bank definition must start with the L1 command and finish with the End command. Ladder Logic Bank also finishes with two CRLFs without any command. Multiple commands in a single line must be separated by a comma. The maximum number of commands per motor is 500 commands in total.

Basic format for CML Ladder Logic Bank is as below.
(#: Memory No. , n: Motor ID. ↵ : Enter Key Input)

```
L#.n
P#.n = V#.n + V#.n
I#.n && I#.n, V#.n = V#.n, T0
END
```

Transfer the predefined text files to the motor or input data directly via COOL WORKS LITE or Hyper Terminal.

[L#.n ↵ …A specified Ladder Logic Bank performs operator processing based on predefined data.

[Operation Example]

Let's make a Ladder Logic Bank, download to Cool Muscle and execute it.

First of all, define the data as below.

S1.1=50

S2.1=10

V1.1=”Px”

V2.1=5000

Then define a Ladder Logic Bank

L1.1	Start definition of Ladder Logic Bank
V1.1> V2.1, S.1= S1.1, S.1= S2.1	
END	End of definition of Ladder Logic Bank

This example shows Cool Muscle 2 moves with S1 (50) when V1 (current position) is bigger than V2 (5000) but with S2 (10) when V1 is smaller than V2.

After the definition, enter the command as below and execute the Ladder Logic Bank 1.

[L1.1

Lets make a motion in Direct Mode as follows.

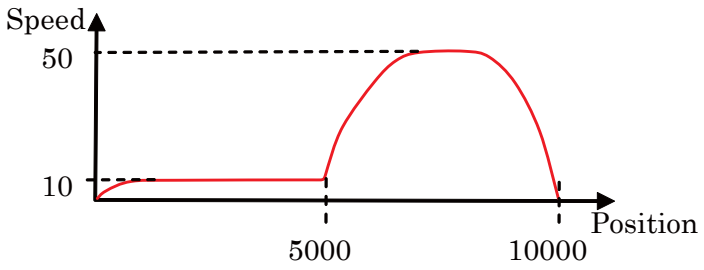
A.1=100

P.1=10000

^.1

This example shows Cool Muscle 2 moves with Speed 10 when the current position is smaller than 5000 and with Speed 50 when the current position is bigger than 5000 by executing Ladder Logic Bank in the background.

To stop or pause Ladder Logic Bank,]L command is needed

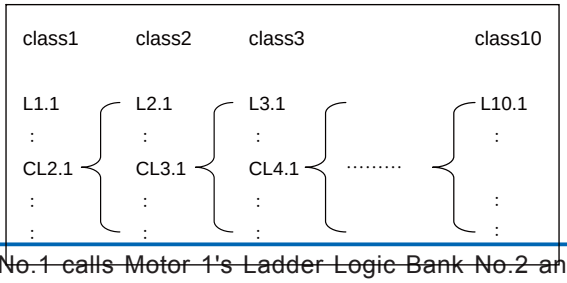


Ladder logic bank commands are explained in the format below.

Bank command	Function	Available memory space
Description		
Example	Explanation of Example	

L	Beginning of Ladder Logic Bank	1 ~ 30
This command defines the beginning of a Ladder Logic Bank. Format: L#.n (#=Program Bank No., n=Motor ID)		
L2.1	Begin the definition of Motor 1's Ladder Logic Bank 2.	

CL	Call other Ladder Logic Bank	1 ~ 30
This command calls and executes the specific Ladder Logic Bank, and back to the original Ladder Logic Bank line after completing the called Ladder Logic Bank. CL command can not be used to call the other ID's Ladder Logic Bank. The maximum layer (nesting) should be under 10.		
L1.1 CL2.1	Motor 1's Ladder Logic Bank No.1 calls Motor 1's Ladder Logic Bank No.2 and executes it.	



JL	Jump to other Ladder Logic Bank	1 ~ 30
This command jumps to and executes specific Ladder Logic Bank. But different from CL command, it will not go back to the original Ladder Logic Bank. JL command can be used to jump out of a looped Ladder Logic Bank. JL command can not be used to jump to the other ID's Ladder Logic Bank.		
L1.1 JL2.1	Motor 1's Ladder Logic Bank No.1 calls Motor 1's Ladder Logic Bank No.2 and executes it.	

I	Conditional Branching on Input Status	1 ~ 6
This command makes conditional branching based on the specified input status. Conditional branching is possible based on the status of all Motors' ID on daisy chain network. Use a logic operator when an action is based on the status of 2 inputs.		
I2.1, CL3.1, CL4.1	If Motor1's input 2 is on(true), then execute Ladder Logic Bank No.3. if off(false), then call execute Ladder Logic Bank No.4	
I1.2 && I2.3, CL3.1, CL4.1	If Motor 1's input 1 and 2 are on(true), then execute Ladder Logic Bank No.3. if not then, execute Ladder Logic Bank No.4.	

T	Timer	0 ~ 8
This command sets the timer in timer memory locations. T0 means no action. * Please specify same Motor ID for T command and L command.		
T2.1	Motor 1 waits for the time defined by Timer memory No.2.	

W	Timer in Conditional Branching	0 ~ 8
Use this command instead of T to wait for the time defined by T command while the specified input status is true. If the input status changes while the motor is waiting, then it resumes motion. If it is set to 0 then the motor waits indefinitely. * Please specify same Motor ID for W command and L command.		
I2.1, W2.1, ?99.1 O1.1	If motor1's input 2 is on (true) then the motor waits for the time defined by T memory No.2. If the input status changes during the wait then the motor executes ?99 and the next line (move to P memory No.2).	

#	Capture Position Data
This command sets the current position data to a specified memory. This function is the same as the position teaching.	
#2.1	Take the position memory No.2 from Motor 1's current position.

V	Conditional Branching, calculation and data display using variable data	1 ~ 15
1) Conditional branching can be executed using variable data. Arithmetic or logical operators can realize conditional branching with 2 variable data. 2) Arithmetic operator performs data calculations. 3) When this command is used alone, it means the specified variable data. This is used for a message sent to a host. * Please specify same Motor ID for V command and L command. B1.3 • • • V1.3 > V2.3, ~ , ~		
V2.1, ?99.1, ?98.1 V2.1== V3.1, ?99.1, ?98.1 P2.1= P3.1 + V2.1 V2.1	If V2.1>0, then execute ?99.1. If not, execute ?98.1. If V2.1 equals V3.1, then execute?99.1. if not, execute?98.1 Define the value of P3 + V2 as Motor 1's P memory 2. Motor 1 shows the data defined in General Data memory 2.	

END	End of Ladder Logic Bank
This command defines the end of each Ladder Logic Bank.	
L1.1 V2.1= V2.1 + V3.1 END	End of Ladder Logic Bank No.1.

, (comma)	Command Concatenation
When multiple commands are listed in a single line, each command need to be separated with a comma.	
V2.1>V3.1, V2.1=V3.1, T0.1	Combines commands

; (semi colon)	Command Concatenation in Multiple Lines
This allows for multiple commands to combine over multiple lines. This can be used for combining commands, Merge motion.	
V2.1>V3.1; V2.1=V3.1, T0.1	Combines commands over several lines.

: (colon)	Command Concatenation in Branching
This command can realize to execute multiple commands in conditional branching.	
V1.1> V2.1, ?99.1: O1.1, ?96.1: F1.1	If V1.1>V2.1, then execute ?99.1 and O1.1. If V1.1≦V2.1, then execute ?96.1 and F1.1.

//	Comment
This command allows you to write comments in Ladder Logic Program files. The description between this command and CRLF is not recognized as commands. Comments are not stored into Cool Muscle memory. Comment must be entered by English one byte character.	
// Comments here	Comments

Execute Commands	Execute commands within program bank
Various commands for Direct Mode are available in Ladder Logic Bank. Please refer to 2.1.2.]1, [L,]L, >, <, }, $ commands can not be used.	

Chapter 3

Parameter Setting

The Cool Muscle has initial settings that can be adjusted based on your application. Please refer the section 6.1. Each parameter is identified by a unique number and has a specific function. To set a parameter, enter a desired value following the = sign as below.

K [Parameter No.] . [Motor ID] =value

Each parameter has individual setting range.
The value out of the range will not be reflected. The changed value is saved automatically.
Do not change parameters during motion due to that unexpected motion is possibly produced.

3.1. K parameters

The following chart outlines each K Parameter's usage

Parameter No.	Setting Item	Unit
Parameter Description		

[Setting Example]

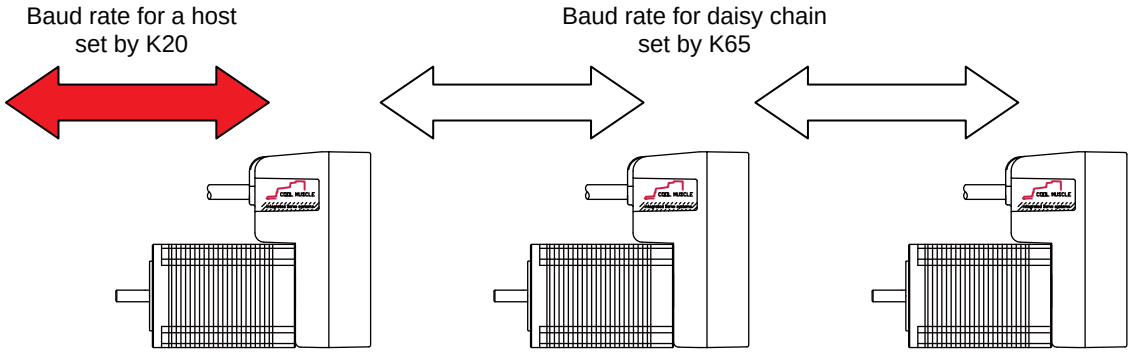
The example and explanation about parameters.

K20	Baud Rate	Unit : —

Set the baud rate for the communication between Cool Muscle and a host.
When changed, the host baud rate needs to be changed to match Cool Muscle's changed baud rate.

Value	Baud rate
0	38.4 kbps
1	9.6 kbps
2	19.2 kbps
3	57.6 kbps
4	115.2 kbps
5	230.4 kbps

Some PCs and host instruments can not be adapt the set baud rate.
Please enter a proper value that matches their specifications.



[Setting Example]

K20.1=1 Set 9.6kbps to the baud rate.

Cool Muscle's communication buffer could be overflowed by a delay of communication data processing when a lot of data are transferred to Cool Muscle and over-written, then unexpected motion is possibly produced.

K23	Status Report	Unit : —

Defines the status report method as an automatic report by each event when status changes. Local echo of sent data from a host, confirmation messages or error massages for mis-operation can be set by this parameter as well. It can be set by the addition of the function No. 1-16 (Max. value is 31)

Value	Status Report Method
0	No status report
1	Automatically report to a host when in-position and alarm occur.
2	Automatically report to a host when input status changes.
4	Automatically report to a host when output status changes. * only for general output.
8	No local echo
16	Various confirmation messages and error messages will be reported to a host. [Confirmation Messages]

Messages	Description
[End of Bank]	Program Bank input is finished properly.
Change Baud Rate ?? XXX kbps (Y/N)	Confirmation message when the baud rate is changed by K20

[Error message]

Messages	Description
error00.n: Out Of Range!!	K Parameter value is out of range
error01.n: syntax error!!	Program Bank syntax error
error02.n: too many steps!!	Program Bank steps exceed max. numbers.
error03.n: XX is not allowed in bank.1	XX command can not be defined.
error04.n: XX can not be followed by DD	XX command can not be defined before DD.
error05.n: Program Bank does not exist!!	Program Bank does not exist.
error06.n: Ladder Bank does not exist!!	Ladder Logic Bank does not exist.
error07.n: CW Limit!!	CW limit sensor is on
error08.n: CCW Limit!!	CCW limit sensor is on

[Setting Example]

K23.1=13

1: Automatically report to a host when in-position and alarm occur.

4: Automatically report to a host when output status changes.

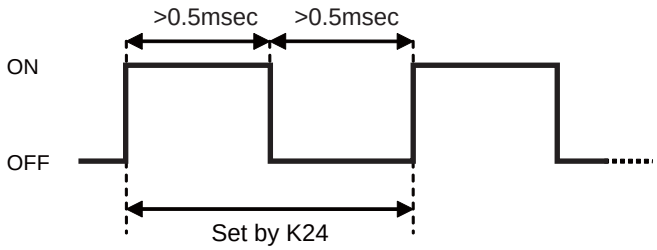
8: No local echo

When 3 functions are combined, the value shall be 1+4+8=13 by addition.

K24	Rotational Pulse Output	Unit : pulses

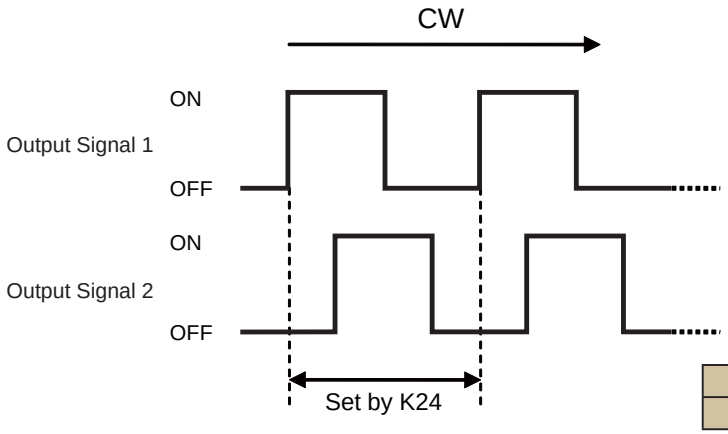
When Output Functions Parameter K34=7, the output is turned ON/OFF at regular interval of pulses set by this parameter.

The signal wave is as shown in the diagram below. The output is turned ON at the first half of the set pulses, then OFF at the last half.



Note: The ON/OFF output pulse width is required to be set more than 0.5 msec as shown in the diagram.

When K34=77, the outputs are guadrature encoder pulse signals, in which the phase between two signals is different by 90-degrees, as shown below.



Min	10
Max	50000

[Setting Example]

K24.1=1000 The output, set by K34=7, turns ON and OFF every 1000 pulses.

K25	Delay Time for Slow Response Signal	Unit : 0.1sec

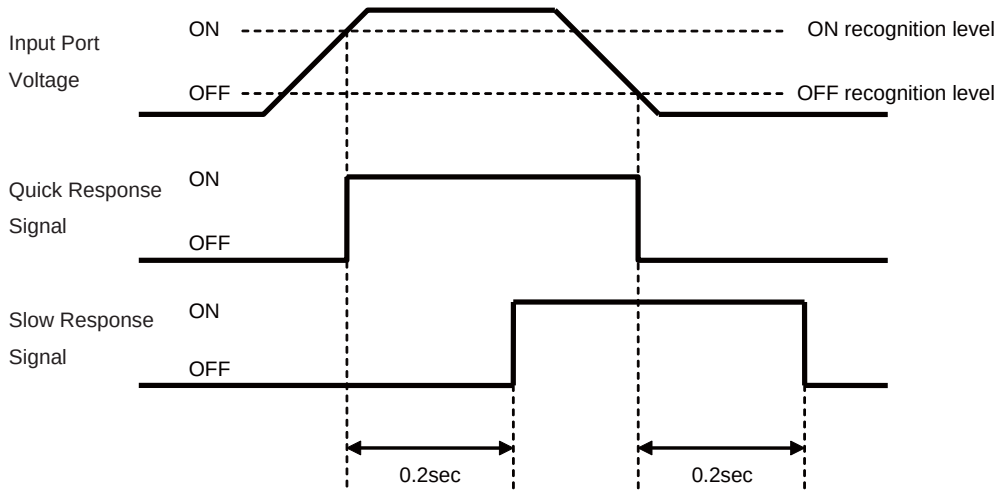
Based on the original signal, 2 signals of Quick and Slow Responses can be recognized. Slow Response is a virtual signal that is generated after a specified delay time. This increases the number of input points to which functions can be assigned. This parameter sets the offset time for Slow Response Signal to be recognized after Quick Response Signal.

Each digit must be set individually in order of Input 6,5,4,3,2,1.

▪ Quick / Slow Response Signals

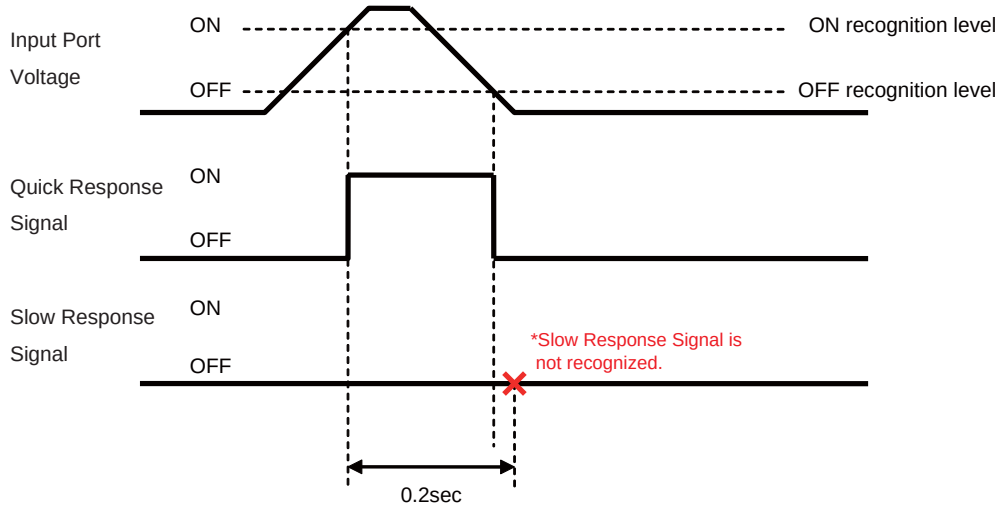
The diagrams below show Quick Response Signal is recognized as ON when the actual input voltage to the input port exceeds the ON recognition level, and as OFF when the voltage falls below the OFF recognition level. (In case of K26=0) The input logic is set by K26.

When delay time for Slow Response Signal is set to 0.2sec, Slow Response Signal is generated 0.2sec after the Quick Response Signal is recognized. Functions can be assigned to the rising edge, the target level and the falling edge of each signal.



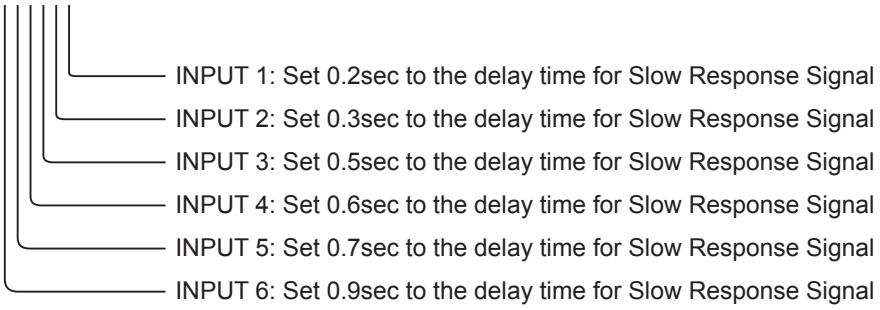
▪ Short signal width

When a signal disappears within the offset time, only a Quick Response Signal is recognized.



[Setting Example]

K25.1 = 976532



K26	Input Logic / P type Operation	Unit : —

This parameter sets

① Input Logic (the logic for input signals and the effective edge for command pulse inputs)

② Execution of P type Operation (applied to C/R type)

Set each function by the digit in order of Input 6,5,4,3,2,1

To each Input 1 ~ 6,

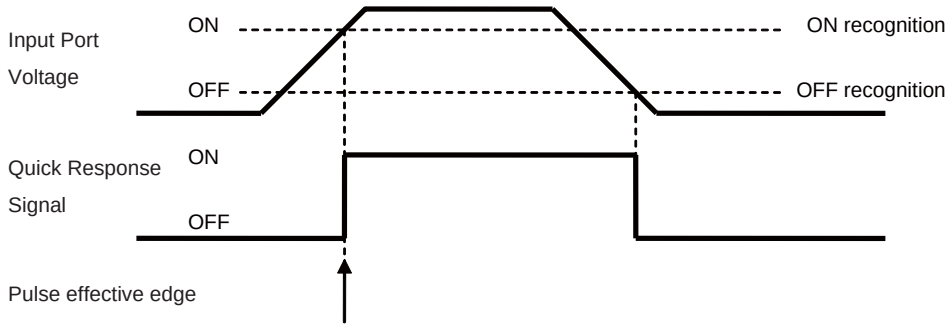
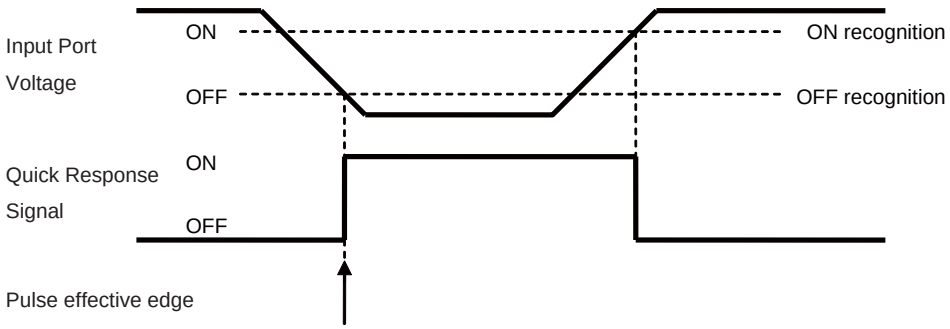
- Set "0" or "1" for only setting Input Logic
- Set "2" or "3" for setting the execution of P type Operation besides Input Logic.

The setting value of "2" or "3" should be used when the rotation control of motor, P type Operation, by the command pulse train to Input 1 and Input 2 is needed for C/R type Cool Muscle.

The execution of P type Operation is enabled by the input of which the setting value is "2" or "3" in Input 3, 4, 5 and 6.

① Setting for Input Logic

Value	Judgment of "Input Signal ON"		Effective edge of Command Pulse Input	
0 or 2	When the specified Input port is	ON	Rising Edge of	Input Port
1 or 3		OFF	Falling Edge of	

Value	Description
0 or 2	Input signal is ON when input port is ON Effective edge: Rising edge of input port 
1 or 3	Input signal is ON when input port is OFF. Effective edge: Falling edge of input port 

[Setting Example]

K26.1 = 000010

INPUT 1: Input signal is ON when Input port is ON.
INPUT 2: Input signal is ON when Input port is OFF.
INPUT 3: Input signal is ON when Input port is ON.
INPUT 4: Input signal is ON when Input port is ON.
INPUT 5: Input signal is ON when Input port is ON.
INPUT 6: Input signal is ON when Input port is ON.

② Setting for execution of P type Operation (Applies to C/R type)

The input to switch either P type Operation is available or unavailable is specified by this setting.
Set the value "2" or "3" to the input for switching use in Input 3 to Input 6.
The execution of P type Operation is available or unavailable by the state of specified input signal.
P type Operation is executed as long as the input signal is ON, and then the command pulse input to Input 1 and Input 2 is effective.

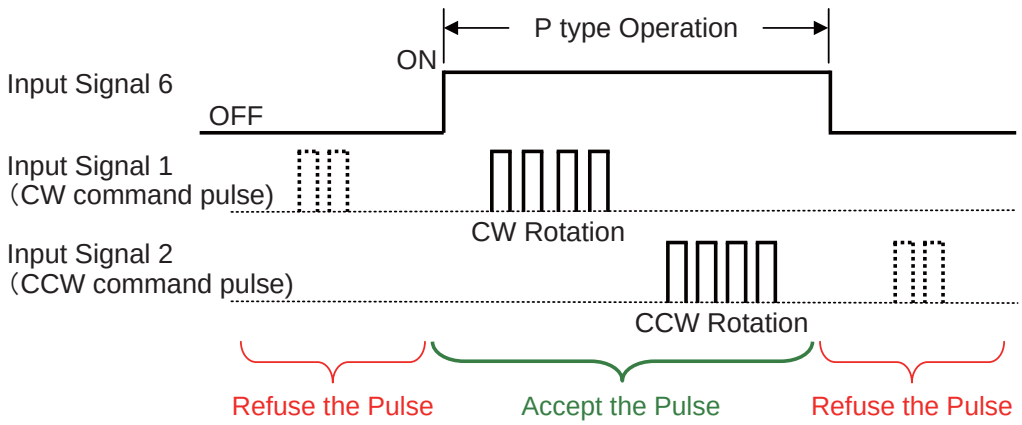
When Input Signal is	Execution of P type Operation
ON	P type Operation is valid and accept the Command Input Pulse
OFF	P type Operation is Invalid and refuse the Command Input Pulse

- When multiple inputs are set to "2" or "3", P type Operation is executed as long as the signal of any input of them is ON.
- When Cool Muscle receives commands from the host during P type Operation, the processing of the command is given priority and executed. (C type Operation priority)

When any Program Bank is not executed, the execution of P type Operation is permitted.
During the execution of Bank Program, it can not be switched to P type Operation even if the specified input signal is ON.

[Setting Example]

K26.1 = 2XXX00



* When the setting value of Input 1 or Input 2 is "2" or "3".
  P type Operation is executed at all times and the motor rotation is controlled by only the command pulse input to Input 1 and Input 2.

[Setting Example]

K26.1 = XXXX22
K26.1 = XXXXX2
K26.1 = XXXX2X

P type Operation Only (C/R type Operation is not available)

K27	Input Functions at the Quick Response Target Voltage (QTV)	Unit : —
K30	Input Functions at the Slow Response Target Voltage (STV)	Unit : —

These parameters assign functions performed at the target voltage level of quick and slow response signals.

Please note that input functions should not be interfered with each other, when assinging. (Ref: the diagram in K25 description)

Set each function by the digit order of Input 6,5,4,3,2,1.

#	Functions	Description
0	No Function	—
1	General Use	Used by Command I in program execution.
2	Origin Sensor Signal (K27) — (K30)	The signal from Origin Sensor. (K27) — (K30)
3	Manual feed CW	Motor rotates in CW direction while the input signal is ON, with the speed and acceleration set by K49 and K43.
4	Manual Feed CCW	Motor rotates in CCW direction while the input signal is ON, with the speed and acceleration set by K49 and K43.
5	Stop Ladder Logic Bank	Stop Ladder Logic Bank
6	CW Direction Limit Sensor (CW Origin Sensor combined use)	Usually used for a CW direction limit sensor. When an origin sensor signal is not assigned to other inputs, this input works as an origin sensor signal for the origin search motion to CW direction.
7	Emergency Stop	Emergency Stop by an input signal on (stop by Max. deceleration) Emergency Stop is canceled by an input signal off. Emengency Stop can not be canceled by CML command when excuted by a signal.
8	Stop Program Bank	Stops motion and Program Bank execution. Same as]] command.
9	CCW Direction Limit Sensor (CCW Origin Sensor combined use)	Usually used for a CCW direction limit sensor. When an origin sensor signal is not assigned to other inputs, this input works as an origin sensor signal for the origin search motion to CCW direction.

[Setting Example]

K27.1=871243

- INPUT 1: Manual Feed CW
- INPUT 2: Manual Feed CCW
- INPUT 3: Origin Sensor
- INPUT 4: General Use
- INPUT 5: Emergency Stop
- INPUT 6: Stop Program Bank

K28	Input Functions at the Quick Response Rising Edge (QR)	Unit : —
K31	Input Functions at the Slow Response Rising Edge (SR)	Unit : —

These parameters assign functions performed at the Quick and Slow rising edges of signals.

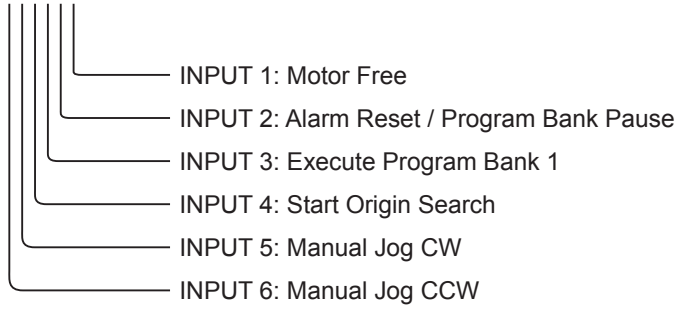
Please note that input functions should not be interfered with each other, when assinging. For example, assign “Motor Free” to a rising edge of Quick Response Signal and “Start Origin Search” to a falling edge of Slow Response Signal, Cool Muscle goes into motor free state before starting the origin search. (Ref: the diagram in K25 description)

Set each function by the digit in order of Input 6,5,4,3,2,1.

Value	Function	Description
0	No Function	—
1	Alarm Reset / Program Bank Pause	This resets alarms, and pauses motion. Pause Program Bank being executed. Re-start from paused position is possible by 6: Execute Program Bank 1.
2	Motor Free	Make a motor go into motor free state and servo OFF.
3	Position Counter Reset	Make the current position to 0 (the Origin)
4	Execute Next Program Bank Line	Execute the next line in a Program Bank B1 S1,A1,P3 (Line 1) S2,A2,P2 (Line 2) Rising Edge: Execute line 1 Next Rising Edge : Execute Line 2
5	Execute Previous Program Bank Line	Execute a previous line in a Program Bank This function could not be performed depending on the content of Program Bank.
6	Execute Program Bank 1	Execute Program Bank 1.
7	Start Origin Search	Start Origin Search.
8	Manual Jog CW / Execute Program Bank 2	Motor rotates to the amount of feed pulses set in parameter K50, in CW direction. When K36=2 or 3, execute Program Bank 2.
9	Manual Jog CCW / Execute Program Bank 3	Motor rotates to the amount of feed pulses set in parameter K50, in CCW direction. When K36=2 or 3, execute Program Bank 3.

[Setting Example]

K28.1 = 987612



K29	Input Functions at the Quick Response Falling Edge (QF)	Unit : —
K32	Input Functions at the Slow Response Falling Edge (SF)	Unit : —

These parameters assign functions performed at the Quick and Slow falling edges of a signals.

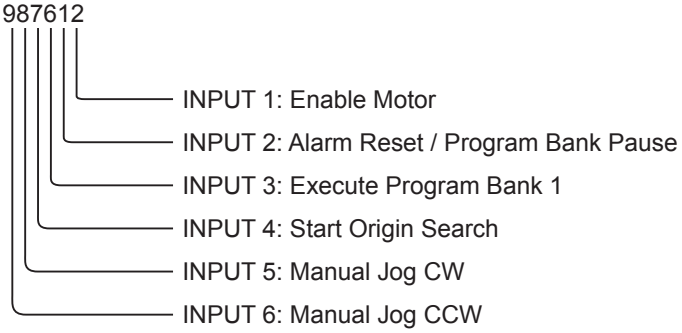
Please note that input functions should not be interfered with each other, when assinging. For example, assign “Motor Free” to a rising edge of Quick Response Signal and “Start Origin Search” to a falling edge of Slow Response Signal, Cool Muscle goes into motor free state before starting the origin search. (Ref: the diagram in K25 description)

Set each function by the digit in order of Input 6,5,4,3,2,1.

Value	Function	Description
0	No Function	—
1	Alarm Reset / Program Bank Pause	This resets alarms, and pauses motion. Pause Program Bank being executed. Re-start from paused position is possible by 6: Execute Program Bank 1.
2	Enable Motor	Cancel “Motor Free” and servo ON.
3	Position Counter Reset	Make the current position to 0 (the Origin).
4	Execute Next Program Bank Line	Execute the next line in a Program Bank. B1 S1,A1,P3 (Line 1) S2,A2,P2 (Line 2) Rising Edge: Execute line 1 Next Rising Edge : Execute Line 2
5	Execute Previous Program Bank Line	Execute the previous line in a Program Bank. This function could not be performed depending on the content of Program Bank.
6	Execute Program Bank 1	Execute Program Bank 1.
7	Start Origin Search	Start Origin Search.
8	Manual Jog CW / Execute Program Bank 2	Motor rotates to the amount of feed pulses set in parameter K50, in CW direction. When K36=2 or 3, execute Program Bank 2.
9	Manual Jog CCW / Execute Program Bank 3	Motor rotates to the amount of feed pulses set in parameter K50, in CCW direction. When K36=2 or 3, execute Program Bank 3.

[Setting Example]

K29.1 = 987612



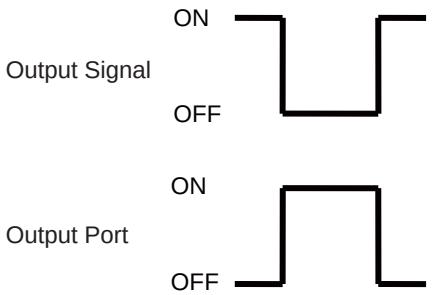
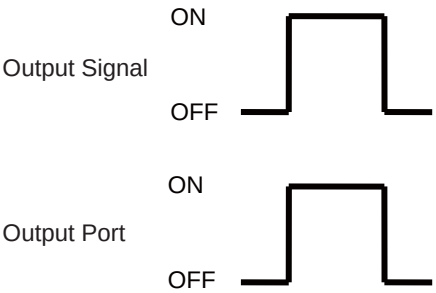
K33	Output Logic	Unit : —

This parameter sets the output logic.

0 (Low Active): Command F or when output signal by output function is OFF, turn ON the output port.

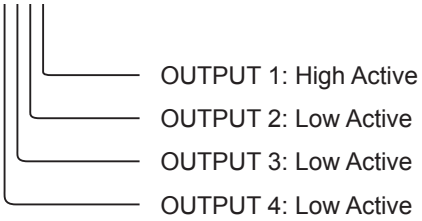
1 (High Active): Command O or when output signal by output function is ON, turn ON the output port.

Set each function by the digit in order of Output 4,3,2,1.

Value	Description
0	Low Active. Output port is ON when output signal is OFF. 
1	High Active. Output port is ON when output signal is ON. 

[Setting Example]

K33.1 = 0001



K34	Output Functions	Unit : —

This parameter assigns a function to an output.

Set each function by the degit in order of Output 4, 3, 2, 1.

Value	Functions	Description
0	No Function	—
1	In-Position	In-Position signal.
2	Alarm	Alarm signal.
3	General Use	Output by Command O / Command F.
4	Completion of Origin Search	Output In-Position signal only when the origin search is completed.
5	—	—
6	In-position Signal in Merge Motion	Output In-Position signal at the passing points in merge motion. Set a signal width by parameter K73.
7	Rotation Pulse Output	Output a signal at certain intervals. Set its interval by parameter K24. When Output 1 and Output 2 are set to 7 , they are the quadrature encoder outputs.
8	In Motor Free	Output a signal during motor free state.
9	In Push Motion	Output a signal during push motion.

[Setting Example]

K34.1=2177

- OUTPUT 1: Quadrature Encoder Output
- OUTPUT 2: Quadrature Encoder Output
- OUTPUT 3: In-position
- OUTPUT 4: Alarm

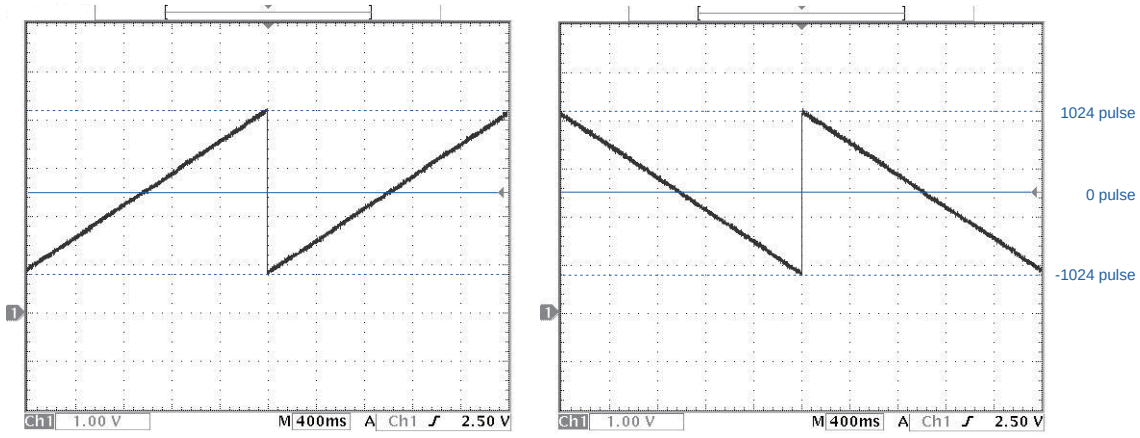
K35	Analog Output Functions	Unit : —

This parameter sets a function to Analog Output.

Value	Analog Output Types	Unit
0	Target Position	± 1024 pulses/ ± 1.67V
1	Target Position data magnified by 8	± 128 pulses/± 1.67V
2	Current Position	± 1024 pulses/± 1.67V
3	Current Position data magnified by 8	± 128 pulses/± 1.67V
4	Position Error	± 1024 pulses/ ± 1.67V
5	Position Error data magnified by 8	± 128 pulses/ ± 1.67V
6	Current Speed	± 2400min^{-1}/ ± 1.67V
7	Current Speed data magnified by 8	± 300min^{-1}/ ± 1.67V
8	Current Torque	±100%/ ± 1.67V
9	Current Torque data magnified by 8	±12.5% / ± 1.67V

The analog output that you select can be monitored by an oscilloscope. The output wave is plus minus 1.67V based on the center value of DC+2.5V. When the wave goes over the range 2.5V, it will be replicated.

[Position Data output example]



[Setting Example]

K35.1=3 Set “Current Position data magnified by 8” to Analog Output

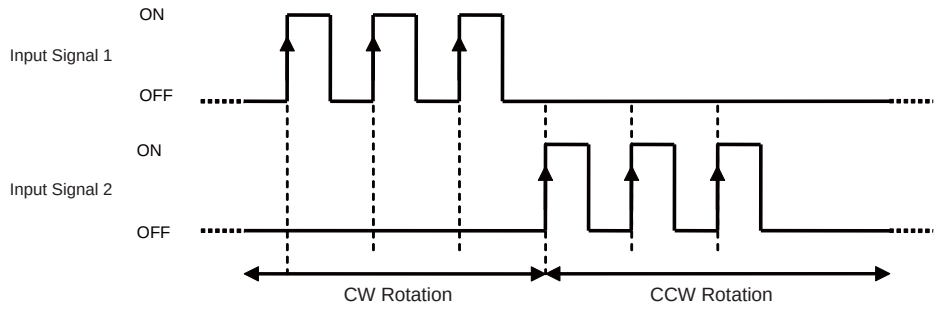
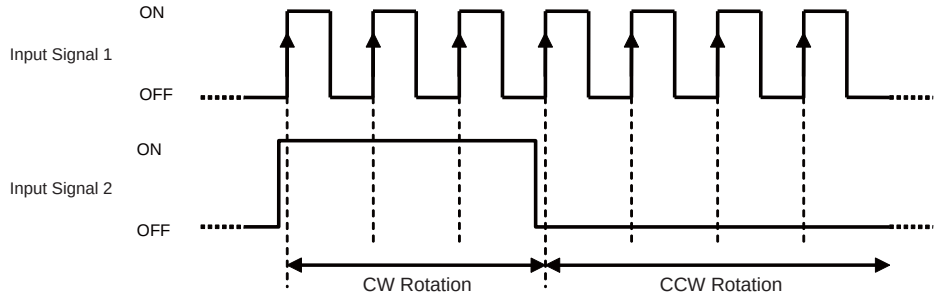
K36	Command Pulse Format	Unit : —

This parameter sets the format of command pulse Input.

Either CW/CCW or Pulse/Direction can be chosen according to the command pulse train to Input 1 and Input 2.

When K36 is set to 2 or 3 for the other type of Cool Muscle than P type, the function of "Execute Program Bank 2" and "Execute Program Bank 3" can be assigned to the rising edge and/or the falling edge of input signals. (Refer to K28, K29, K31, K32)

Value	Input form of Input signal	Execute Program Bank 2 and 3
0	CW/CCW	—
1	Pulse/Direction	—
2	CW/CCW	Can be assigned by K28, K29, K31, K32
3	Pulse/Direction	Can be assigned by K28, K29, K31, K32

Value	Description
0 or 2	CW / CCW Pulse Set Input Signal 1 to CW pulse, Input Signal 2 to CCW pulse.  When detecting the rising edge of Input Signal 1, count up in CW direction When detecting the rising edge of Input Signal 2, count up in CCW direction
1 or 3	Pulse / Direction Set Input Signal 1 to command pulse, Input Signal 2 to direction pulse.  When detecting the rising edge of Input Signal 1, count up in CW direction in case Input Signal 2 is ON When detecting the rising edge of Input Signal 2, count up in CCW direction in case Input Signal 2 is OFF
2 or 3	Execute Program Bank 2 and Program Bank 3 (Can be assigned by K28, K29, K31, K32) *Except for P type

[Setting Example]

K36.1=0 Set "CW/CCW Pulse" for Command Pulse Format

K36.1=3 Set "Pulse/Direction" for Command Pulse Format

"Execute Program Bank 2 and Program Bank 3" is available by Input Functions

K37	Resolution / Speed Unit	Unit : —

This parameter sets the motor's resolution and the speed unit that is used by S command.

Each value of 0-10 or 40-50 sets 100pps as the speed unit, each value of 20-30 or 60-70 sets 10pps as the speed unit and each value of 80-90 sets 1pps as the speed unit. The maximum position data is limited depending on the Motor Resolution.

Speed unit 100pps			Speed unit 10pps			Speed unit 1pps		
#	Resolution	Max Position (±)	#	Resolution	Max Position (±)	#	Resolution	Max Position (±)
0	200	8,589,934	20	200	8,589,934	80	200	8,589,934
1	400	17,179,869	21	400	17,179,869	81	400	17,179,869
2	500	21,474,836	22	500	21,474,836	82	500	21,474,836
3	1000	42,949,672	23	1000	42,949,672	83	1000	42,949,672
4	2000	85,899,345	24	2000	85,899,345	84	2000	85,899,345
5	2500	107,374,182	25	2500	107,374,182	85	2500	107,374,182
6	5000	214,748,364	26	5000	214,748,364	86	5000	214,748,364
7	10000	429,496,729	27	10000	429,496,729	87	10000	429,496,729
8	25000	999,999,999	28	25000	999,999,999	88	25000	999,999,999
9	N/A	N/A	29	N/A	N/A	89	N/A	N/A
10	50000	999,999,999	30	50000	999,999,999	90	50000	999,999,999
40	300	12,884,901	60	300	12,884,901			
41	400	17,179,869	61	400	17,179,869			
42	600	25,769,803	62	600	25,769,803			
43	800	34,359,738	63	800	34,359,738			
44	1200	51,539,607	64	1200	51,539,607			
45	1500	64,424,509	65	1500	64,424,509			
46	3000	128,849,018	66	3000	128,849,018			
47	4000	171,798,691	67	4000	171,798,691			
48	6000	257,698,037	68	6000	257,698,037			
49	8000	343,597,383	69	8000	343,597,383			
50	12000	515,396,075	70	12000	515,396,075			

When it is set to 40-70, the incremental motion cannot be executed.

Continuous motion (P=1000000000) is still available in any resolution.

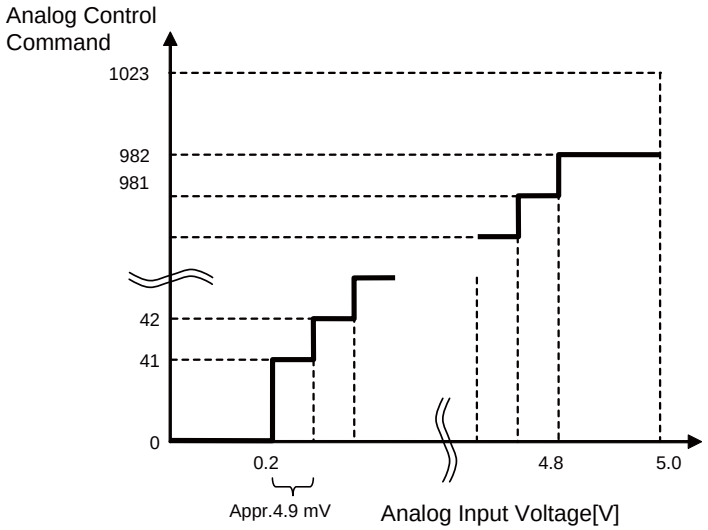
[Setting Example]

K37.1=3 Set 1000ppr to the Motor Resolution, 100pps as the Speed Unit

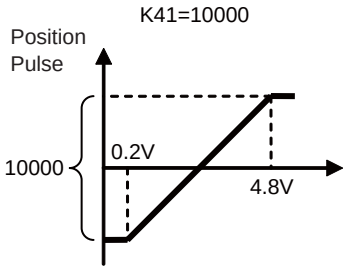
K38	Analog Control Type	Unit : —

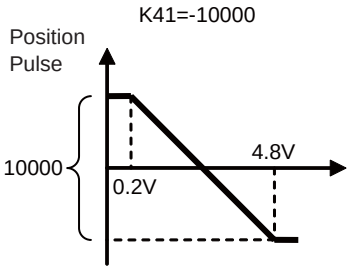
This parameter sets the control type for Analog Input.

Cool Muscle is equipped with 10 bit A/D converter. The analog input voltage 0 to 5V is divided into 1024, and utilized as an analog control command from 0 to 1023. Therefore the control command changes per approximately 4.9mV. However, from 0 to 0.2V and from 4.8 to 5V are the dead zone so that actual control range is from 0.2V to 4.8V.

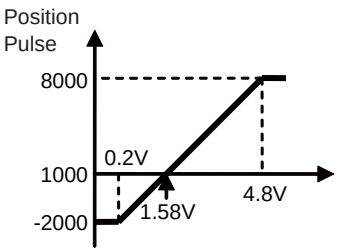


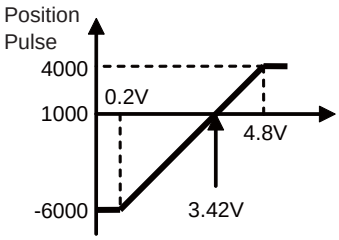
#	Functions	Description
0	Not Function	Analog control is not applied.
1	Position control	Control the position in the range of K41 by changing the analog input voltage when motor is not rotating.

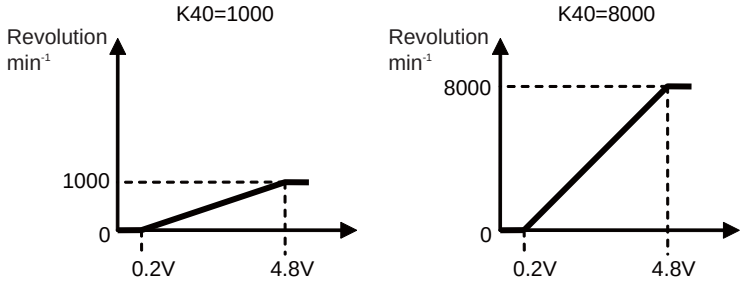
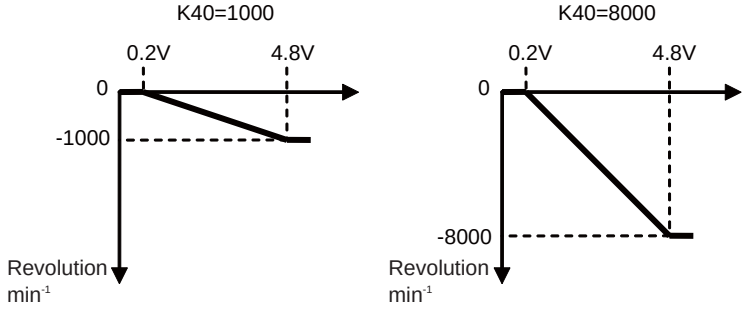
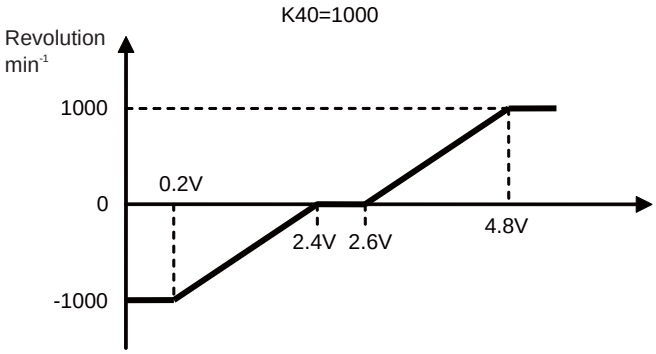
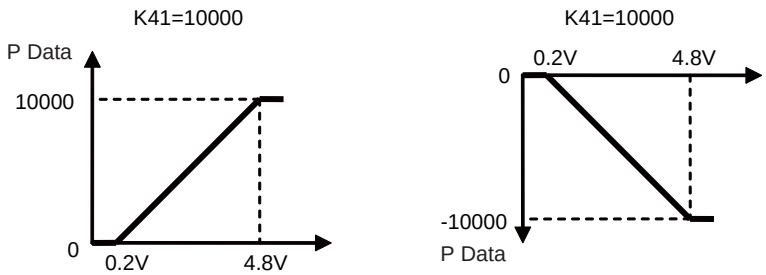


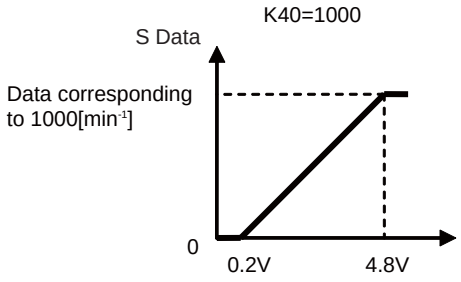
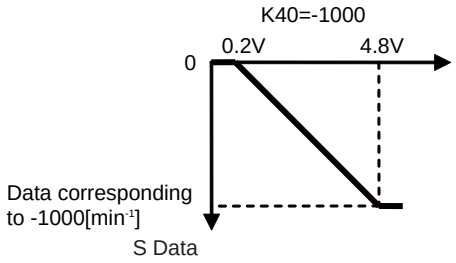
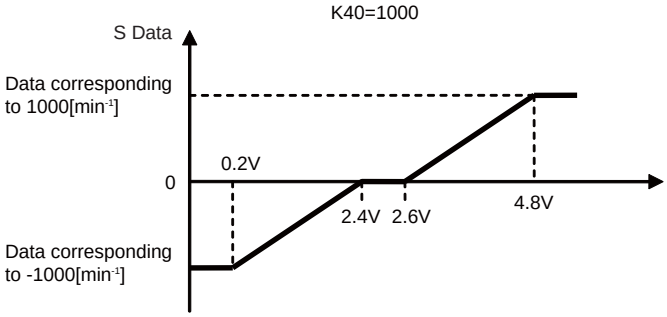
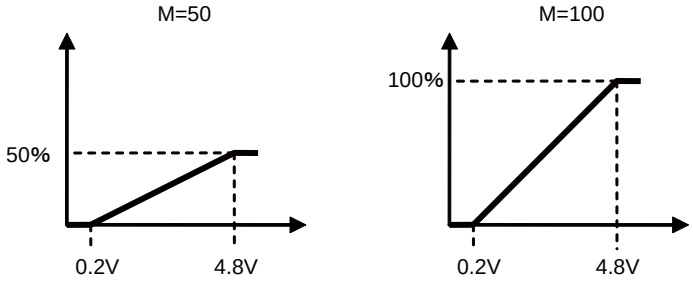


* The plus/minus control range in the set range is different depending on the current position and the applied voltage when the analog control is activated.





2	Speed control for CW	Control the speed in CW direction in the range of K40 by changing the analog input voltage. * Will not be functional unless set to 0 [min^{-1}] (analog voltage less than 0.2V) only for the first time in control. 
3	Speed control for CCW	Control the speed in CCW direction in the range of K40 by changing the analog input voltage. * Will not be functional unless set to 0 [min^{-1}] (analog voltage less than 0.2V) only for the first time in control. 
4	Speed control for CW / CCW	Control the speed in CW/CCW direction in the range of K40 by changing the analog input voltage. 2.5V for 0 [min^{-1}], rotate in CW direction by Input Voltage>2.5V, rotate in CCW direction by Input Voltage < 2.5V. From 2.4V to 2.6V is dead zone. * Will not be functional unless set to 0 [min^{-1}] (analog voltage from 2.4V to 2.6V) only for the first time in control. 
5	P data for Direct Mode	Change the Position Data P for Direct Mode in the range of K41 by changing the analog input voltage. 

6	S data (+) for Direct Mode	Change the Speed Data S for Direct mode in plus(+) direction in the range of K40 by changing the analog input voltage. 
7	S data (-) for Direct Mode	Change the Speed Data S for Direct mode in minus(-) direction in the range of K40 by changing the analog input voltage. 
8	S data (+/-) for Direct Mode	Change the Speed Data S for Direct Mode in the range of K40 by changing the analog input voltage. Change S data in plus(+) direction when Input Voltage>2.5V. In minus(-) direction when Input Voltage<2.5V. (Between 2.4V and 2.6V is the dead zone). 
9	Torque control	Control the torque within the range of set value by M command. 
10	Torque feedback control	Feedback control by inputting the output analog voltage from an external torque sensor to keep stable torque on the control target that the sensor is equipped with. Ref, Section 5.4 Torque Feedback Control. Ref, Parameters K74, K75, K76, K77 for the Gain (proportional and integral gain), Torque Sensor Input Offset Value and Torque Sensor Input Range.

[Setting Example]

When using the speed control for CW/CCW direction

K38.1=4 Set "Speed Control for CW/CCW" as the analog control type

K40.1=2000 Set 2,000min-1 to Max. Speed

Increase the speed in CW direction by applying analog input voltage from 2.6V to 4.8V and increase the speed in CCW direction when applying analog input voltage from 2.4V to 0.2V.

Reach the Max. Speed 2000min^{-1} in each direction when 0.2V or 4.8V is applied.

When using the position control

K38.1=1 Set "Position Control" as the analog control type

K41.1=10000 Set 10000 pulse to the travel range

Move 0 to 10000 pulses when changing analog input voltage from 0.2V to 4.8V.

K39	Low Pass Filter Cut-off Frequency	Unit : ×5rad/s

Cut-off frequency of low pass filter for the analog input
There is no filter when the value of 1024 is set.
(unit: 5[rad/sec] = 5000[times/sec]/1024)

Min	0
Max	1024

[Setting Example]

K39.1=128 Set 640[rad/sec] to the analog input cut-off frequency

K40	Maximum Speed	Unit : min^{-1}

This parameter sets motor's maximum speed.

For the speed control by the analog input, this parameter sets the maximum speed when the maximum analog voltage is applied.

The conversion from the speed unit [min^{-1}] to S value is as show in below.

S value = speed[min^{-1}] x resolution[ppr] / speed unit[100pps or 10pps] / 60

Ex) K40=2000, K37=3 (Resolution 1000ppr, Speed Unit 100pps)

Max S value = 2000 x 1000 / 100 / 60 = 333

Min	1
Max	Depends on motor type

[Setting Example]

K40=2000

Set 2000[min^{-1}] to the motor's maximum speed.

When using the speed control by the analog input through setting parameter K38, the motor's maximum speed reaches to 2000[min^{-1}] when the maximum analog voltage is applied.

K41	Analog Travel Range	Unit : pulses

This parameter sets the maximum travel range in the position control by the analog input, where the input voltage varies from 0.2V to 4.8V.
(Ref: K38)

Min	-999999999
Max	999999999

[Setting Example]

K38=1

K41=4000

If the current position is 0, the position of motor will be controlled in the range from 0 to 4000 according to an analog input voltage level (0.2V-4.8V)

K42	Origin Search Speed	Unit : 100pps 10pps 1pps (Depends on K37)

This parameter sets the speed for Origin Search.

Min	1
Max	32767

[Setting Example]

K37=3

K42.1=50 Set 5000pps to Origin Search Speed

K43	Acceleration for Origin Search / Manual Feed	Unit : $kpps^2$

This parameter sets the acceleration for Origin Search.
This is also used for the acceleration for Manual Feed.

Min	1
Max	32767

[Setting Example]

K43.1=100 Set 100 $kpps^2$ to Origin Search Acceleration

K44	Deceleration Ratio	Unit : %

This parameter sets the deceleration ratio relatibe to the acceleration in percentage. Acceleration and deceleration are the same when 100% is set.
This parameter is applied to all motion. When individual deceleration is needed, use CML command.

Min	1
Max	500

[Setting Example]

K44.1=100 Set 100% to the Deceleration Ratio. (Deceleration is the same as acceleration)

K45	Origin Search Direction / Reverse Coordinates / Measure of Offset and Software limit	Unit : —

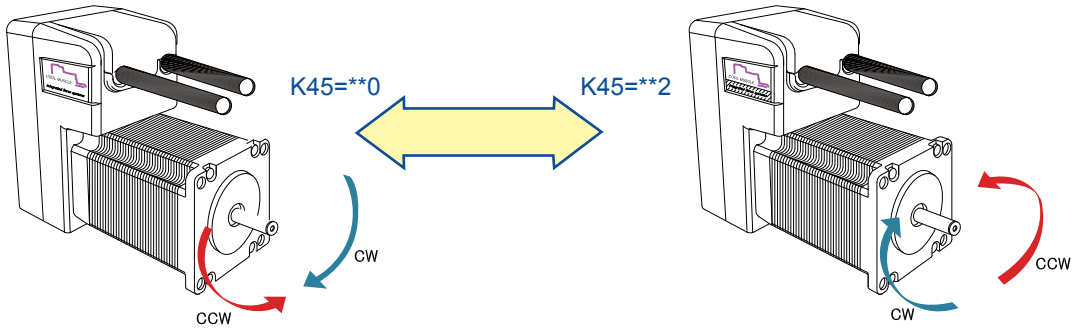
Set by using three digits and setting divides by each digit.

K45.1=□□□

Digit	Functions	Value	Description
First Digit	Setting of Origin search Direction and Reverse Coordinates	0 1 2 3	CW direction CCW direction CW direction Reverse Coordinates CCW direction Reverse Coordinates
Second Digit	Unit of offset by K48	0 1 2	100 pulse unit 10 pulse unit 1 pulse unit
Third Digit	Unit of software limit by K58, K59	0 1 2	100 pulse unit 10 pulse unit 1 pulse unit

▪ First Digit‥Setting of Origin search Direction and Reverse Coordinates

This parameter sets the direction for the Origin Search and Reverse Coordinates. The CW direction usually corresponds to the positive in the coordinate system, but the Reverse Coordinates setting make the CCW direction correspond to the positive. This feature applies for the symmetric machinery without changing signs of all position date but just setting this parameter.



Caution for the Origin Search with an origin sensor

In case the origin search is executed when the origin sensor is ON, the motion to get out of the sensor signal region, to the opposite direction set by K45, is performed for a precise origin search.

(Ref: Section 5.3 Origin Search for the detailed information)

▪ Second Digit ⋯ Unit of offset by K48

To set the offset sensitively, set with second digit.

▪ Third Digit ⋯ Unit of software limit by K58,K59

To set the software limit sensitively, set with third digit.

[Setting Example]

K45.1=102

- Set origin search direction to CW direction and Reverse Coordinates.
- The unit of the offset set with K48 is set to 100 pulses.
- The unit of software limit with K58 and K59 are set to 10 pulses.

K46	Origin Signal Source	Unit : —

This parameter specifies the method for the origin search.

In case of stopper-detecting origin search, the origin search operation is completed when a pushing torque to a stopper reaches the set torque level.

In case of using an origin sensor, the origin search operation is completed when detecting the rising edge of signal from an external origin sensor.

#	Origin Signal Sources
0	Stopper Detection
1	Stopper Detection (automatically starts an origin search when powered on)
2	Origin Sensor
3	Origin Sensor (automatically starts an origin search when powered on)
4	Z Phase Signal
5	Z Phase Signal (automatically starts an origin search when powered on)
6	Origin Sensor & Z-Phase Signal
7	Origin Sensor & Z-Phase Signal (automatically starts an origin search when powered on)

Origin Search that starts automatically when powered ON can be set as well.

Z-phase signal is generated by the internal position sensor of Cool Muscle and output once per revolution.

Usage of Z-phase signal to detect an origin makes a precise origin search possible that always detects the same origin without an external origin sensor even in a rotative motion.

Furthermore, it is possible to detect an origin by using AND condition with an origin sensor signal. Therefore an origin search with higher repeatability accuracy is realized.

*Refer to the section 5.3 Origin Search for details.

Automatic origin search when power on can be set.

The following related parameters shall be set separately

Stopper Detection		Origin Sensor	
K42	Origin Search Speed	K27	Origin Sensor Signal
K43	Acceleration for Origin Search	K42	Origin Search Speed
K45	Origin Search Direction	K43	Acceleration for Origin Search
K47	Stopper Detection Torque for Origin Search	K45	Origin Search Direction

[Setting Example]

K46.1=3 Set the origin search by an origin sensor that starts automatically when powered ON for Origin Signal Source.

K47	Stopper-Detecting Torque for Origin Search	Unit : %

This parameter sets the torque level to complete the stopper-detecting origin search.
The torque is relative to the rated torque of the motor in percentage.

Min	10
Max	150

When the acceleration is set too high, the torque required when starting motion reaches the set torque level and could incorrectly detect the origin. Please decrease K43 value.

[Setting Example]

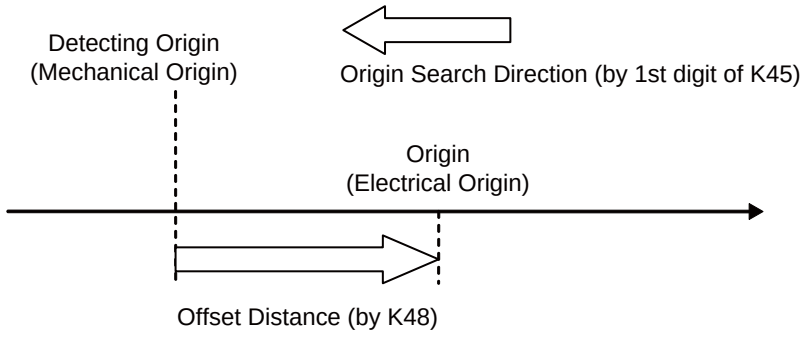
K47.1=30 Set the 30% of motor's rated torque for stopper detection torque level.

K48	Offset Distance Between Mechanical and Electrical Origins	Unit : 100 pulses 10 pulses 1 pulse (Depends on 2nd digit of K45)

This parameter sets the offset distance between the mechanical and electrical origins.

When it is set to 0, the motor stops at the mechanical origin. When it is set to other than 0, the motor automatically goes to the electrical origin set by this parameter. The speed moving from the mechanical origin to the electrical origin is the same as K42(return to origin speed)

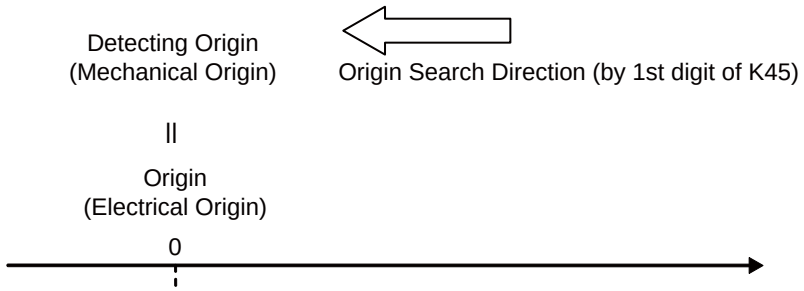
Min	-32767
Max	32767



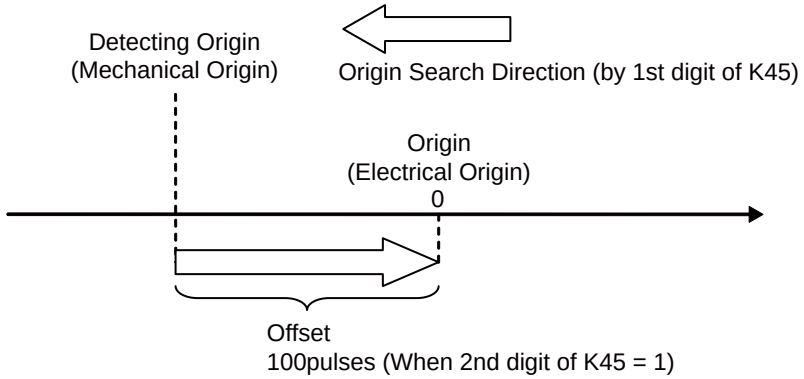
[Setting Example]

K48.1=0

The mechanical and electrical origins are the same



K48.1=10



K49	Speed for Manual Feed	Unit : 100pps 10pps 1pps (Depends on K37)

This parameter sets the speed for manual feed.
Acceleration for manual feed can be set by K43.

Min	1
Max	32767

[Setting Example]

K49.1=100 Set 100 x 100pps = 10000pps for the speed for manual feed.

K50	Feed Pulses for Manual Jog	Unit : pulses

This parameter sets the numbers of feed pulses for manual jog in the pulse unit.

Min	1
Max	100

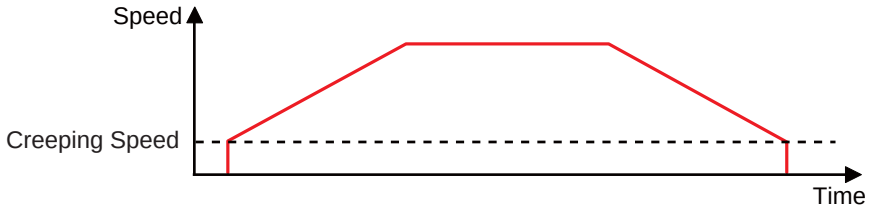
[Setting Example]

K50.1=10 Set 10 pulses for the numbers of feed pulses in manual jog operation.

K51	Creeping Speed	Unit : 100pps 10pps 1pps (Depends on K37)

This parameter sets creeping speed for the initial and terminal speed for a motion. Creeping speed is the speed from which motor starts to move and stop. The motor response or tact time will be adjusted finely by changing creeping speed. Setting creeping speed too high may cause the motor to vibrate.

Min	0
Max	1000



The value that can be used for this parameter depends on K37 (motor resolution).

K37			K51
Value		Resolution	Usable Values
7	27	10000	2 and over
8	28	25000	5 and over
10	30	50000	10 and over
48	68	6000	2 and over
49	69	8000	2 and over
50	70	12000	5 and over

K55	In-Position Range	Unit : pulses

This parameter sets the range for In-position in the pulse unit.

Different from motion completion signal, in-position is detected when the current position is within the set range against the target position.

Min	1
Max	100

When stopping the motor by a stop command, the stopped position is recognized as the target position, therefore In-position is detected within the set range against the current position.

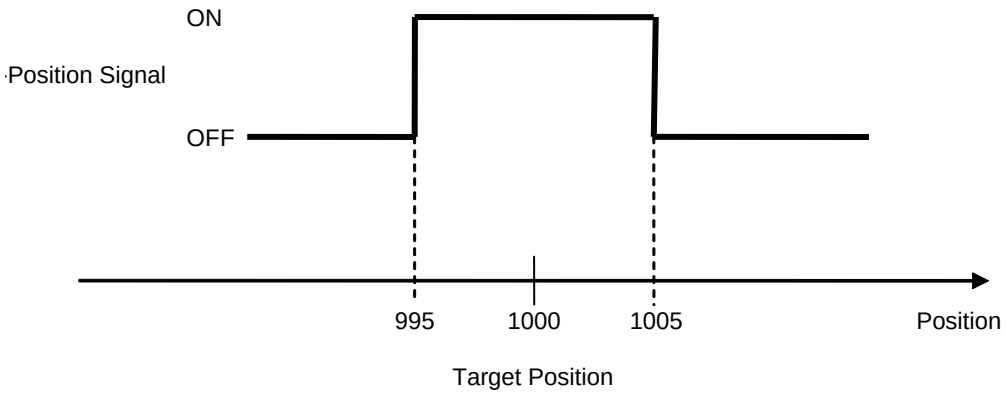
When recognized as In-position, In-position signal is ON and the motor status goes in Ux.n=8 (Ref: K23, n: Motor ID).

In-position signal can be output by assigning an output function (Ref: K34).

When the range is set to small, In-Position may not be detected and can not execute the next step in a program.
When the range is set too big, the resolution is too small and the speed is too slow, In-Position may be detected before reaching the target position.

[Setting Example]

K55=5 In-Position signal range is set to 5 pulses. In-position signals will be sent out between 995 and 1005, when the target position is 1000.



K56	Position Error Overflow Threshold Level	Unit : 100 pulses

This parameter sets a threshold value for the position error overflow in the 100-pulse units. When the deviation between the current position and command position exceeds the threshold level, the motor outputs (Ux.n=1) an alarm and goes into motor free state.

Min	1
Max	32767

[Setting Example]

K56.1=50

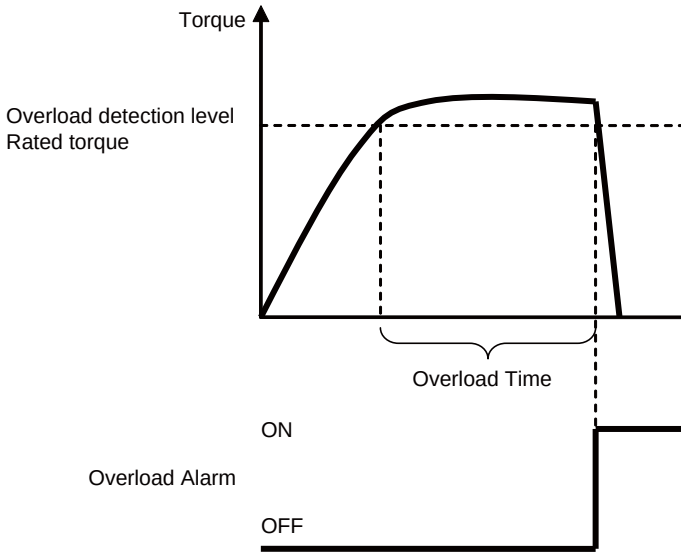
Set 50K pulses to Position Error Overflow Threshold Level.

When the deviation between the current position and command position exceeds 5000 pulses. Motor goes into Position Error Overflow alarm (Ux=1) and stops in motor free state.

K57	Overload Detection Time	Unit : msec

When the overload condition for motor continues more than set time (msec), the overload alarm is detected. Then motor outputs overload alarm (Ux=4) and stops in motor free state.

Min	100
Max	10000



[Setting Example]

K57.1=3000

Motor outputs overload alarm when the overload condition continues more than 3000msec, and stops in motor free state.

K58	Software Limit (+)	Unit : 100 pulses 10 pulses 1 pulse (Depends on 3rd digit of K45)

K58 sets the software limit in the positive direction, to prevent the motion over the set position.
There is no software limit available when 0 is set.
This function provides the safety stop and cost reduction without an external hardware as limit sensor.

Min	0
Max	999999999

K59	Software Limit (-)	Unit : 100 pulses 10 pulses 1 pulse (Depends on 3rd digit of K45)

K59 sets the software limit in negative direction in the 100-pulse units, to prevent the motion over the set position.
There is no software limit available when 0 is set.

Min	-999999999
Max	0

[Setting Example]

K58.1=200 Set 200 pulse to + direction software limit. (When 3rd digit of K45 = 2)

K59.1=0 Set no software limit in - direction.

K60	Push Motion Torque Level	Unit : %

This parameter sets the torque level for the Push Motion, that is relative to the motor's rated torque in percentage.

When the odd number is set the push motion error will not occur.

Min	10
Max	100

K61	Push Motion Holding Time	Unit : msec

This parameter sets the holding time for the Push Motion.

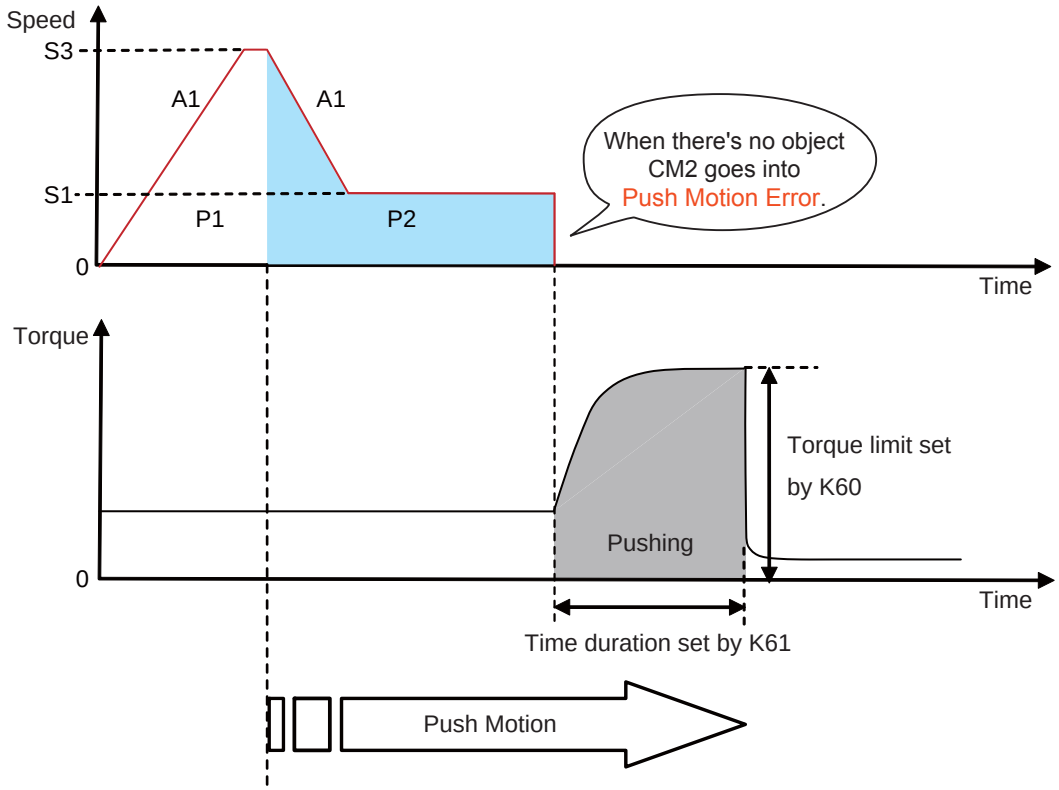
The endless Push Motion can be applied by setting K61=0

Min	0
Max	30000

[Setting Example]

K60.1 = 50 Set 50% of rated torque to Push Motion Torque Level

K61.1 = 5000 Motor keeps pushing an object for 5000msec



K62	Ladder Logic Bank No. Executed when Powered ON	Unit : —

Set a Ladder Logic Bank No. that is executed automatically when powered ON.
No Ladder Logic Bank will be executed when 0 is set.

Min	0
Max	30

[Setting Example]

K62.1=2 Ladder Logic Bank 2 is executed automatically when powered ON.
(The same as [L2.1)

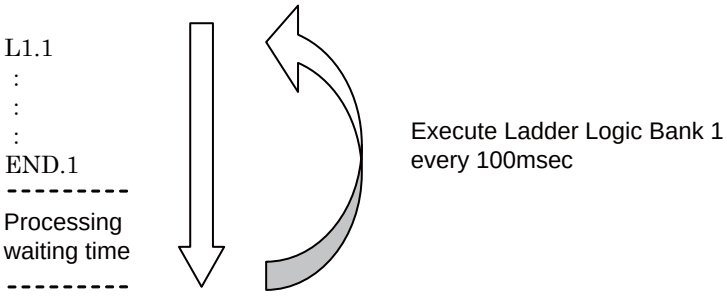
K63	Ladder Logic Bank execution cycle time	Unit : msec

Sets the execution cycle time for Ladder Logic Bank.
When all processing in a Ladder Logic Bank is finished within a set cycle time, the execution of processing is forced to wait until the next cycle. When all processing is not finished within a set cycle time, remaining processing is carried over to the next cycle.
When K63=0, a Ladder Logic Bank is not executed.

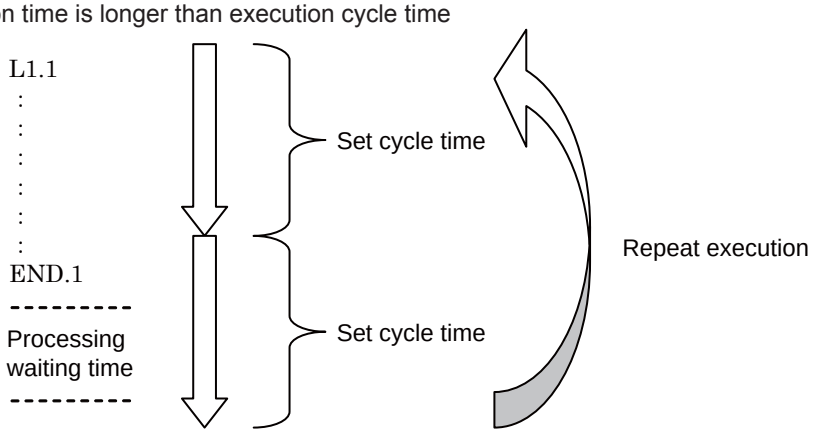
Min	0
Max	30000

[Setting Example]

K63=100 Execute Ladder Logic Bank every 100msec



When execution time is longer than execution cycle time



K64	Status LED Setting	Unit : —

This parameter sets either the status LED is activated or inactivated.

The default value is 0 (Activated).

When setting 1 (Inactivated), the LED will be off all the time including an alarm status.

CM2 User's Guide shall be referred to for the LED activated pattern.

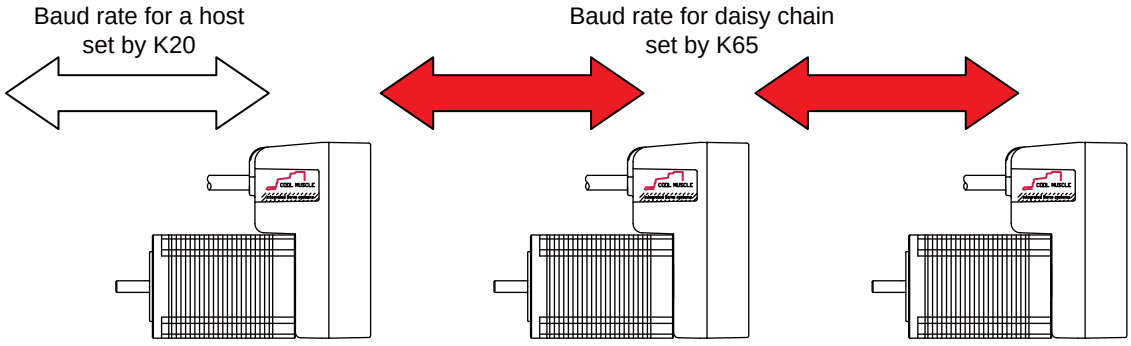
#	Description
0	Status LED Activated
1	Status LED Inactivated

K65	Baud Rate Between Slave Motors	Unit : —

This parameter sets the baud rate between slave motors in the daisy chain operation.

When changing the setting of ID1, the settings of other motors will be changed automatically. When changing the setting of slave motors except ID1, the baud rate between slave motors will not be changed.

#	Baud rate
0	38.4 kbps
1	9.6 kbps
2	19.2 kbps
3	57.6 kbps
4	115.2 kbps
5	230.4 kbps



When setting a high baud rate, the synchronization will be better but the communication will become sensitive against the noise.

[Setting Example]

K65.1=5 Set "230.4 kbps" to the baud rate between slave motors.

K68	Motor Free when Powered ON	Unit : —

This parameter sets either servo ON or motor free when powered ON.

Value	Set content
0	Motor free when powered ON
1	Servo ON when powered ON

[Setting Example]

K68.1=1 Servo on when powered on

K69	S-Curve gain	Unit : —

This parameter sets the S-curve gain in positioning.

By setting S-curve, the form of target speed for acceleration and deceleration periods will be S-shaped according to its gain. Therefore it may effect a smoother positioning or vibration reduction.

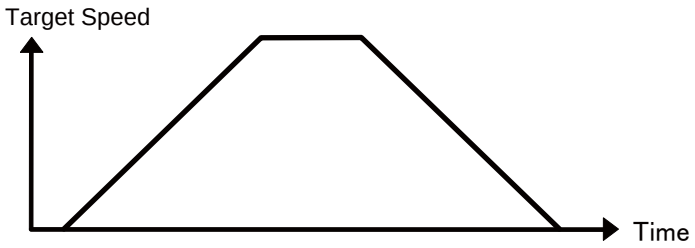
When 0, motor makes a trapezoidal motion.

Min	0
Max	1024

[Setting Example]

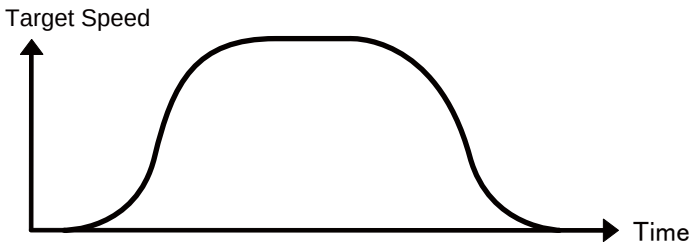
K69.1=0

Trapezoidal Motion



K69.1=1024

S-curve Motion



K70	Delimiter	Unit : —

This parameter sets the delimiter type at the end of replied data.

Value	Delimiter
0	CR
1	CRLF

[Setting Example]

K70.1=1 Set “CRLF” to the delimiter.

K71	External Encoder Type	Unit : —

Set the external encoder type.

Value	Set content
0	No external encoder
1	A-phase index
2	A-phase index, B-phase rotation direction
3	A-phase & B-phase index
4	A-phase & B-phase feedback
5	A-phase pulse counting
6	A-phase pulse measuring B-phase rotation direction
7	A-phase & B-phase pulse counting

Index :

Motor keeps rotating until the numbers of pulses from an external encoder reaches the specified numbers of pulses.(It will not adjust the overrun pulses)

It will be useful for the motion winds in specified amount in one direction without loosening as used in a winding machine.

Feedback :

By the feedback pulses from the external encoder equipped for the control target, the whole system can be controlled as a full closed-loop system.

Pulse Counting :

Input the pulses from an external encoder to Cool Muscle and only count the numbers of pulses.

This feature is useful for the control according to the amount of movement or speed of the control target.

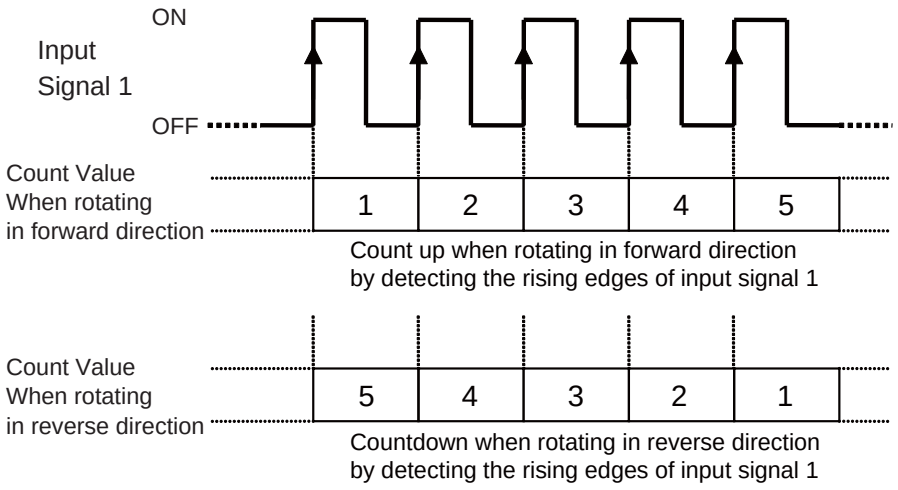
Count Timing for the external encoder depends on input type and is shown as the diagram below.

Note: The input logic for the input voltage can be set by the parameter K26.

[A-Phase Index]

Input encoder pulse to input port 1.

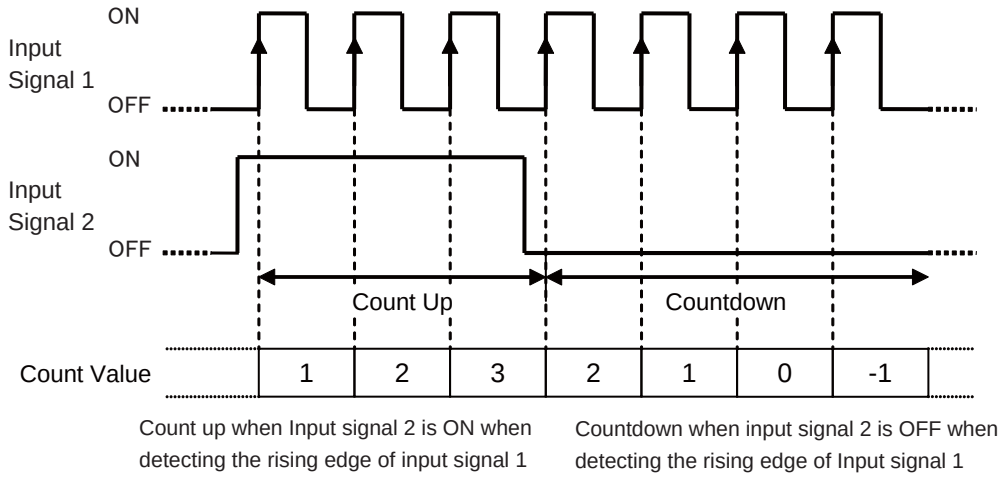
Count the pulse when detecting the rising edge. Count up when rotating in forward direction and countdown when rotating in reverse direction.



[A-Phase Index, B-Phase Direction]

Input encoder pulse to input port 1 and direction pulse to input port 2.

Count the pulse by the rising edge of input signal 1. Count up when input signal 2 is ON when detecting the rising edge and countdown when input signal 2 is OFF.

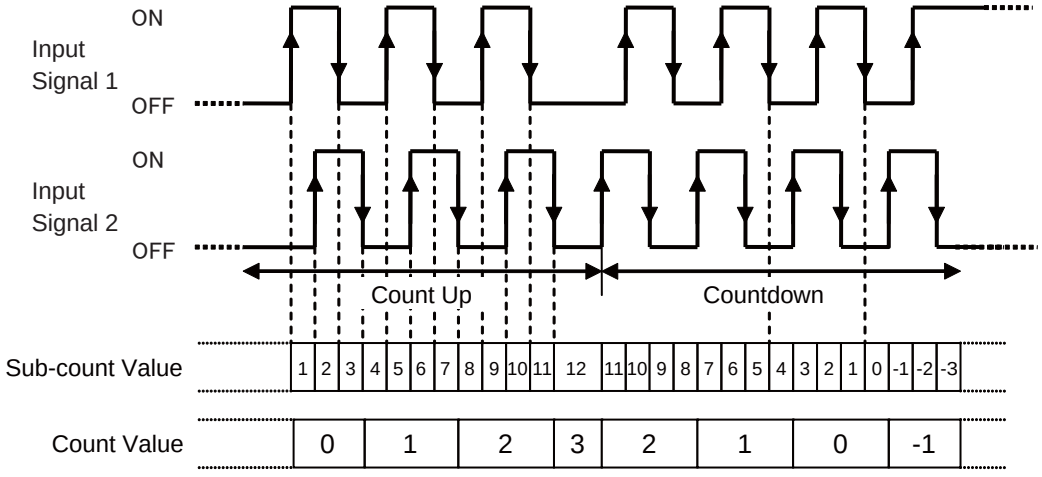


[A-Phase & B-Phase Phase Index]

Count the pulse automatically recognizing count up or countdown by input signals that phases are shifted 90 degrees to each input port 1 and input port 2 as the timing shown in the diagram below.

In this mode, sub-count value will be 4 for 1 cycle of input signal because the rising and falling edges of 2 phase signals for input are counted.

Encoder pulse count value will be 1/4 integral part of sub-count value.



K72	External Encoder Resolution	Unit : ppr
This parameter sets the resolution for the external encoder.	Min	0
	Max	32767

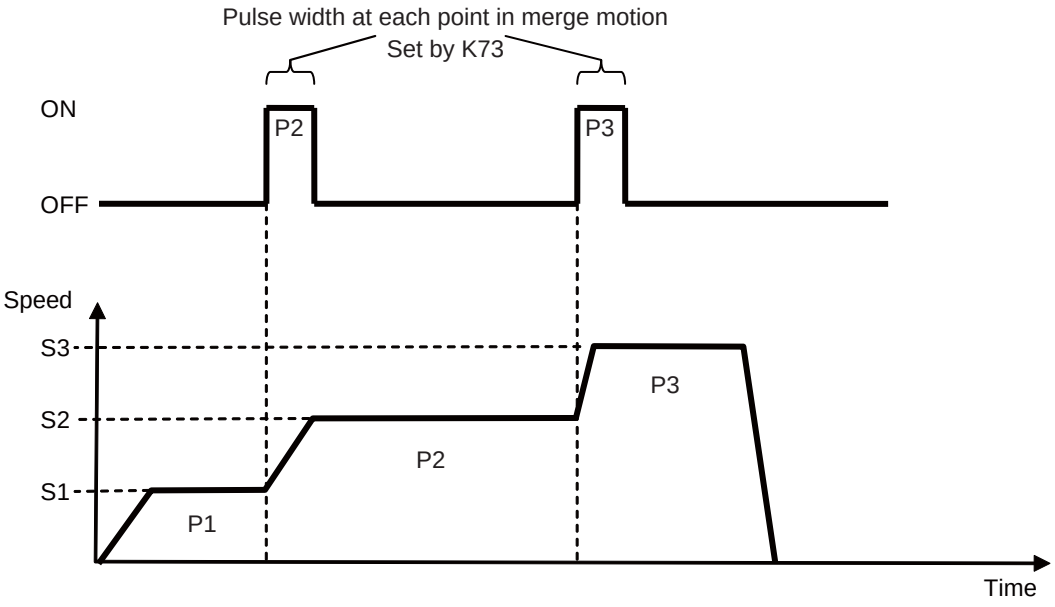
[Setting Example]

K72.1=1000 Set 1000ppr to the external encoder resolution

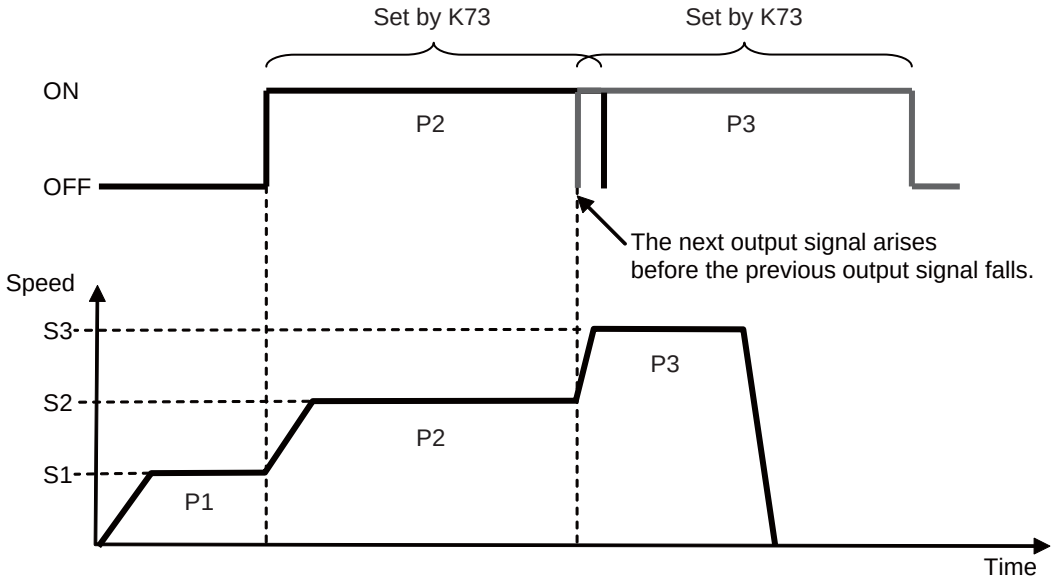
K73	Output Pulse Width at Passing Point in Merge Motion	Unit : msec

This parameter sets the pulse width in msecs that is sent out when the motor passes each point in merge motion. Pulse signals are sent out only at the passing points but not at the starting and end points.

Min	1
Max	1000



When the pulse width is set too big, the motor can reach the next passing point and the signal arises before the signal falls down. This results in one signal covering multiple points. When this happen, please reset the pulse width smaller.



[Setting Example]

K73.1=100 Set 100msec to the pulse width at passing point in merge motion

K74	Torque Control P Gain	Unit : —

Set proportional gain for external torque sensor feedback.

Min	0
Max	1000

K75	Torque Control I Gain	Unit : —

Set integral gain for external torque sensor feedback.

Min	0
Max	500

K76	Input Offset for Torque Sensor	Unit : 0.01V

Set the offset value of an external torque sensor input for torque feedback control.
The offset value is the output voltage of external torque sensor when torque sensor is 0[N.m].

Min	0
Max	500

K77	Input Range for Torque Sensor	Unit : 0.01V

Set the input range of an external torque sensor for torque feedback control.
In the torque feedback control, the motor output can be controlled in accordance with K74(P gain) and K75(I gain), where the feedback data from external torque sensor equipped for the control target track the torque command value specified in the range of 0~±100 by Variable 15.
This parameter sets the voltage level in the unit of 0.01V. The value is the output voltage of torque sensor when the torque command value is 100.

Min	-1000
Max	1000

[Setting Example]

K76.1=250

K77.1=200

Output 1[V] for 0.5[N.m], connected to a torque sensor with offset voltage 2.5[V].

Since the offset voltage is 2.5[V], set K76=250.

When set command torque 100 as 1.0[N.m]

Since the torque sensor output when 10[N.m] is 2[V], set K77=200.

K78 Input Address for Modbus Host Communication

Unit : —

Set the Modbus input address for the host communication.

Set K78=0 for relative address. When K78=-1 is set, this function is not activated.

Min	-1
Max	32767

K79 Input Address for Modbus Slave Communication

Unit : —

Set the Modbus input address for the slave communication.

Set K79=0 for relative address. When K78=-1 is set, this function is not activated.

Min	-1
Max	32767

K80 Output Address for Modbus Slave Communication

Unit : —

Set the Modbus output address for the slave communication.

Set K80=0 for relative address. When K80=-1 is set, this function is not activated.

Min	0
Max	32767

K81 COM0 Station Address

Unit : —

Set Cool Muscle's station address for a host device.

Min	-255
Max	255

K82 Parity

Unit : —

Set the parity when transferring data.

Value	Description
0	None
1	Even
2	Odd

Host communication port is defined as COM0, slave communication port is defined as COM1.
Ref : Section 5.6 Modbus protcol for the detailed information.

K84 COM1 Communication Mode Setting — Unit : —

Communication mode of COM1 shall be set as shown in the below diagram.

K81	K84	COM0 Communication Mode	COM1 Communication Mode
0	0	RS-232C	RS-232C
	< 0		RS-232C
	1		Modbus Host
0 >	0	Modbus Slave	RS-232C
	< 0		RS-232C
	1		Modbus Host

Min	-256
Max	1

K85 Endian — Unit : —

Set Endian for data transmission in Modbus Communication.

Value	COM0	COM1
0	Big Endian	Big Endian
1	Little Endian	Big Endian
2	Big Endian	Little Endian
3	Little Endian	Little Endian

Chapter 4

Sample Program

In this section, we will show some program examples by CML that is explained in the section 2.
This section is comprehensive to learn basic to advanced CML.
* Please use Cool Muscle 2 alone since those are sample programs.

4.1. Various PTP motion

Using one motor, basic single axis point to point motion (one point on one straight line to another point) is executed.

4.1.1. Basic PTP motion

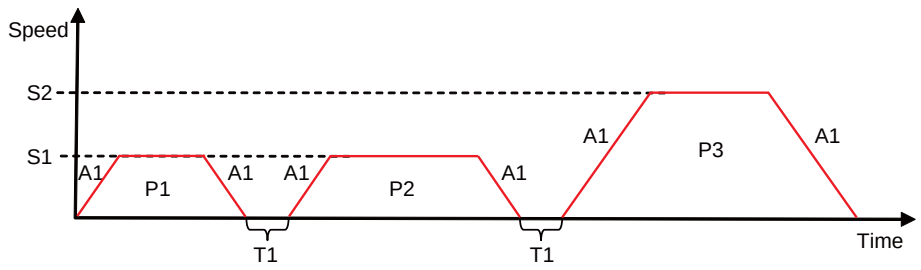
```
P1.1=20000
P2.1=72000
P3.1=120000
S1.1=100
S2.1=200
S3.1=300
A1.1=100
A2.1=200
T1.1=500
```

Position Data
Speed Data
Acceleration Data
… Timer Data
Motion Data Definition

```
B1.1                …Beginning of Program Bank 1
S1.1, A1.1, P1.1    …Move to P1 with speed S1 and acceleration A1
T1.1                …Timer for T1, motor no action
P2.1                …with the same acceleration and speed as in line 2
T1.1                   move to P2
S2.1, P3.1          …Change speed to S2 and move to P3
END                 …End of Program Bank
```

Program Bank

One line represents one motion. When speed and acceleration are not specified, the previously used speed and acceleration are applied. In the example above, the same acceleration A1 is used for the entire program and the same speed S1 is applied until the motor reaches P2 (line 4). In line 6, the speed changes to S2 and motor moves to P3.



4.1.2. Merge Motion

```
B2.1
S1.1, A1.1, P1.1, S2.1, P2.1, S3.1, A2.1, P3.1
```

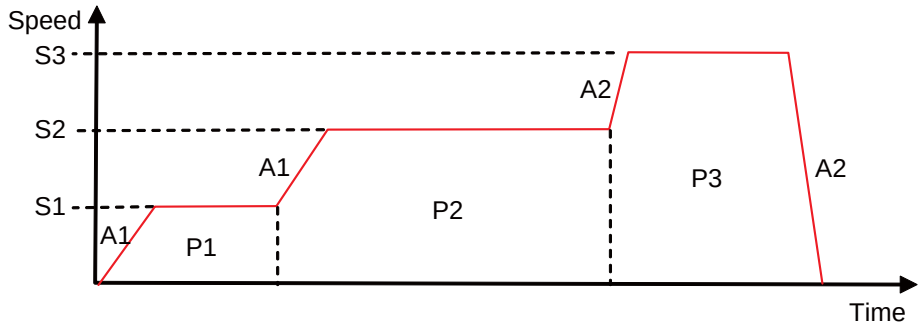
…Beginning of Program Bank 2

Motion data are same as 4.1.1.

Motion before P1 | Motion before P2 | Motion before P3

When multiple P commands are used in a single line, the motor does not stop at each position that is called merge motion. In Merge Motion, A and S commands can be specified, changing speeds and accelerations at passing points.

In the example program above, the motor passes P1 and P2 and moves to the final destination.



But when a movement direction is turn over, Merge Motion is removed and it performs normal motion.

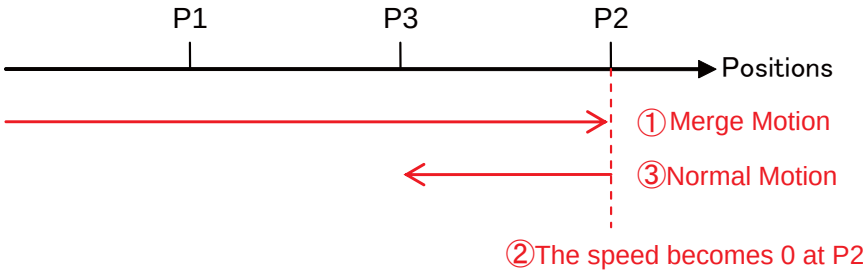
```
P1.1=10000
P2.1=30000
P3.1=20000
```

Position Data

```
B2.1
S1.1, A1.1, P1.1, S2.1, P2.1, S3.1, A2.1, P3.1
```

…Beginning of Program Bank 2

Motion before P1 | Motion before P2 | Motion before P3



4.1.3. PTP motion with Different Accelerations and Decelerations

Related parameter
K44

```
B3.1
S1.1, A1.1, P1.1, A2.1, P2.1
```

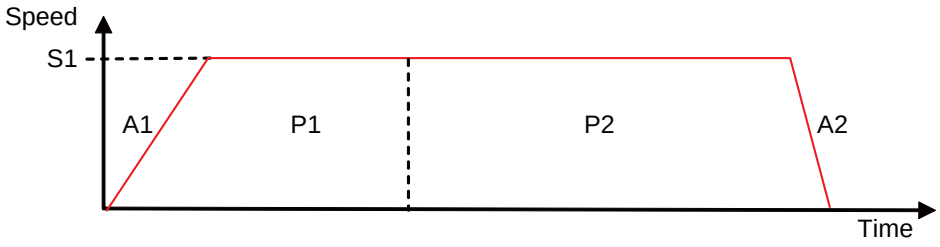
Motion before P1 | Motion before P2

…Beginning of Program Bank 3

Motion data are same in the 4.1.1.

Acceleration and Speed remain the same unless specified otherwise.

When multiple A commands are used in a single line, you can set accelerations and decelerations independently. As the chart below shows the motor reaches the final destination with a slow acceleration and a quick deceleration. Another way to set deceleration separately is to use parameter K44. (by a percentage of acceleration.)



4.1.4. Push Motion

Related parameter
K60, K61

```
B4.1
S3.1, A1.1, P1.1, S1.1, Q2.1
```

Motion before P1 | Motion before P2

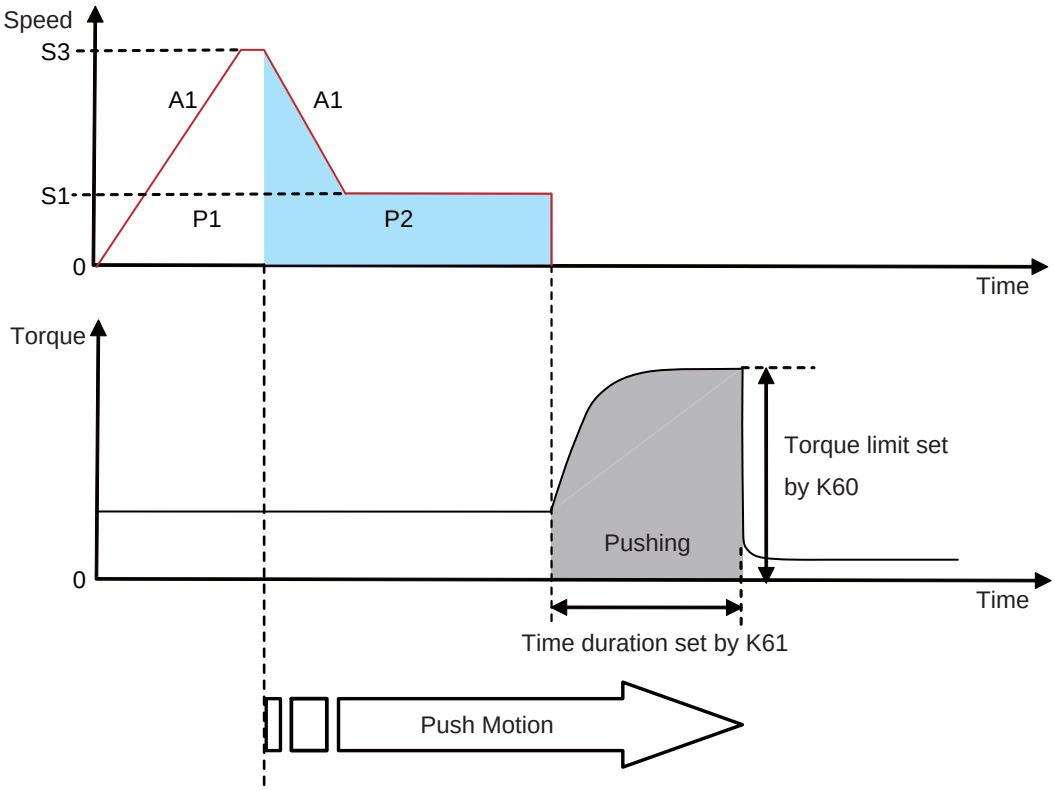
…Beginning of Program Bank 4

Motion data are same as 4.1.1.

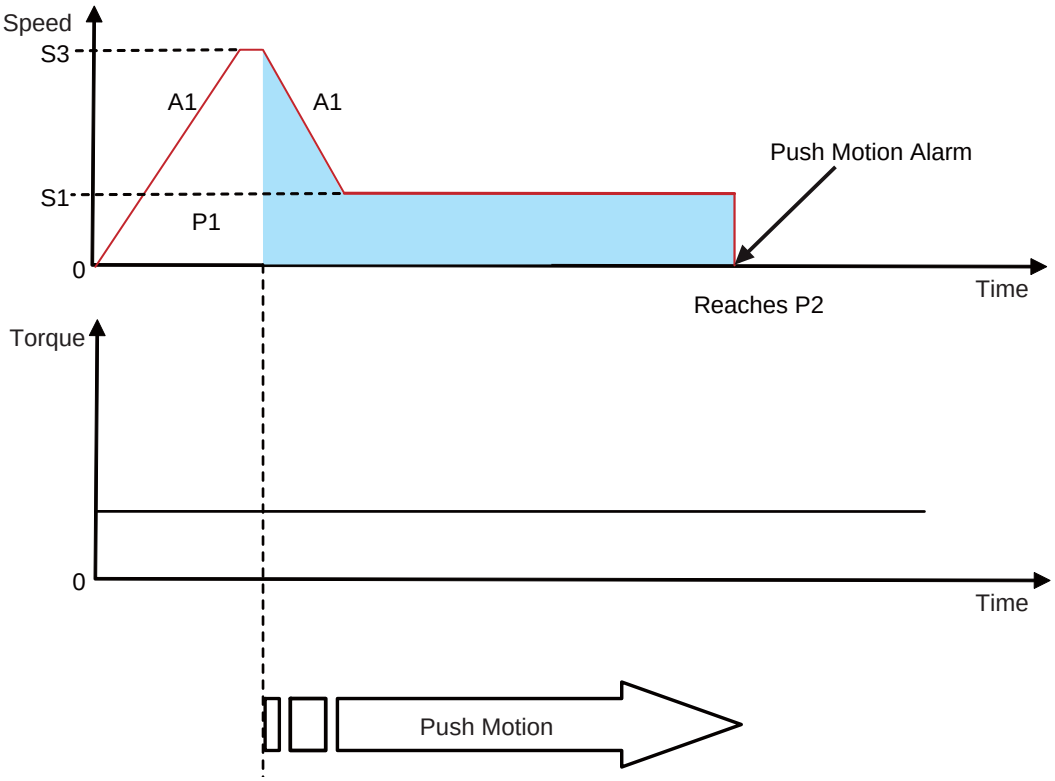
Using Q command instead of P command, it performs Push Motion within the torque limit designed by parameters.

The CML program above shows the motion that the motor changes the speed to S1 at P1 and start performing Push Motion toward P2.

Torque limit and Push Motion duration time need to be defined by Parameter K60 and 61. The following charts show relationship between the motion and torque.



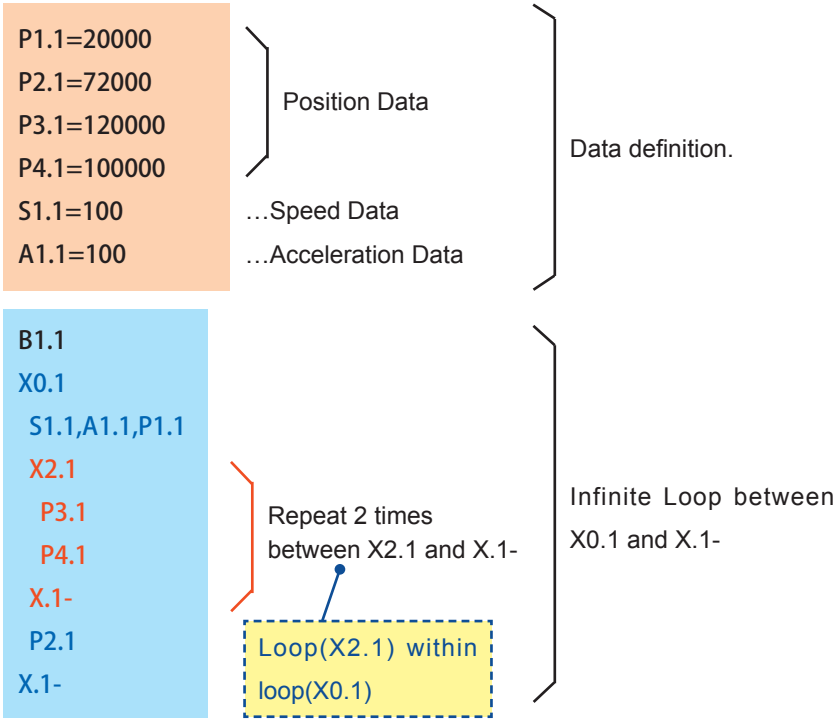
During the Push Motion, Cool Muscle 2 goes into an alarm state (Ux=256) being in Push Motion when reaches a target position by the reason that pushing object does not exist or push torque is too high.



4.2. Various Processing

More complex CML program flows are introduced and described in this section.

4.2.1. Loop Processing



The lines between [X loop count . Motor ID] command and [X . Motor ID -] command are repeated the number of times that is specified by Loop Count. By using command X between loops, it performs multiple loops up to 10 classes.

4.2.2. Basic Branch Processing

By specifying branching condition, different processes can be executed by conditions true or false.

When defining a branching processing as below, describe a condition (I or V command), true condition and false condition dividing with comma.

[Format] Branching Condition, True Condition, False Condition

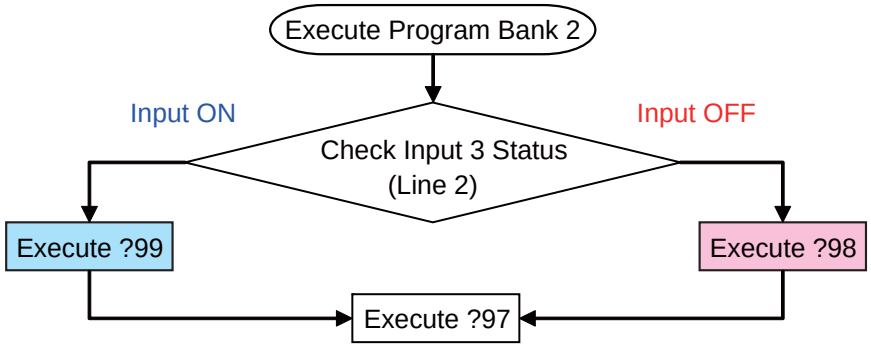
When using I command, execute the conditional branching by the specified input status.

```
B2.1
I3.1, ?99.1, ?98.1
?97.1
END
```

…Conditional branch Processing
…Merge back to normal command processing

Program Bank

The flow of above CML program is as shown in below.



When using only V command, the branch processing depends the specified V data is larger than 0 or not.

When larger than 0, execute the true condition otherwise false condition.

```
V1.1="Sx"
```

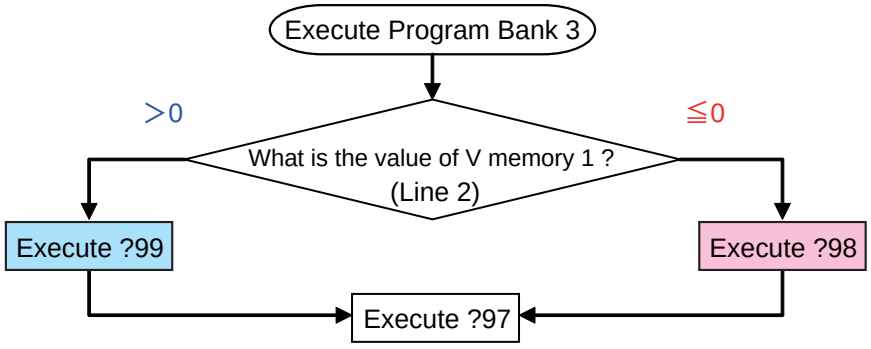
Data definition. Define the current speed to V1

```
B3.1
V1.1, ?99.1, ?98.1
?97.1
END
```

…Conditional Branching Processing
…Return from Conditional Branching

Program Bank

In the above program bank, execute the true condition when the current speed > 0, and the false condition when the current speed < 0. The processing shall be shown in below.



4.2.3. Branch Processing using Logical Operator

Using a logical operator, more complicated branch processing than the programs in section 4.2.2 is possible (Ref Section 6.7 for Arithmetic Operator, Ref: Section 6.8 for Logical Operator).

When executing branching processing, two conditions (I or V command), arithmetic or logical operator between two conditions, true condition and false condition dividing by comma shall be described.

[Format] Branching Condition 1, Operation, Branching Condition 2, True Condition, False Condition.

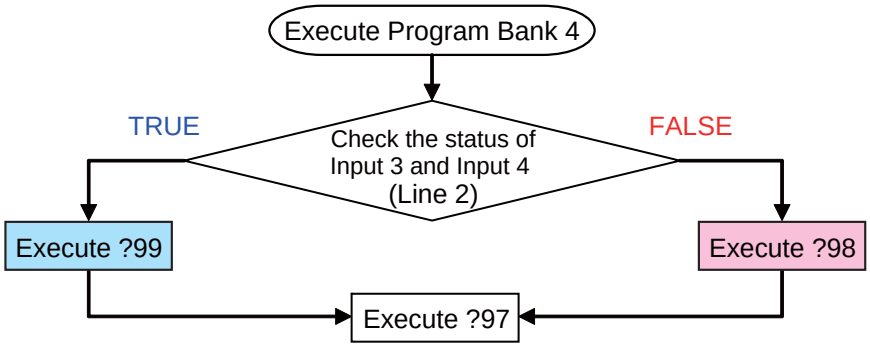
A CML program example using the I command and its flow is as below.

```
B4.1
I3.1 && I4.1, ?99.1, ?98.1
?97.1
```

…Conditional Branching with Logical Operator

…Merge back to a normal command processing.

Program Bank



The criteria of condition of 2 input status and Logical Operator is as shown in below.

Logical Operator && (AND)		INPUT 2	
		ON	OFF
INPUT 1	ON	TRUE	FALSE
	OFF	FALSE	FALSE

Logical Operator || (OR)		INPUT 2	
		ON	OFF
INPUT 1	ON	TRUE	TRUE
	OFF	TRUE	FALSE

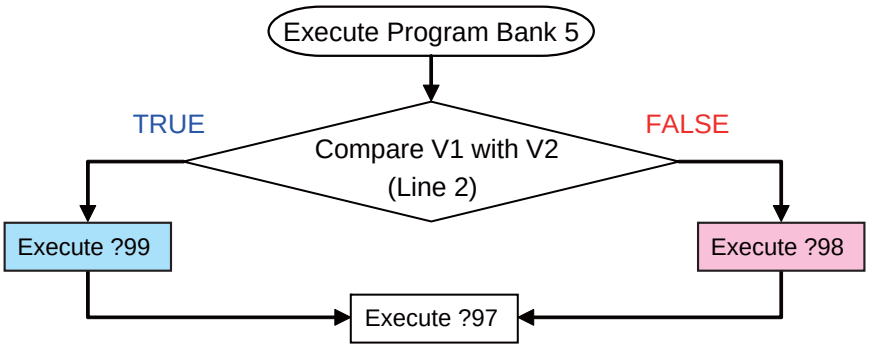
A CML program example using the V command as a condition and its flow is as below.

```
B5.1
V1.1> V2.1, ?99.1, ?98.1
?97.1
END
```

…Conditional Branching with comparison Operator

…Merge back to normal command processing.

Program Bank

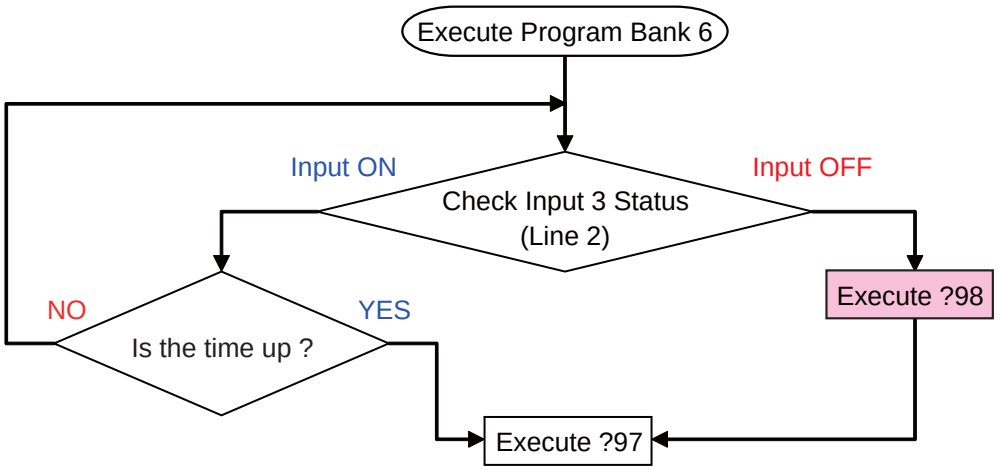


4.2.4. Branch Processing with Wait function

```
B6.1
I3.1, W1, ?98.1      …Branching with timer function
?97.1                …Merge back to normal command processing.
```

Program Bank

The W command can be used for branching with wait function (line 2). The motor waits for the time specified by the timer memory to pass and keeps on monitoring the status of the specified input for that duration. When the time is up, the motor finishes the branch processing and executes the next command line. The flow of the CML program above is as below.

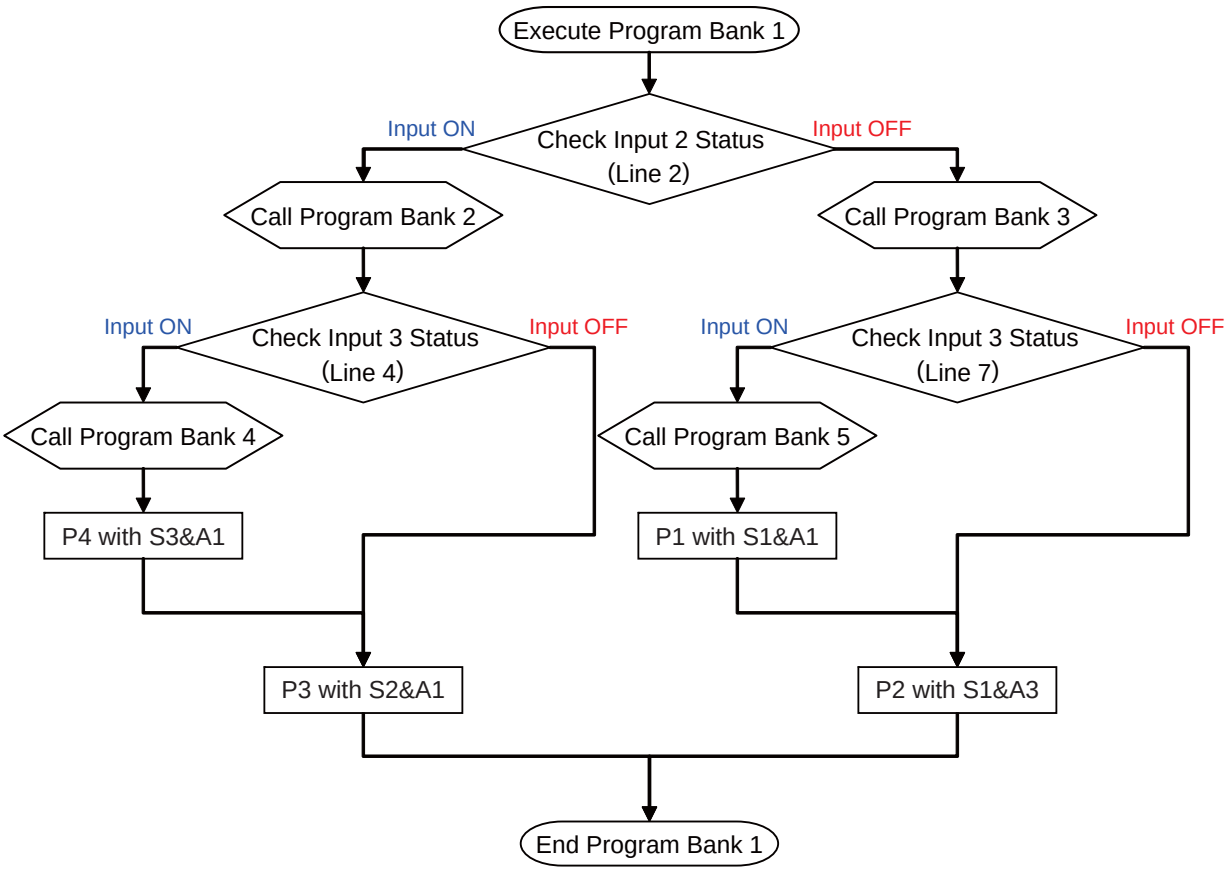


4.2.5. Nesting

By using C command (call), Program Bank goes deeper and its depth is called “Nesting”. Depending on how to compose of a program, the programming that a hierarchy becomes deeper is possible.
The maximum nesting level for COOL MUSCLE 2's programming is up to 10.

By combining nesting and branching, a specified program bank can be executed according to the specified input status.
The CML program below shows how one of the 4 program banks is executed according to the status of Input 2 and 3.

```
B1.1
I2.1, C2.1, C3.1    …Conditional branch Processing      ] Program Bank 1
B2.1
I3.1, C4.1, T0.1    …Conditional branch Processing      ] Program Bank 2
S2.1, A1.1, P3.1
B3.1
I3.1, C5.1, T0.1    …Conditional branch Processing      ] Program Bank 3
S1.1, A3.1, P2.1
B4.1
S3.1, A1.1, P4.1                                        ] Program Bank 4
B5.1
S1.1, A1.1, P1.1                                        ] Program Bank 5
```



4.3. Controlling Multiple Motors

The CML program examples introduced in the section 4.1, 4.2 use a single motor. CML programs using multiple motors are introduced in this section.

To control multiple motors, various data and commands have to be defined for each motor.

4.3.1. Synchronized motion by 2 Axes

```
P1.1=2500
P2.1=1000
P3.1=3000
S1.1=200
A1.1=100
P1.2=1000
P2.2=2000
S1.2=100
A1.2=50
```

Motor 1 Data definitions

Motor 2 Data definitions

```
B1.1
A1.1, S1.1, P1.1, A1.2, S1.2, P1.2
P2.1, P2.2
P3.1
```

…Motor 1 and Motor 2 move to P1 at the same time
…Motor 1 and Motor 2 move to P2 at the same time
…Motor 1 moves to P2.

Program Bank 1

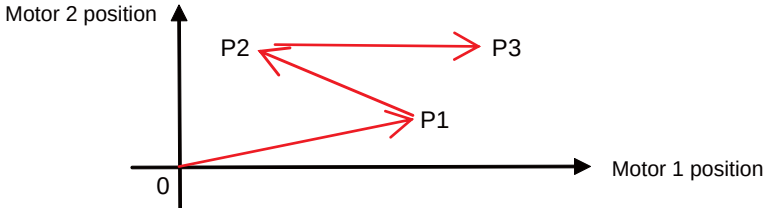
Program description

Line 2 : Motor 1 and Motor 2 start to move at the same time. Motor 1 moves to position 2500 with the speed of 200 and acceleration of 100. Motor 2 moves to position 1000 with the speed of 100 and acceleration of 50.

Line 3 : Once both Motor 1 and Motor 2 complete the motion defined by line 2, Motor 1 and Motor 2 start to move at the same time. Motor 1 moves to position 1000 with the same speed and acceleration as in the previous motion. Motor 2 moves to position 2000 with the same speed and acceleration as in the previous motion.

The line 3 is not executed until both Motor 1 and Motor 2 complete the current motion (line 2). One motor waits until the motion of another is completed.

Line 4 : When Motor 1 and Motor 2 complete the motion defined by line 3 in Bank 1, only Motor 1 moves to position 3000.



4.3.2. Non-synchronized motion by 2 Axes

In the previous CML program example, either motor does not initiate the next motion until both motors complete the current motion. In this CML program, both motors independently initiate their own motion without waiting for the completion of motion each other.

B2.1	…Use the same data as in section 4.3.1
A1.1, S1.1, P1.1, A1.2, S1.2, P1.2	…Motor 1 and Motor 2 move to P2 at the same time.
P2.1, Y2.2	…Substitute Y command for P command to Motor 2
P3.1	…Motor 1 moves without waiting for Motor 2

Program Bank 2

Description of the program above

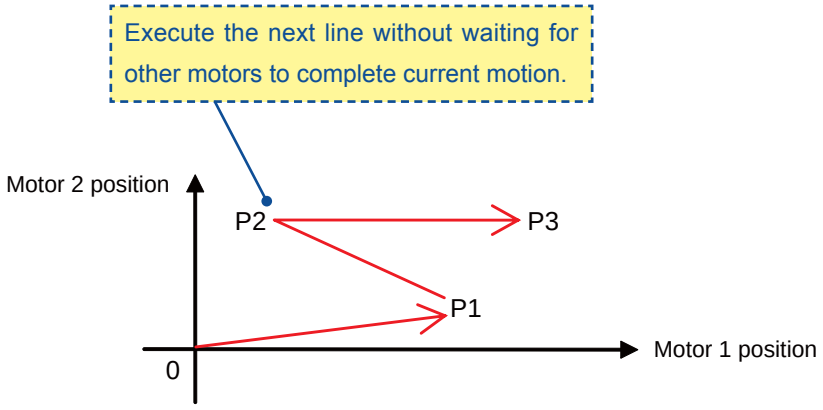
Line 3 : When Motor 1 and Motor 2 complete the current motion (line 2), then Motor 1 moves to P2 with the same speed and acceleration as in the previous line, and Motor 2 moves to P2 with the same speed and acceleration as in the previous line

Line 4 : Motor 1 starts to move to P3 without waiting for Motor 2 to reach P2 (line 3)

When Y command is used instead of P command, the command in the next line is enabled to execute without waiting for the completion of the motion by Y command.

For performing Push Motion, substitute Z command for Q command to allow the motor to perform the next motion independently.

Note that the motor completes one motion before executing the next command when Y commands or Z commands is used continuously. In series of Y commands or Z commands, the last command is effective for non-synchronized motion, although commands other than the last one complete the positioning motion.



4.4. Interpolation (Optional: R Type only)

In this section, interpolation programs for two motors are introduced. In order to make sure of synchronization, the condition that adjacent Motor IDs are assigned to two motors needs to be met.

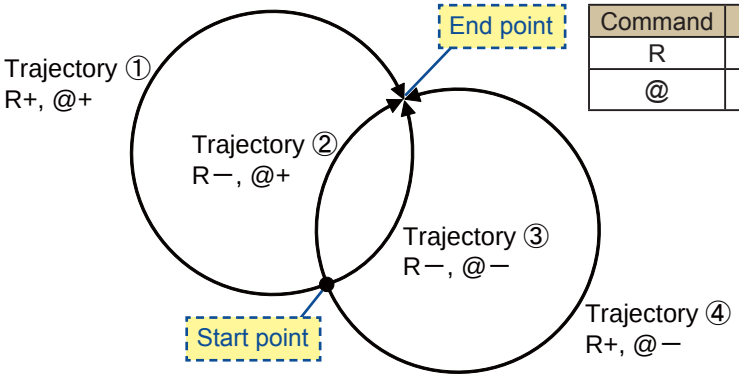
Using two motors, assign the current position as a starting point, and set the end point by P command, then circular interpolation is possible with specifying radius or center point of circle. Linear interpolation is performed when radius is set to 0 (zero).

Interpolation should be performed by the adjacent motors for ensuring of synchronization.
CM2 can operate merge motion, during even at the interpolation.
By using the " ; " command, multiple commands can be concatenated in multiple lines.
Set speed for interpolation is synthetic speed by 2 axes.

4.4.1. Circular Interpolation by Specifying Radius

There are 4 different motion trajectories when starting point (current position), end point and radius are specified in the circular interpolation. See diagram below. Select one of the trajectories by combining R command (specify radius), @ command (execute interpolation) and + or - modifier.

In this case, the center of a circle is automatically calculated.



Command	+	-
R	Long Arc	Short Arc
@	CW	CCW

```
A1.1=100
S1.1=100
P1.1=0
P2.1=1000
R1.1=2000
A1.2=100
S1.2=100
P1.2=0
P2.2=1000
R1.2=2000
```

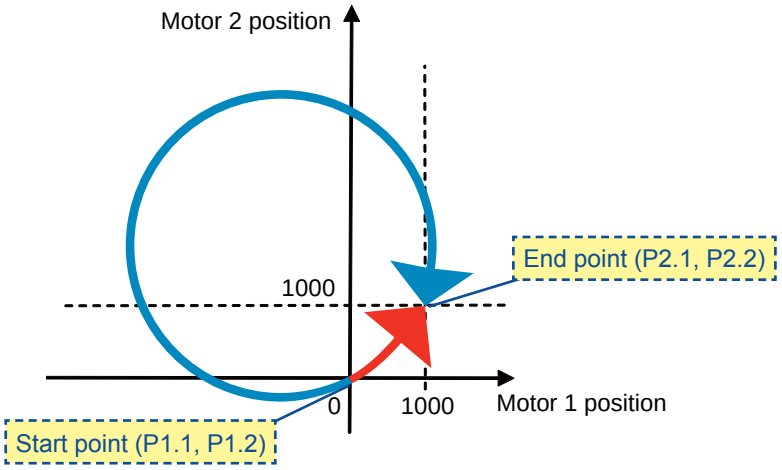
…Definition of Radius — Motor 1 (X axis) Data definition

…Definition of Radius — Motor 2 (Y axis) Data definition

```
B1.1
A1.1,S1.1,P1.1,A1.2,S1.2,P1.2
R1.1,R1.2,@2.2+,@2.1+
END
```

…Move to the starting point of circular arc.
…Move to the end point (P2.1,P2.2).
Draw a long arc in the CW direction with Radius R1.

The Program Bank above draws a circular arc trajectory outlined in blue, where the modifier for R command is + (Long Arc) and the modifier for @ command is + (CW).



In contrast, the program below draws a circular arc trajectory outlined in red, where the modifier for R command is - (Short Arc) and the modifier for @ command is - (CCW).

```
B2.1
A1.1,S1.1,P1.1,A1.2,S1.2,P1.2
R1.1-,R1.2-,@2.2-,@2.1-
END
```

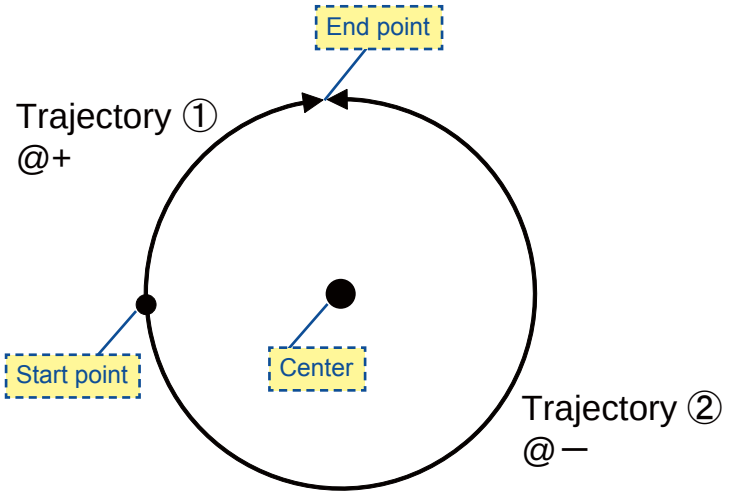
…Move to the starting point
…Move to the end point (P2.1,P2.2).
Draw a short arc in the CCW direction with radius R1.

4.4.2. Circular Interpolation by Specifying Center Point

By specifying starting point (current position), end point and center point (N), circular interpolation is possible with the motors. There are 2 different motion trajectories by combining N command (specify center point), @ command (execute interpolation) and + or - modifier.

In this case, the radius of a circle is automatically calculated.

Command	+	-
@	CW	CCW




```
A1.1=100
S1.1=100
P1.1=0
P2.1=1000
N1.1=-823
A1.2=100
S1.2=100
P1.2=0
P2.2=1000
N1.2=1823
```

…Definition of center — Motor 1 (X axis) Data definition

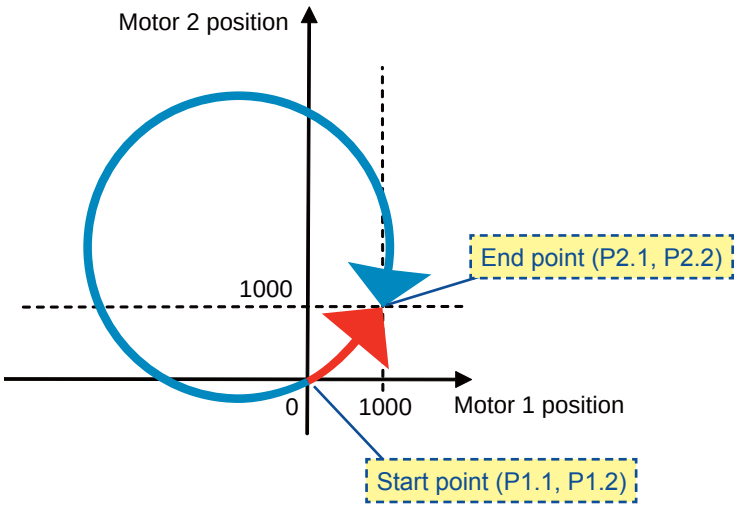
…Definition of center — Motor 2 (Y axis) Data definition

```
B1.1
A1.1, S1.1, P1.1, A1.2, S1.2, P1.2
N1.1, N1.2, @2.2+, @2.1+
END
```

…Move to the starting point of circular arc.

…Move to the end point(P2.1,P2.2).
Draw a circular arc in the CCW direction with radius R1.

The program above draws a circular arc outlined in blue.



The program below draws a circular arc outlined in red.

```
B2.1
A1.1,S1.1,P1.1,A1.2,S1.2,P1.2
N1.1,N1.2,@2.2-,@2.1-
END
```

…Move to the starting point

…Move to the end point (P2.1,P2.2).

Draw a circular arc in the CCW direction with radius R1.

4.4.3. Linear Interpolation

When R memory (radius data) is set to 0 (zero) in circular interpolation by specified radius, the motors perform linear interpolation.

Define the end point and set R memory to 0. The motors perform linear interpolation starting from the starting point (current position) to the end point. + or - modifier for R command and @ command do not affect the motion trajectory.

```
A1.1=100
S1.1=100
P1.1=0
P2.1=1000
R1.1=0
A1.2=100
S1.2=100
P1.2=0
P2.2=1000
R1.2=0
```

…Specify Linear interpolation

Motor 1 (X axis) Data definition

Motor 2 (Y axis) Data definition

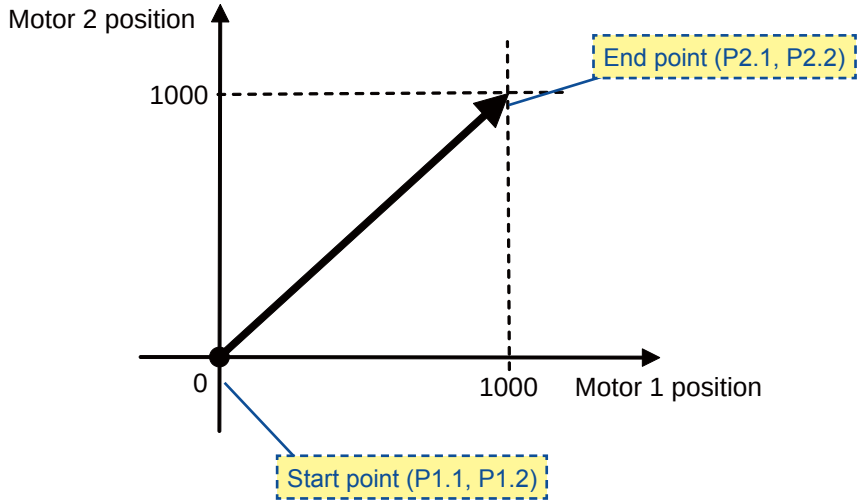
…Specify Linear interpolation

```
B1.1
A1.1,S1.1,P1.1,A1.2,S1.2,P1.2
R1.1,R1.2,@2.2,@2.1
END
```

…Move to the starting point.

…Perform linear interpolation to the end point (P2.1,P2.2).

The program above draws a line outlined in black.



4.5. Ladder Logic Banks

In this section Ladder Logic Banks are introduced. Execution of commands in a Ladder Logic Bank does not accompany the motion of motor. Only arithmetic and/or logical operations and branch processing are executed in the bank.

4.5.1. Basic Operations

```
L1.1
V1=V1+V2          …Add V2 to V1
V1>V3, V1=V3, T0  …Branching without motion
V1<V4, V1=V4, T0  …Branching without motion
V3=V1             …Set value of V1 to V3
P1.1              …Display P1 value
END
```

Ladder Logic Bank1

In describing a Ladder Logic Bank, place [L Bank No. Motor ID] at the beginning of bank and describe any command lines after that.

When P command is used in a Ladder Logic Bank, it does not cause any motion. It only displays the value of P memory.

As a Ladder Logic Bank is continuously executed in the period of time based on parameter K63, X command can not be available in Ladder Logic Bank.

Chapter 5

Setting Examples

In this section, parameter settings or procedures required for realizing various functions are described.

5.1. Manual Jog / Feed

【Manual Jog】

Manual jog makes the motor move incrementally by the number of pulses set by parameter, with each input of one-shot signal. This is useful for fine adjustments.

The setting of parameters is as below.

Parameter	Contents	
K28	Quick Response Rising Edge	Set to either of followings. 8 : Manual Jog in CW direction 9 : Manual Jog in CCW direction
K29	Quick Response Falling Edge	
K31	Slow Response Rising Edge	
K32	Slow Response Falling Edge	
K50	Number of pulses for one movement	

【Manual Feed】

Manual feed makes the motor move in a specified direction continuously while the signal is ON. The motor stops when the signal is OFF.

The setting of parameters is as below.

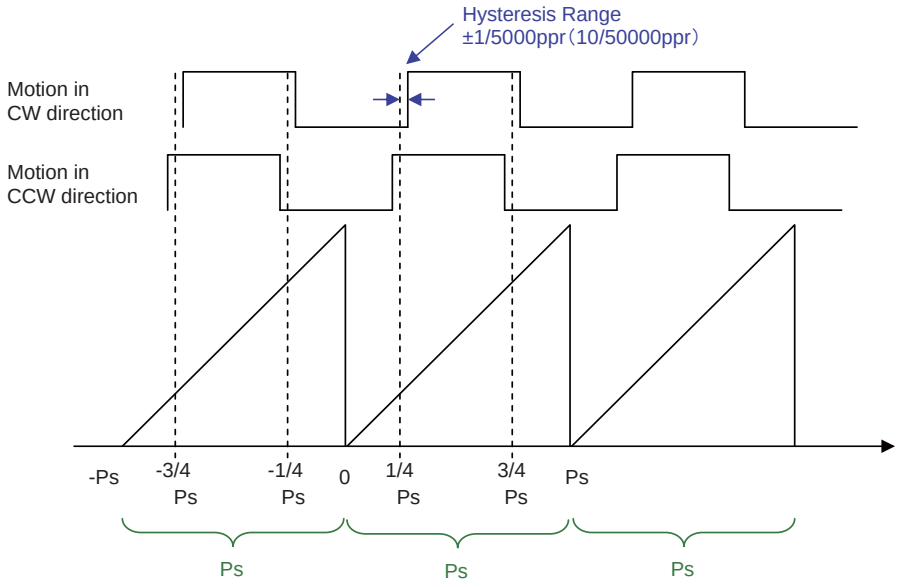
Parameter	Contents	
K27	at the Quick Response Target Voltage	Direction of continuous rotation 3 : CW direction, 4 : CCW direction
K30	at the Slow Response Target Voltage	
K49	Manual Feed Speed	

* If a motion is stopped by an alarm or stop command. Please cancel an alarm then turn signal off then back on.

5.2. Rotation Pulse Output

The motor's current position shall be divided by the range of K24 value, the output will be ON at the first half of set position by K24 then OFF at the last half.

However the output timing will be different in CW and CCW direction because the threshold for output signal ON and OFF has plus minus 1/5000ppr (plus minus 10/50000ppr) hysteresis to the noise.



Parameter	Contents
K34	Output Functions [7 : Rotation Pulse Output] In case of Quadrature Encoder Output, both Output 1 Function and Output 2 Function should be set to 7.
K24	Position interval (number of pulses) for Rotation Pulse Output
K33	Output logic by ON or OFF.

Depending on the value of parameter K24 and the rotation speed of motor, the time interval of output pulse may be less than 0.5 msec.
In that case, the Rotation Pulse could not be output correctly.

5.3. Origin Search

Origin Search can be executed by transmitting “| (bar)” command or by using the input to which Origin Search Start Function is assigned through setting “7” in parameter K28, K29, K31 or K32.

Origin Search operates according to the following parameter setting.

Parameter	Contents
K42	Speed for Origin Search
K43	Acceleration for Origin Search
K45	Origin Search Direction : CW or CCW
K46	Origin Signal Source
K48	Offset Distance Between Machine Origin and Electrical Origin

Besides, "Origin Signal Source" of parameter K46 and related parameter settings are necessary.

5.3.1. Origin Search using Stopper

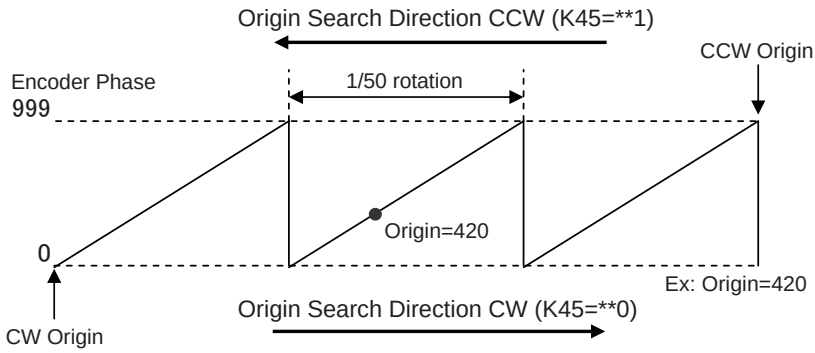
The following parameter setting is also necessary for the Origin Search by Stopper.

Parameter	Contents
K46	Origin Signal Source 0 or 1: Origin Search by Stopper
K47	Torque Level when searching for origin using a Stopper

Origin Search completes when the torque pushing against the stopper reaches the set level by K47 and the speed goes 1/16 below the set speed by K42. Then the encoder phase value will be displayed.

For the stable origin search, adjust an attachment as a coupling for the encoder phase value indicated in “Origin=* * * ” to be between 200 and 800.

The encoder phase will straightly changes from 0 to 999 per 1/50 rotation.
When the completion of Origin Search, in-position signal will be output and the motor stops at the encoder phase 0 point that is 1 cycle ahead of completion.



5.3.2. Origin Search using Sensor

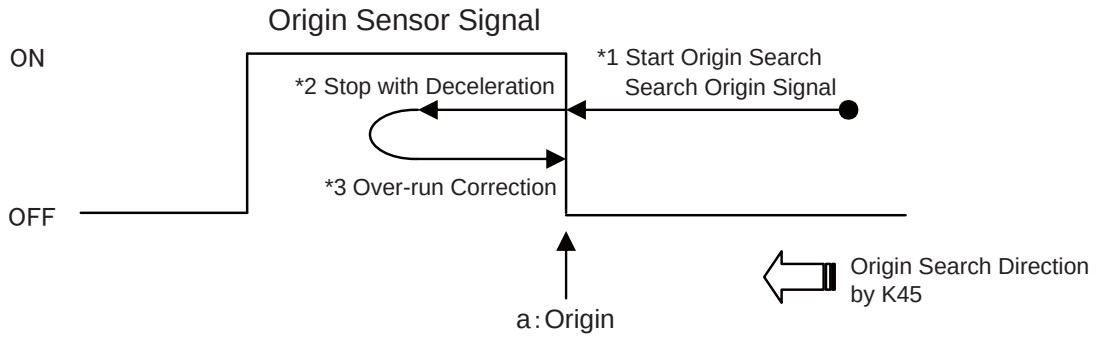
The following parameter setting is also necessary for the Origin Search by sensor.

Parameter	Contents
K27	Input Functions at the Quick Response Target Voltage “2 : Origin Sensor” Do not set “2 : Origin Sensor” to multiple inputs to prevent abnormal detection of the origin sensor signal caused by the conflict between the inputs.

Moreover, depending on the status of origin sensor signal input when origin search starts, there are the following differences in the movement of origin search.

【When an origin sensor signal is OFF】

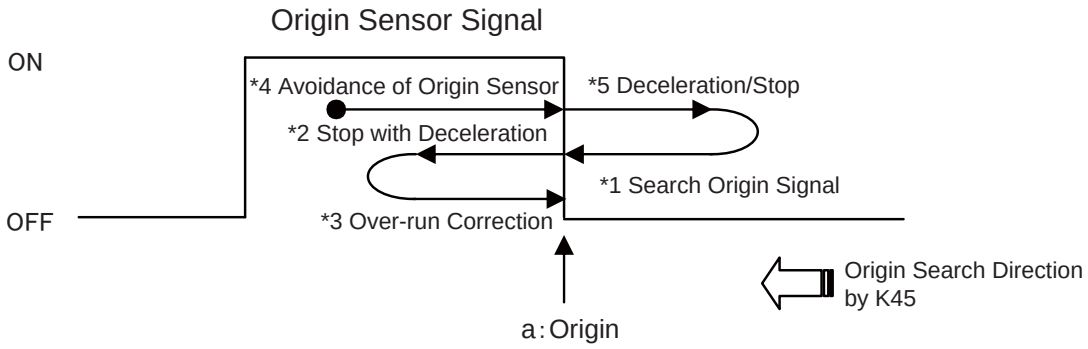
Start Origin Search, move in the direction set by K45, start deceleration at the rising edge of sensor signal and stop. Complete origin search after returning to the point a.



【When an origin sensor signal is ON】

For detecting the rising edge of sensor signal to be possible, move in the opposite direction from what is set by K45 to turn off a sensor signal.

When passing the point a in the figure, start to decelerate after detecting a sensor signal off, then the same motion as “When an origin sensor signal is OFF” in the previous paragraph will be executed.

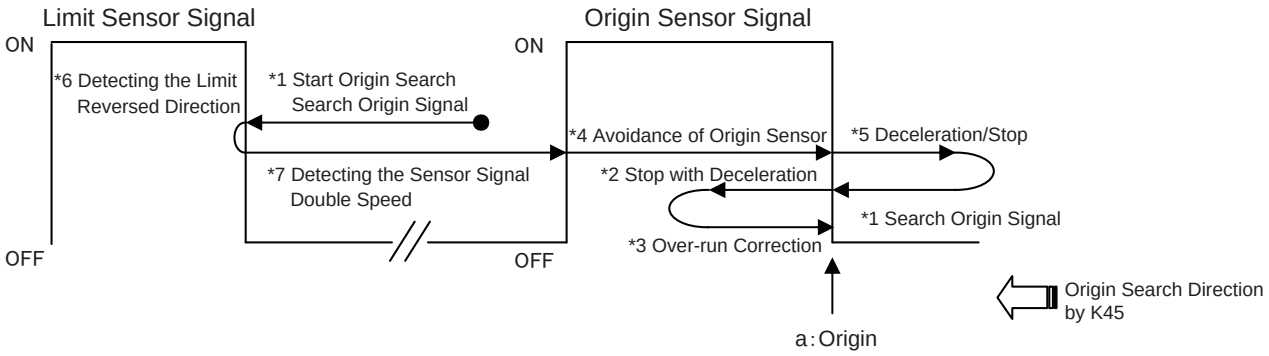


【Use of Limit Sensor concurrently】

Parameter	Contents
K27	Input Functions at the Quick Response Target Voltage “6 : CW Limit Sensor” or “9 : CCW Limit Sensor”

It will be operated as below when the Limit Sensor in the same direction as an origin search is assigned to another input.

Start Origin Search, move in the direction set by K45. After detecting the limit sensor signal, start to move in the reverse direction. Move at the double speed of what is set by K42, and detect the origin sensor signal. After detecting the origin sensor signal, then the same motion as "When an origin sensor signal is ON" in the previous paragraph will be executed.



【Example】

Input Functions at the
Quick Response Target Voltage
K27=629000

Origin Search Direction : CW

INPUT6 : CW Limit Sensor
INPUT5 : Origin Sensor
INPUT4 : CCW Limit Sensor
INPUT1～3 : No Operation

*If origin sensor signal is not asigned to "Input Functions at the Quick Response Target Voltage(QTV)"(K27), origin search using sensor can to be implemented.

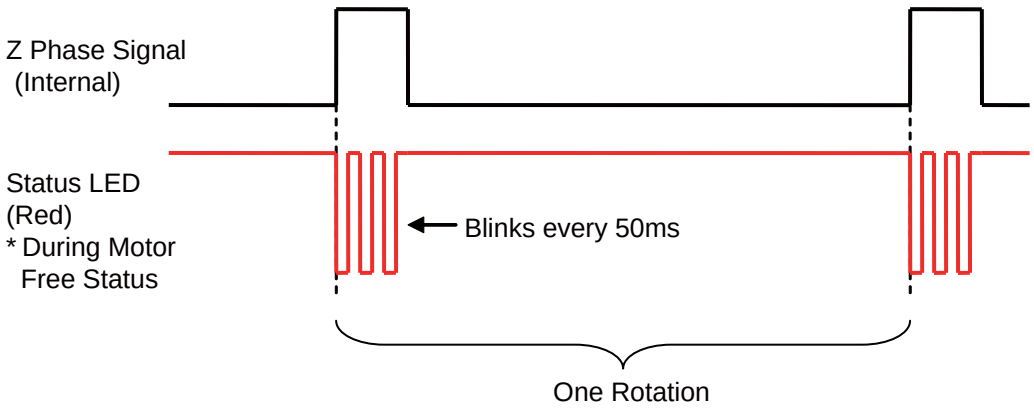
5.3.3. Origin Search with Z Phase Signal

The following parameter setting is also necessary for the Origin Search with Z Phase Signal.

Parameter	Contents
K46	Origin Signal Source 4-7: Z Phase Signal

Z Phase Signal is the signal generated by an internal position sensor of Cool Muscle 2 and output once per rotation. Usage of Z Phase Signal to detect an origin makes a precise origin search possible that always detects the same origin without an external origin sensor even in a rotary motion. The sequence for the origin search is the same as the origin search with sensor.

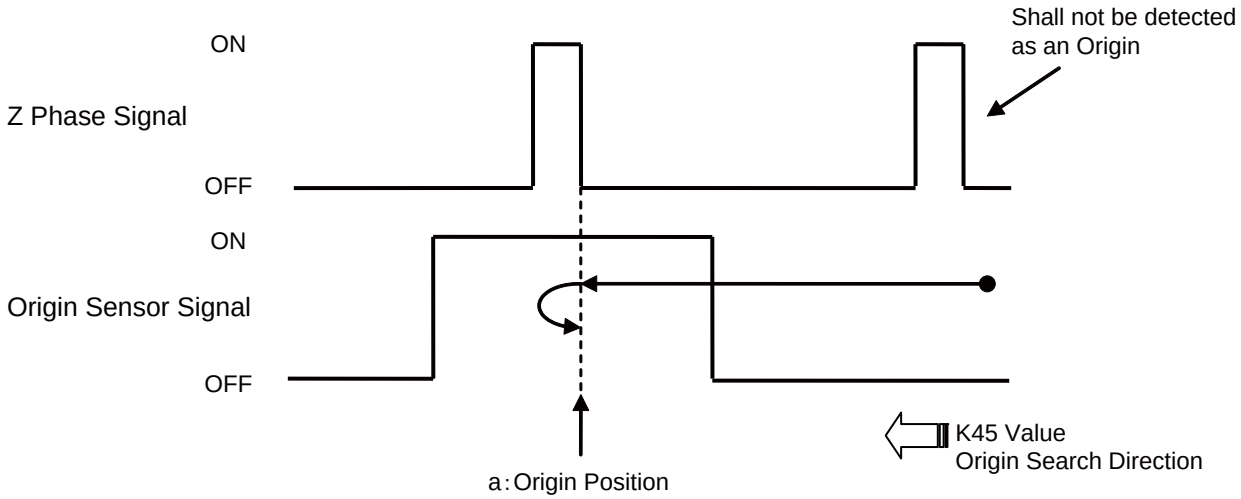
When the motor free by the command ") " or an input function, the status LED shall be on all the time but when the Z Phase Signal is selected by K46, the status LED shall blinks quickly only during the Z Phase Signal is output.



【Concurrent Usage with an Origin Sensor Signal】

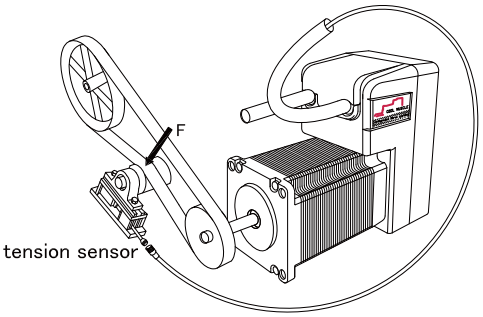
it is possible to detect an origin by a combination with the Z Phase signal and an origin sensor signal. Therefore an origin search with better repeat accuracy is possible.

The sequence of the Origin Search is the same as the Origin Search by sensor but the origin shall be the position where the effective edges of both a Z Phase signal and an origin sensor signal are detected.



5.4. External Encoder

The full closed-loop position control is available by using the output signal of external encoder equipped for the control target. It is possible to be compatible with the compensation for belt-slipping or backlash of gears, or position control for the stage with linear encoder.



When applying an external encode, the following parameter settings are needed.

Parameter	Contents
K71	External Encoder Type
K72	External Encoder Resolution

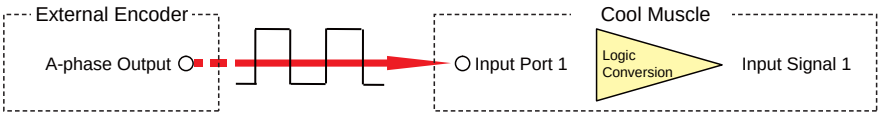
The outputs of external encoder are connected with Input port 1 and Input port 2 of Cool Muscle. Therefore the input functions assigned to Input 1 and Input 2 through parameter settings of K27 – K32 are not available.

【Signals connection between external encoder and Cool Muscle】

Configure the effective edge of input pulse signal by setting of parameter K26.

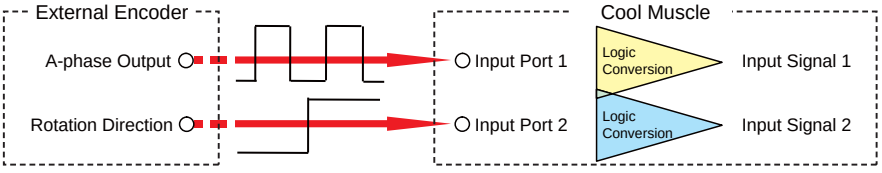
[A-phase signal: pulse input]

Every rising edge of input pulse, pulse counting is performed with either counting-up when moving with increasing position, or countdown when moving with decreasing position. The effectiveness of pulse is determined only at the rising edge of input signal, miscounting caused by noise or vibration of load axis could occur.



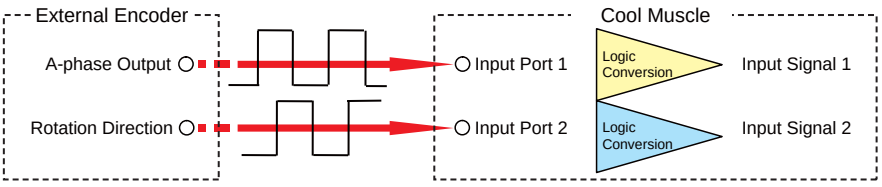
[A-phase signal: pulse input, B-phase signal: rotation direction]

Every rising edge of input pulse, either counting-up or countdown is performed in accordance with the rotation direction signal of external encoder. The effectiveness of pulse is determined only at the rising edge of input signal, miscounting caused by noise or vibration of load axis could occur.



[A-phase signal: pulse input, B-phase signal: pulse input]

When two-phase signal, of which phase is shifted by 90 degree each other, is input to Input 1 and Input 2, pulse counting is performed with automatically discriminating whether counting-up or countdown.



*Refer to Parameter K71 for detail information such as the timing of counting.

5.4.1. External Encoder / Index Operation

The motor continues to rotate until the count of external encoder pulse reaches the specified number of pulses. Then, the motor stops to rotate when count value reaching the specified number of pulses. (Recovering operation for the amount of overrun is not supported.)

This operation is appropriate for the equipment such as winding machine, where a fixed amount is required to be wound without slack in a fixed direction.

*In Index Operation, the motor operation is not affected by the setting for External Encoder Resolution (K72).

[Example of Use]

Set the parameter K71 according to the pulse type of external encoder.

K71.1=1 : A-phase Index

Set the data of position, speed and acceleration in the same manner as in normal positioning, and execute the operation.

P.1=10000 : Set the target position of load for the position data.

S.1=10 : Set the speed of Cool Muscle.

A.1=100 : Set the acceleration of Cool Muscle.

^.1

The motor continues to rotate at a set speed of S until the count value of external encoder pulse reaches 10000. Then, the rotation stops when the count value reaching 10000.

Although the actual count could overrun for the target position at this time, the motor stops right there without recovering operation for the amount of overrun.

It is possible to confirm the current count value of external encoder with using query command “?76”.

?76.1 : Transmission command to Cool Muscle

Ecnt.1=10005 : Receiving data from Cool Muscle

5.4.2. External Encoder / Feedback Operation

The whole system can be controlled as a full closed-loop system by utilizing the feedback pulse from external encoder equipped for the control target.

[Example of Use]

Set the pulse type and resolution of external encoder.

K71.1=4 :A&B phase feedback

K72.1=1000 :1,000 ppr

Set the data of position, speed and acceleration in the same manner as in normal positioning, and execute the operation.

P.1=10000 : Set the target position of load for the position data.

S.1=10 : Set the speed of Cool Muscle.

A.1=100 : Set the acceleration of Cool Muscle.

^.1

With tracking the command value, the feedback control for the position of control target is performed.

It is possible to confirm the current count value of external encoder with using query command “?76”.

?76.1 : Transmission command to Cool Muscle

Ecnt.1=10000 : Receiving data from Cool Muscle

5.4.3. External Encoder / Pulse-Counting Operation

The counting operation of pulses input to Cool Muscle from an external encoder is simply performed. The motor operates in the same manner as in normal positioning.
This operation is used for the control with responding to amount of movement or speed of control target.

[Example of Use]
In the following example, with using the Ladder Logic Bank described in the section 2.2.3, the motor speed can be changed according to the count of pulses from external encoder equipped for the control target.

Change the setting of General Variable 1, from V1.1=”Px” (current position) to V1.1=”Ecnt” (External Encoder Count).

V1.1 = “Ecnt” : Set the current count value of external encoder into General Variable 1.
Other settings and the definition of Ladder Logic Bank is the same as in the section 2.2.3.

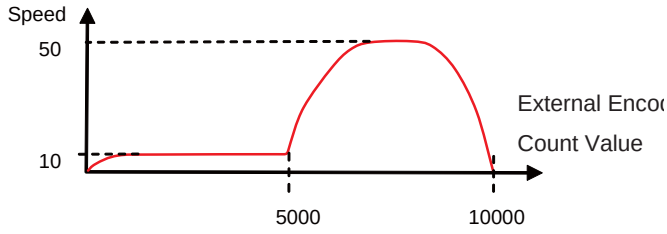
After completing all the definitions, execute the Ladder Logic Bank 1 through inputting the command as below.

```
[L1.1
```

Operate the motor in the Direct Mode as follows.

```
A.1=100
P.1=10000
^.1
```

In this example, the motor operates at the speed of 10 when the count value of external encoder is less than 5000, shown in the right.
However, it operates at the speed of 50 when the count value is over 5000.



5.5. Torque feedback control

The torque feedback control is available for applications such as push control common in pneumatic sliders or constant tension control.

It is needed to specify positions and speeds because the control is performed during the positioning operation.

When applying torque feedback control, the following parameter settings are needed.

Parameter	Contents
K38	Target controlled by Analog Input
K74	Proportional Gain for Torque Control
K75	Integral Gain for Torque Control
K76	Torque Sensor Input offset value
K77	Input range for Torque Sensor Signal

[Example of Setting]

Set Torque Feedback Control into parameter K38, “Target controlled by Analog Input”.

K38.1=10 : Setting the target controlled by Analog Input

Next, set K76, “Torque Sensor Input offset value”, and K77, “Input Range for Torque Sensor Signal”.

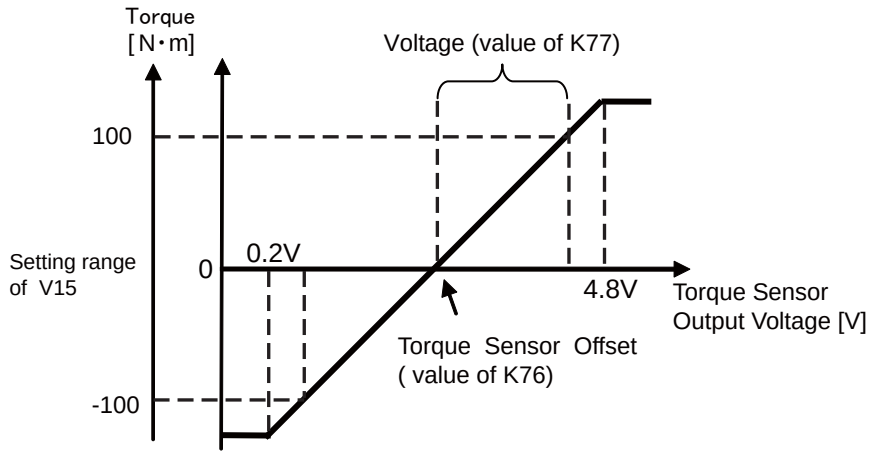
In the torque feedback control, the motor output can be controlled in accordance with K74 “Proportional Gain for Torque Control” and K75 “Integral Gain for Torque Control”, for the feedback data from external torque sensor to track the torque command value specified in the range 0 - ±100 by using General Variable 15.

When using the torque sensor with output of 1[V] per 0.2[N▪m] and offset voltage of 2.5[V], the controllable range is 0 - ±0.46[N▪m] because the analog input voltage is in the range of 0.2[V] - 4.8[V].

For example, the torque command value is required to be maximized (V15=100) when the detected torque of sensor is 0.4[N▪m], set parameters as below.

K76.1=250 : Set the offset voltage for Torque Sensor Input. (unit : 0.01 V)

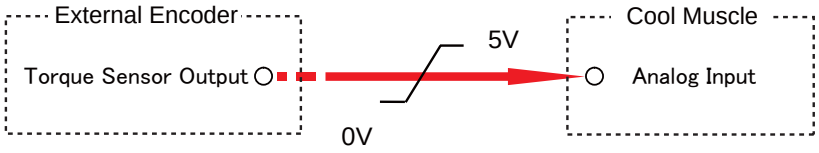
K77.1=200 : Set the difference between the output voltage of torque sensor at maximum torque command value and the offset voltage. (unit : 0.01 V)



At last, set the torque command value and operation range for torque feedback control. The torque command value is set into the General Variable 15 in the range 0 - ±100.
For example, Cool Muscle operates at the speed of 60[min-1] from current position to the position of 10000 pulses, meanwhile the load torque is required to be controlled with the constant torque of 0.1[N▪m] , set as below.

V15 = 25	: Setting for torque command value (0.1[N▪m]/0.4[N▪m] × 100)
S0 = 100	: Speed setting for Cool Muscle (at resolution[K37]=3)
P0 = 10000	: Setting for target position

After completing every setting, input the output voltage of torque sensor to Analog Input of Cool Muscle, and start operation. Torque feedback control is performed until Cool Muscle reaching the position of 10000.



5.6. Modbus Protocol

Modbus protocol, developed by Modicon Inc, is a communication protocol for PLC industry. The protocol is also widely used in FA and PA fields because its specifications are open to the public and the protocol structure is simple.

Cool Muscle can communicate with Modbus devices by only setting following parameters. There is no extra protocol converter needed.

Parameter	Contents
K20	Communication baud rate (Modbus host → Cool Muscle)
K65	Communication baud rate between slave devices (Cool Muscle → Modbus Slave)
K78	Modbus Host Communication. → Holding Register Address (Set -1 when not using)
K79	Modbus Slave Communication. → Coil Register Address (Set -1 when not using)
K80	Modbus Slave Communication. → Input Register Address (Set -1 when not using)
K81	COM0 Station Address
K82	Parity
K84	COM1 Communication Mode setting
K85	Endian

There are host and slave devices in Modbus communication. One device (the host) can initiate transactions (called queries). The other devices (the slaves) respond by supplying the requested data to the host or by taking the action requested in the query. Cool Muscle can be programmed as either a host or a slave device.

[Modbus Host Communication]

Cool Muscle can be used as a Modbus slave by connecting a Modbus host device to the host communication side of Cool Muscle. The host device can transmit commands to Cool Muscle, and read or write the data of Cool Muscle.

[Modbus Slave Communication]

Cool Muscle can be used as a Modbus host by connecting a Modbus slave device to the slave communication side of Cool Muscle. The I/O control or the status read of a slave device can be performed by Cool Muscle.

In the Modbus slave communication, a slave device can be treated as it exist on the daisy-chained network of Cool Muscles through automatically generating a Modbus message from some CML commands related to I/O. Accessing to a Modbus slave device can be performed by assigning the final Motor ID + 1 for the CML command.

Host communication port is defined as COM0, slave communication port is defined as COM1.

5.6.1. Message Transmission Mode

Modbus protocol equipped in Cool Muscle performs the message transmission in RTU (Remote Terminal Unit) mode.

Item		Contents
Communication method		Half-duplex, Asynchronous method
Communication Protocol		Modbus RTU mode
Baud Rate		9.6k, 19.2k, 38.4k, 57.6k, 115.2k, 230.4kbps (set by parameter K20 or K65)
Transmission Code		Binary
Error check (Error detection)	Vertical	Parity
	Horizontal	CRC-16
Character Format	Start Bit	1 bit
	Data Length	8 bit
	Parity Bit	None/Even/Odd (Set by parameter K82)
	Stop Bit	1 bit
Time internal between characters		Less than 8 byte time

5.6.2. Time Interval between Data

When transmitting a message, be sure that the time interval between data in a message must not exceed 8 byte times. If a longer interval than specified time occurs, Cool Muscle assumes a transmission has terminated and performs reception of an illegal message.

Baud Rate	Time Interval of Data
9.6 kbps	Less than 6.66msec
19.2 kbps	Less than 3.33msec
38.4 kbps	Less than 1.66msec
57.6 kbps	Less than 1.11msec
115.2 kbps	Less than 0.55msec
230.4 kbps	Less than 0.27msec

5.6.3. Message Framing

The Modbus message is constructed as below.

Slave Address (8 bits)	Function Code (8 bits)	Data	Error Check CRC-16 (16 Bits)

● Slave Address

The slave address is specified in the range of 1 - 247 decimal defined by parameter K81.

● Function Code

The function code is classified briefly as below. Refer to section 5.6.4 “Function Code” for detail information.

Code	Function	Remark
01	Read the status of slave output	only in the slave communication
02	Read the status of slave input	only in the slave communication
03	Read the motor information	only in the host communication
04	Read the I/O and status	only in the host communication
05	Single ON/OFF for slave outputs	only in the slave communication
15	Multiple ON/OFF for slave outputs	only in the slave communication
16	Command transmission to Cool Muscle and parameter setting	only in the host communication

● Data

The data field is formatted differently according to the function code. Refer to section 5.6.4 “Function Code” for detail information.

● Error Check

The 16-bit error checking code generated by CRC-16 method is appended as the last field in the message.

5.6.4. Broadcast Communication Function

The Modbus slave device execute a broadcast Modbus command without response, when the address in a Modbus frame is 0.

5.6.5. Endian (The order of transmitting data)

Big or little endian can be set by parameter K85. Endian is applied only to the data field, consisted of words, in a Modbus frame. A word consists of 2 bytes.

Ex. Transmission of 6553600(0x640000)

Big Endian

[Word 1] [Word 2]

0x0064 0x0000

Little Endian

[Word 1] [Word 2]

0x0000 0x0064

5.6.6 Modbus Setting and How to Use in Daisy Chain

Cool Muscle has 2 communication ports as host and slave port. Those ports can be set as Modbus communication and RS-232C communication individually.

Setting Example 1:

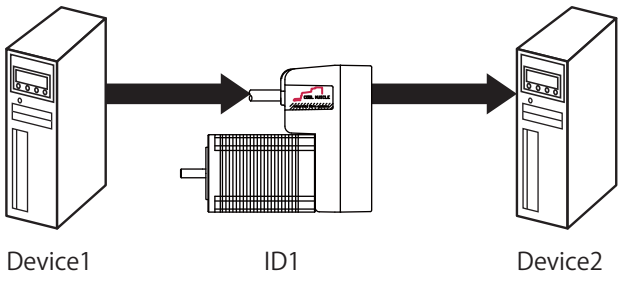
The system is shown in Fig.1. Device 1 accesses Cool Muscle ID1 or device 2, which is connected in the daisy chain.

Cool Muscle communication mode

COM0: Modbus slave

COM1: Modbus host

Fig.1



Set K81=1, K84=1

Cool Muscle's slave address is set as 1 by K81. Device 1 is able to read Cool Muscle's information. Set the register address by K78 (K78 + defined address)

Setting Example 2

The system consists of multiple Cool Muscles, shown in Fig.2.

Communication Mode of Cool muscle ID1

COM0: Modbus slave communication

COM1: RS-232C communication

Communication Mode of Cool muscle ID2

COM0: RS-232C communication

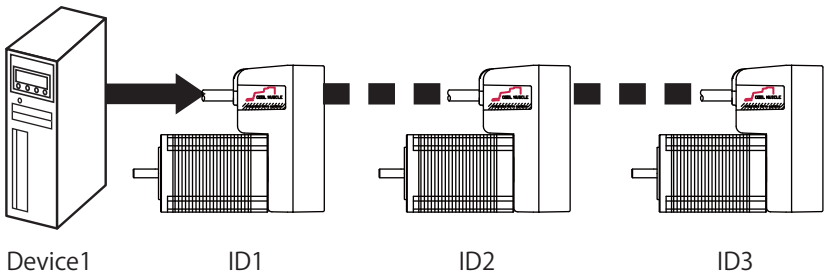
COM1: RS-232C communication

Communication Mode of Cool muscle ID3

COM0: RS-232C communication

COM1: RS-232C communication

Fig.2



Parameter	ID1	ID2	ID3
K81	1	0	0
K84	0	-4	-5

By setting a negative value to K84 (K84<0) to the Modbus slave addresses of cool muscle ID2 and ID3, Cool Muscles' Modbus addresses from Device 1 can be set.

Device 1 accesses Cool Muscle ID1 with address 1 set by K81, ID2 with address 4 (K84 value without a sign) and ID3 with address 5 (K84 value without a sign).

* K84 is only used as a Modbus address. CML ID number shall be used when operating ID2 and ID3 Cool Muscles in Daisy Chain by Direct Command or Program Banks.

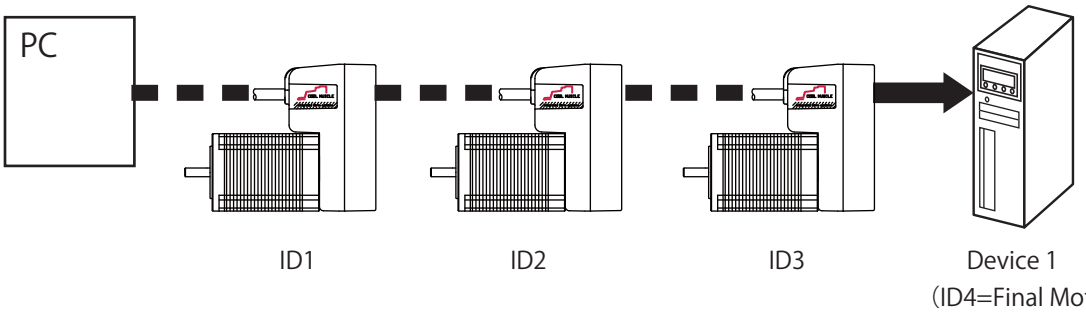
Example: Device 1disables Cool Muscle ID2

Field Name	Content (Hex)	Remark
Slave Address	0x04	Modbus Address
Function Code	0x10	
Starting Address(Hi)	0x00	
Starting Address(Lo)	0x64	
Number of Register(Hi)	0x00	
Number of Register(Lo)	0x02	
Number of Byte	0x04	
Data1(Hi)	0x29	)
Data1(Lo)	0x2E	.
Data2(Hi)	0x32	2
Data2(Lo)	0x0D	CR
	0x0D	CR
Error Check	CRC(16 Bit)	

Setting Example 3

To set Only COM1 of Cool muscle ID3, shown in Fig.3, as Modbus communication mode.

Fig.3



Parameter	ID1	ID2	ID3
K81	0	0	0
K84	0	0	1

By setting K84=1 to the Cool Muscle connected at the end of Daisy Chain, only COM1 of ID3 Cool Muscle is set to Modbus host communication mode.

When multiple Cool Muscles are connected, the Device 1 (ID4) can not access to ID1-ID3. Set the final motor ID + 1 to the ID number of transmitted data to access the Device 1 (ID4) through Daisy Chain from PC. Be sure to set the Modbus address of Device 1 (ID4) as 1.

Example: PC Queries input information from Device 1(Modbus address 1).

Sending data: ?70.4[CR]

Receiving data: IN.4=1A04

* The number of register of Device 1 is 16. Receiving data is displayed by hex number.

5.6.7 Function Code

In case of using the following parameter settings, an example of a response to each function code is shown as below. (In Modbus slave communication, Modbus slave device's Daisy Chain ID is ID4)

Parameter	Content	Set value
K78	Modbus host communication - input address	100
K79	Modbus slave communication - input address	200
K80	Modbus slave communication - output address	300
K81	Slave address	1

【Function Code : 01 (0x01)】

● Function

The output status in the slave can be read.

This function is supported only in communication with Modbus slave device.

● Transmission Message

The transmission message to the slave is generated automatically by transmitting Output Status - Query Command "?50.n" to Cool Muscle. (n = the final Motor ID + 1 : indicating the Modbus slave device ID) The number of Read Registers is fixed to 16.

Example : An automatically generated transmission message to the slave when transmitting "?50.4" to Cool Muscle.

When the starting address is set to 300 (0x2C hex) by K80, the 16 output status are read from address 301 in a slave device.

Field Name	Content (Hex)	Remark
Slave Address	0x01	Set by K81
Function Code	0x01	
Starting Address (Hi)	0x01	Set by K80
Starting Address (Lo)	0x2C	
Number of Registers (Hi)	0x00	Fixed
Number of Registers (Lo)	0x10	
Error Check	CRC (16 bits)	

● Response

The response from the slave is interpreted by Cool Muscle automatically.

The Modbus Slave device address is 1.

【Function Code : 02 (0x02)】

● Function

The input status in the slave can be read. This function is supported only by Modbus slave communication.

● Transmission Message

The transmission message to the slave is generated automatically by transmitting Input Status - Query Command “?70.n” (n = the final Motor ID + 1 : indicating the Modbus slave device ID) to Cool Muscle. The number of Read Registers is fixed to 16.

Example : An automatically generated transmission message to the slave when transmitting “?70.4” to Cool Muscle.

When the starting address is set to 200 (0xC8 hex) by K79, the 16 output status are read from address 201 in a slave device.

Field Name	Content(Hex)	Remark
Slave Address	0x01	Set by K81
Function Code	0x02	
Starting Address (Hi)	0x00	Set by K79
Starting Address (Lo)	0xC8	
Number of Registers (Hi)	0x00	Fixed
Number of Registers (Lo)	0x10	
Error Check	CRC (16 bits)	

● Response

The response from the slave is interpreted by Cool Muscle automatically.

The Modbus Slave device address is 1.

【Function Code : 03 (0x03)】

● Function

Read registers (motor information) at given address. This function is only supported in communication with a Modbus host device. The length of data bytes is 4 bytes.

Address	Correspondent CML	Motor Information
K78	?95	Position Error
K78+2	?96	Current Position
K78+4	?97	Current Speed
K78+6	?98	Current Torque
K78+8	?99	Motor Status
K78+10 ~ +40	V0 ~ V15*	V variables
K78+52	?74	Analog Input
K78+54		Analog Output
K78+56	?70	Input Status
K78+58	?50	Output Status
K78+200 ~ +600	P0 ~ P200*	Position Data 0 ~ 200
K78+602 ~ +632	S0 ~ S15*	Speed Data 0 ~ 15
K78+634 ~ +650	A0 ~ A8*	Acceleration Data 0 ~ 8
K78+652 ~ +668	M0 ~ M8*	Torque Limit 0 ~ 8
K78+670	H0	Servo Stiffness
K78+686	?71	Temperature
K78+696 ~ +710	T1 ~ T8*	Timer Data 1 ~ 8
K78+752 ~ +890	K20 ~ K89*	Parameter 20 ~ 89

*The number of addresses shall be increased incrementaly with 2 since all the data are Long type (2 Word).
Ex. V0:K78+10, V1:K78+12

● Transmission Message

Example: The transmission data frame in order to read register P0, which is set as P0=12345(0x3039) is shown as follows.
Note that the start address is set as 300 when K78=100.

Field Name	Content (Hex)	Remark
Slave Address	0x01	Modbus Address
Function Code	0x03	Function 3
Starting Address(Hi)	0x01	300
Starting Address(Lo)	0x2C	P0 Address :K78+200
Register Number(Hi)	0x00	(Address =100 + 200)
Register Number(Lo)	0x02	
Error Check	CRC(16 Bit)	Fix

● Response

Example: The response of reading of P0=12345(0x3039). The slave address and function code are echoed back without modification. The data byte number is 2Word (4 bytes).

Field Name	Content (Hex)	Remark
Slave Address	0x01	Modbus Address
Function Code	0x03	Function 3
Data Bytes	0x04	
Data 1(Hi)	0x00	2Word
Data 1(Lo)	0x00	
Data 2(Hi)	0x30	
Data 2(Lo)	0x39	
Error Check	CRC(16 bit)	

In the above case, the P0 is 0x3039(Decimal: 12345).

【Function Code : 04 (0x04)】

● Function

The I/O and the status information can be read.

This function is supported only in the Modbus host communication.

Motor Information	Register Address	Corresponding CML
Input Status (ID1∼ID15)	K78 setting ∼K78+14	?70.n (n : Motor ID)
Output Status (ID1∼ID15)	K78 setting +16 ∼K78+30	?50.n (n : Motor ID)
Motor Status (ID1∼ID15)	K78 setting +32 ∼K78+46	?99.n (n : Motor ID)

● Transmission Message

Example : The transmission message to read the 3 input status of ID3 - ID5.

The set value of K78 represents ID1, so that ID3 is the set value of K78 + 2. Note that the starting address is 102 (0x66 hex), which indicates ID3.

Field Name	Content (Hex)	Remark
Slave Address	0x01	Set by K81
Function Code	0x04	
Starting Address (Hi)	0x00	
Starting Address (Lo)	0x66	
Number of Registers (Hi)	0x00	
Number of Registers (Lo)	0x03	
Error Check	CRC (16 bits)	

● Response

Example: Responses from Cool Muscle.

The slave address and the function code are echoed back without modification.

Field Name	Content (Hex)	Remark
Slave Address	0x01	
Function Code	0x04	
Number of Data Bytes	0x06	
Data1 (Hi)	0x00	
Data1 (Lo)	0x3F	
Data2 (Hi)	0x00	
Data2 (Lo)	0x02	
Data3 (Hi)	0x01	
Data3 (Lo)	0xFF	
Error Check	CRC (16 bits)	

【Function Code : 05 (0x05)】

● Function

Turn a single output either ON or OFF in the slave.

This function is only supported in the communication with Modbus slave device.

● Transmission Message

The query message to the slave is generated automatically by sending Output ON / OFF Command “O#.n” or “F#.n” to Cool Muscle. (n = the final Motor ID + 1 : indicating the Modbus slave device ID)

Example : A query message to the slave when transmitting “O7.4” to Cool Muscle. (automatically generated).

Note that the starting address is 206 (0xCE hex), which is the 7th address from 200 (set value of K80) of a slave device address.

Field Name	When Output is On	When Output is Off
Slave Address	0x01	0x01
Function Code	0x05	0x05
Starting Address (Hi)	0x00	0x00
Starting Address (Lo)	0xCF	0xCF
Preset Data (Hi)	0xFF	0x00
Preset Data (Lo)	0x00	0x00
Error Check	CRC (16bits)	CRC (16 bits)

● Response

The response from the slave is interpreted by Cool Muscle automatically.

The Modbus Slave device address is 1.

【Function Code : 15 (0x0F)】

● Function

Turn multiple outputs either ON or OFF. This function is only supported in communication with a Modbus slave device.

● Transmission Message

The query message to the slave is generated automatically by sending Output ON/OFF Command “O#. n=X” to Cool Muscle (n = the final Motor ID + 1 : indicating the Modbus slave device ID, X=output status). The number of registers is fixed to 16 and the number of bytes is fixed to 2.

Example: Set the 16 output status from address 301 in a slave device.

Address	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316
Status	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
Binary	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	1

The data is 0xCD01 hex, so that the data to be set to the output status is 52481 decimal.

Example : The query message to the slave when transmitting “ O.4=52481” to Cool Muscle (automatic generation).

Field Name	Content (Hex)	Remark
Slave Address	0x01	Set by K81
Function Code	0x05	
Starting Address (Hi)	0x01	Set by K80
Starting Address (Lo)	0x2C	
Number of Registers (Hi)	0x00	Fixed
Number of Registers (Lo)	0x10	
Number of Bytes	0x02	Fixed
Preset Data (Hi)	0xCD	
Preset Data (Lo)	0x01	
Error Check	CRC (16 bits)	

● Response

The response from the slave is interpreted by Cool Muscle automatically.

The address of the Modbus slave device is 1 in this application.

【Function Code : 16 (0x10)】

● Function

Sends specified commands to Cool muscle

Function	Register Address	Remark
Set V0 ~ V15 value	K78+10 ~ 40*	
Send CMLCommand	K78+100	Command is formatted in ASC II code. Refer to Table 1 for ASCII code table
Send CMLCommand (For Modbus)	K78+102	
Set P0 ~ P200 value	K78+200 ~ 600*	
Set S0 ~ S15 value	K78+602 ~ 632*	
Set A0 ~ A8 value	K78+634 ~ 650*	
Set M0 ~ M8 value	K78+652 ~ 668*	
Set H0 parameter value	K78+670	Servo Stiffness
Set T1 ~ T8 value	K78+696 ~ 710	
Set K20 ~ K89 param. value	K78+752 ~ 890	

● Transmission Message

Example: Set P0=12345(0x3039) when K78=100. The data byte number is 2Word (4 bytes).

Example: Method by writing to Register Address

Filed Name	Content (Hex)	Remark
Slave Address	0x01	Modbus Address
Function Code	0x10	Function 16
Starting Address(Hi)	0x01	Set Address to 300 Address of P0 :K78+200 (Address =100 + 200)
Starting Address(Lo)	0x2C	
Number of Registers(Hi)	0x00	
Number of Registers (Lo)	0x02	
Number of Bytes	0x06	
Data1(Hi)	0x00	Data In 2Words
Data1(Lo)	0x00	
Data2(Hi)	0x30	
Data2(Lo)	0x39	
Data3(Hi)	0x0D	CR
Data3(Lo)	0x00	
Error Check	CRC(16 bits)	

* Enter CR (0x0D) at the end of data. Add 0x00 following CR when data is an odd number.

Example: Method of CML Command

Field Name	Content (Hex)	Remark
Slave Address	0x01	Modbus Address
Function Code	0x10	Function 16
Starting Address(Hi)	0x00	Set Address to 200 CML Address : K78+100 (Address =100 + 100)
Starting Address(Lo)	0xC8	
Number of Registers(Hi)	0x00	
Number of Registers (Lo)	0x02	
Number of Bytes	0x06	
Data1(Hi)	0x50	P
Data1(Lo)	0x31	0
Data2(Hi)	0x3D	=
Data2(Lo)	0x00	In 2Word
Data3(Hi)	0x00	
Data3(Lo)	0x30	
Data4(Hi)	0x39	
Data4(Lo)	0x0D	CR
Error Check	CRC (16bits)	CRC(16 bits)

Endian should be applied to the data field after 0x3D

Example: Method of CML Command by Modbus

Field Name	Content (Hex)	Remark
Slave Address	0x01	Modbus Address
Function Code	0x10	Function 16
Starting Address(Hi)	0x00	Set Address to 202 Modbus CML Command Address : K78+102 (Address =100 + 102)
Starting Address(Lo)	0xCA	
Number of Registers(Hi)	0x00	
Number of Registers (Lo)	0x02	
Number of Bytes	0x0A	
Data1(Hi)	0x50	P
Data1(Lo)	0x31	0
Data2(Hi)	0x3D	=
Data2(Lo)	0x31	1
Data3(Hi)	0x32	2
Data3(Lo)	0x33	3
Data4(Hi)	0x34	4
Data4(Lo)	0x35	5
Data5(Hi)	0x0D	CR
Data5(Lo)	0x00	
Error Check	CRC(16 bits)	

● Response

Example: Response from Cool Muscle is shown as below.

When it is received properly, a part that excludes the number of byte and data area in the query message is copied and responded.

Field Name	Content (Hex)	Remark
Slave Address	0x01	
Function Code	0x10	
Starting Address(Hi)	0x00	
Starting Address(Lo)	0xC8	
Number of Registers(Hi)	0x00	
Number of Registers (Lo)	0x02	
CRC Check	CRC (16 bits)	

Table1. ASCII Code Character Table

High / Low	0	1	2	3	4	5	6	7
0	NUL	DLE	SP	0	@	P	`	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETX	DC3	#	3	C	S	c	s
4	EOT	DC4	$	4	D	T	d	t
5	ENQ	NAC	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF/NL	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	{
C	FF	FS	,	<	L	\	l	|
D	CR	GS	-	=	M	]	m	}
E	SO	RS	.	>	N	^	n	~
F	SI	US	/	?	O	_	o	DEL

5.6.8. Exception Responses

When a slave device receives the query from a host device, it returns a normal response in normal operation. However, it will return an exceptional response if abnormal events occur, as below.

The exception response contains the following fields.

Slave Address (8 bits)	Function Code (8 bits)	Exception Code (8 bits)	Error Check CRC-16 (16 bits)

Slave address shall be set as the normal response.

Function code is the transmission message + 0x80 (Hex).

Function Code	Function Code +0x80
03 (0x03)	0x83
04 (0x04)	0x84
16 (0x10)	0x90

Exception Code

Exception Code	Name	Contents
01	Incorrect Function	The function code received is not allowable
02	Incorrect Data Address	The specified data address does not exist

5.6.9. Termination of Modbus Mode

The normal RS-232C communication cannot be performed under the Modbus host communication mode.

The communication mode of Cool Muscle can be switched from the Modbus communication mode to the normal RS-232C communication by setting K81=0 using a Modbus compatible device.

If the Modbus communication mode is required to be terminated by a Modbus incompatible device or the mode has been set accidentally, it is possible to terminate the Modbus mode and perform normal RS-232C communication temporally by sending “FFFFFFFFF” (Sending F nine times continuously) to Cool Muscle after confirming that the communication baud rate is correct.

In this condition, the Modbus communication mode will be terminated by setting K81=0.

Chapter 6

CML List

6.1. K Parameter

K	Parameter	Min	Max	Default	Unit	Description
20	Baud Rate	0	5	0	-	The communication baud rate between Cool Muscle and a host. 0: 38.4kbps, 1: 9.6 kbps, 2: 19.2 kbps, 3: 57.6 kbps, 4: 115.2 kbps, 5: 230.4 kbps
23	Status Report	0	31	1	-	Event selection for status report setting for Local Echo, confirmation/error messages. 0: No status report 1: In-position and alarm 2: Input status change 4: Output status change 8: No Local Echo 16: Confirmation / error messages
24	Rotation Pulse Output	10	50000	1000	pulses	Output ON/OFF at regular intervals with pulses.(set K34=7) When both Output 1 and Output 2 in K34 values are set to 7, quadurature encoder pulse is output.
25	Delay Time for Slow Response Signal	111111	999999	333333	0.1sec	The delay timel for slow response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1.
26	Input Logic / P type Operation	000000	333333	000000	-	Input Logic and Execution of P type Operation Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. ① Input Logic 0 or 2 : Input signal is ON when Input port is ON. (P type effective edge: rising edge) 1 or 3 : Input signal is ON when Input port is OFF. (P type effective edge: falling edge) ② Execution of P type operation (Apply to C/R type) Set the value "2" or "3" of Input 3 to Input 6 : When Input Signal is ON, P type operation is valid and accept the Pulse signal. When Input Signal is OFF, P type operation is Invalid and refuse the Pulse signal. Set the value "2" or "3" of Input 1 or Input 2 : CM2 operates P type operation when setting values are "2" or "3" to two or more input, during input signal is ON at either Input 1 or Input 2.

K	Parameter	Min	Max	Default	Unit	Description
27	Input Functions at the Quick Response Target Voltage	000000	999999	000000	-	Assign functions at target voltage level of quick response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. 0: No function 1: General Use 2: Origin sensor signal 3: Manual feed CW 4: Manual feed CCW 5: Stop Ladder Logic Bank 6: CW direction limit sensor (Dual usage as CW origin sensor) 7: Emergency stop 8: Terminate the Program Bank (same as]]) 9: CCW direction limit sensor (Dual usage as CCW origin sensor)
28	Input Function at Rising Edge of Quick Response Signal	000000	999999	000000	-	Assign functions at rising edge of quick response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. 0: No function 1: Alarm reset/Program Bank Pause 2: Motor free 3: Position counter reset 4: Execute next Program Bank line 5: Execute previous Program Bank line 6: Execute Program Bank 1 7: Start origin search 8: Manual jog CW (K36=2 or 3, execute Program Bank 2) 9: Manual jog CCW (K36=2 or 3, execute Program Bank 3)
29	Input Function at Falling Edge of Quick Response Signal	000000	999999	000000	-	Assign functions at falling edge of quick response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. 0: No function 1: Alarm reset/Program Bank Pause 2: Enable motor 3: Position counter reset 4: Execute next Program Bank line 5: Execute previous Program Bank line 6: Execute Program Bank 1 7: Start origin search 8: Manual jog CW (K36=2 or 3, execute Program Bank 2) 9: Manual jog CCW (K36=2 or 3, execute Program Bank 3)

K	Parameter	Min	Max	Default	Unit	Description
30	Input Functions at Slow Response Target Voltage	000000	999999	000000	-	Assign functions at target voltage level of quick response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. 0: No function 1: General Use 2: - 3: Manual feed CW 4: Manual feed CCW 5: Stop Ladder Logic Bank 6: CW direction limit sensor 7: Emergency stop 8: Terminate the Program Bank (same as]]) 9: CCW direction limit sensor
31	Input Function at Rising Edge of Slow Response Signal	000000	999999	000000	-	Assign functions at rising edge of quick response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. 0: No function 1: Alarm reset/Program Bank Pause 2: Motor free 3: Position counter reset 4: Execute next Program Bank line 5: Execute previous Program Bank line 6: Execute Program Bank 1 7: Start origin search 8: Manual jog CW (K36=2 or 3, execute Program Bank 2) 9: Manual jog CCW (K36=2 or 3, execute Program Bank 3)
32	Input Function at Falling Edge of Slow Response Signal	000000	999999	000000	-	Assign functions at falling edge of quick response signal. Each digit must be set individually and assigns Input 6, 5, 4, 3, 2, 1. 0: No function 1: Alarm reset/Program Bank Pause 2: Enable motor 3: Position counter reset 4: Execute next Program Bank line 5: Execute previous Program Bank line 6: Execute Program Bank 1 7: Start origin search 8: Manual jog CW (K36=2 or 3, execute Program Bank 2) 9: Manual jog CCW (K36=2 or 3, execute Program Bank 3)
33	Output logic	0000	1111	1111	-	Set output logic. Each digit must be set individually and assigns Output 4, 3, 2, 1. 0: Output port is ON when Output signal is OFF. 1: Output port is ON when Output signal is ON.

K	Parameter	Min	Max	Default	Unit	Description
34	Output Functions	0000	9999	0000	-	Assign Output Functions. Each digit must be set individually and assigns Output 4, 3, 2, 1. 0: No function 1: In-position 2: Alarm 3: General Use 4: Completion of origin search 5: - 6: In-position signal in merge motion 7: Rotation pulse output. When both Output 1 and Output 2 are set to 7, quadrature encoder pulse output. 8: In motor free 9: In push motion
35	Analog Output Functions	0	9	0	-	0: Target position 1: Target position data magnified by 8 2: Current position 3: Current position data magnified by 8 4: Position error 5: Position error data magnified by 8 6: Current speed 7: Current speed data magnified by 8 8: Current torque 9: Current torque data magnified by 8
36	Command Pulse Format	0	3	0	-	Set P type motor to either CW/CCW mode or pulse/direction mode. Or assign functions at rising/falling edge of input signal. 0 or 2 : CW / CCW 1 or 3 : Pulse / direction 2 or 3 : Enable to execute Program Banks 2 and 3 (except for P type)
37	Resolution/Speed Unit 0～10 : speed unit 100pps 20～30 : speed unit 10pps 40～50 : speed unit 100pps 60～70 : speed unit 10pps 80～90 : speed unit 1pps	0	90	3	-	Pulses per rotation and speed unit 0, 20, 80 : 200 40, 60 : 300 1, 21, 81 : 400 41, 61 : 400 2, 22, 82 : 500 42, 62 : 600 3, 23, 83 : 1000 43, 63 : 800 4, 24, 84 : 2000 44, 64 : 1200 5, 25, 85 : 2500 45, 65 : 1500 6, 26, 86 : 5000 46, 66 : 3000 7, 27, 87 : 10000 47, 67 : 4000 8, 28, 88 : 25000 48, 68 : 6000 9, 29, 89 : - 49, 69 : 8000 10, 30, 90 : 50000 50, 70 : 12000 When K37 is set to 40-70, incremental motion is not allowable.

K	Parameter	Min	Max	Default	Unit	Description
38	Analog Control Type	0	10	1	-	Control Target and method for analog input 0 : No function 1: Position control 2: Speed control for CW 3: Speed control for CCW 4 : Speed control for CW / CCW 5 : P data for Direct Mode 6 : S data (+) for Direct Mode 7 : S data (-) for Direct Mode 8 : S data (+/-) for Direct Mode 9 : Torque control 10 : Torque feedback control
39	Low Pass Filter Cut-off Frequency	0	1024	128	5rad/s	Low pass filter cut-off frequency for analog input
40	Maximum Speed	1	Depends on motor type	Depends on motor type	min^{-1}	The maximum speed of motor. Set the speed when the maximum analog voltage is applied in case of speed control with analog input.
41	Analog Travel range	-999999999	999999999	200	Pulses	The max. travel range in case of position control with analog input
42	Origin Search Speed	1	32767	10	100pps 10pps 1pps	The speed for origin search
43	Acceleration for Origin search / Manual feed	1	32767	100	$kpps^2$	Set the acceleration for origin search and manual feed.
44	Deceleration Ratio	1	500	100	%	Deceleration ratio is relative to the acceleration in percentage. When K44=100, deceleration is the same as acceleration.
45	Origin Search Direction, Reverse coordinates	000	223	001	-	· First digit ⋯ Setting of Origin search Direction and Reverse Coordinates 0: CW direction 1: CCW direction 2: CW direction Reverse Coordinates 3: CCW direction Reverse Coordinates · Second digit ⋯ Unit of offset by K48 0: 100 pulses 1: 10 pulses 2: 1 pulse · Third digit ⋯ Unit of software limit by K58, K59 0: 100 pulses 1: 10 pulses 2: 1 pulse

K	Parameter	Min	Max	Default	Unit	Description
46	Origin Signal Source	0	7	0	-	Specify the origin signal source. 0: Stopper detection 1: Stopper detection (Automatic start when powered ON) 2: Origin sensor 3: Origin sensor (Automatic start when powered ON) 4: Z-phase signal 5: Z-phase signal (Automatic start when powered ON) 6: Origin sensor & Z-phase signal 7: Origin sensor & Z-phase signal (Automatic start when powered ON)
47	Stopper Detecting Torque for Origin Search	10	150	30	%	The torque where the motor will determine that the stopper detection has been completed. It is relative to the rated torque of the motor in percentage.
48	Offset distance between mechanical and electrical origins	-32767	32767	0	100 pulses 10 pulses 1 pulse	Offset between the mechanical and electrical origins. When it is not set to 0, the movement to the electrical origin is automatically performed after the detection of mechanical origin. The speed is the same as the origin search speed set by K42. When set to 0, electrical origin and mechanical origins are the same. *Unit depends on 2nd digit of K45.
49	Speed for Manual Feed	1	32767	10	100pps 10pps 1pps	Speed for manual feed
50	Feed Pulses for Manual Jog	1	100	10	pulses	Feed pulses for manual jog (Speed and acceleration are set automatically and can not be changed.)
51	Creeping speed	0	1000	0	100pps 10pps 1pps	Creeping speed.
55	In-position Range	1	100	5	Pulse	In-position range.
56	Position Error Overflow Threshold Level	1	32767	50	100 pulses	Threshold level for position error Over Flow
57	Overload Detection Time	100	10000	3000	msec	Overload alarm is recognized after continuation of overload state more than set time.
58	Software Limit (+)	0	999999999	0	100 pulses 10 pulses 1 pulse	Movable limit in plus direction in reference to the origin. When set to 0, no software limit. *Unit depends on 3rd digit of K45.
59	Software Limit (-)	-999999999	0	0	100 pulses 10 pulses 1 pulse	Movable limit in minus direction in reference to the origin. When set to 0, no software limit. *Unit depends on 3rd digit of K45.
60	Push Motion Torque Level	10	100	30	%	Torque level for push motion is relative to the rated torque in percentage. When set to odd No., push motion error will not occur.
61	Push Motion Holding Time	0	30000	200	msec	Time for keeping push motion. (When set to 0, push motion will continue without end)
62	Ladder Logic Bank No. Executed when Powered ON	0	30	0	-	Ladder Logic Bank No. that is executed automatically when powered ON. When K62=0, Ladder Logic Bank will not be executed.

K	Parameter	Min	Max	Default	Unit	Description
63	Ladder Logic Bank execution cycle time	0	30000	100	msec	Execution cycle time for Ladder Logic Bank. Ladder Logic Bank will be executed repeatedly with set cycle time.
64	Status LED Setting	0	1	0	-	Status LED setting, either activated or inactivated 0 : Status LED activated 1 : Status LED inactivated
65	Baud Rate between Slave Motors	0	5	0	-	Baud rate between the slave motors on the daisy chain network. 0:38.4kbps, 1:9.6 kbps, 2:19.2 kbps, 3:57.6 kbps, 4:115.2 kbps, 5:230.4kbps When K65 of ID1 motor is changed, all K65 values of other motors will be automatically changed. If any motor's K65 except for ID1 is changed, the other motors' K65 values are not changed.
68	Motor Free when Powered ON	0	1	1	-	Select either servo ON or motor free when powered ON 0: Motor free when powered ON 1: Servo ON when powered ON
69	S-Curve Gain	0	1024	0	-	S-curve gain in positioning When 0, motor makes trapezoidal motion.
70	Delimiter	0	1	1	-	Select the delimiter attached to the end of sent data from Cool Muscle. 0: CR 1: CRLF
71	External Encoder Type	0	7	0	-	Set the external encoder type 0: No external encoder 1: A-phase index 2: A-phase index, B-phase rotation direction 3: A-phase & B-phase index 4: A-phase & B-phase feedback 5: A-phase pulse counting 6: A-phase pulse counting, B-phase rotation direction 7: A-phase & B-phase pulse counting
72	External Encoder Resolution	0	32767	400	ppr	Resolution of external encoder
73	Output Pulse Width at Passing Point in Merge Motion	1	1000	10	msec	Output pulse width at passing point in merge motion.
74	Torque Control P Gain	0	1000	100	-	Proportional gain for the torque control using external torque sensor.
75	Torque Control I Gain	0	500	10	-	Integral gain for the torque control using external torque sensor.
76	Input Offset for Torque Sensor	0	500	250	0.01V	Input offset voltage of the external torque sensor for feedback control

<table>
<tr><th>K</th><th>Parameter</th><th>Min</th><th>Max</th><th>Default</th><th>Unit</th><th>Description</th></tr>
<tr><td>77</td><td>Input Range for Torque Sensor</td><td>-1000</td><td>1000</td><td>200</td><td>0.01V</td><td>Input range of the external torque sensor for feedback control.</td></tr>
<tr><td>78</td><td>Input Address for Modbus Host Communication</td><td>-1</td><td>32767</td><td>0</td><td>-</td><td>Input address of Cool Muscle for the Modbus host communication.</td></tr>
<tr><td>79</td><td>Input Address for Modbus Slave Communication</td><td>-1</td><td>32767</td><td>0</td><td>-</td><td>Input address of Cool Muscle for the Modbus slave communication.</td></tr>
<tr><td>80</td><td>Output Address for Modbus Slave Communication</td><td>0</td><td>32767</td><td>0</td><td>-</td><td>Output address of Cool Muscle for the Modbus slave communication.</td></tr>
<tr><td>81</td><td>COM0 Station Address</td><td>-255</td><td>255</td><td>0</td><td>-</td><td>Set Cool Muscle's station address for a host device.</td></tr>
<tr><td>82</td><td>Parity</td><td>0</td><td>2</td><td>0</td><td>-</td><td>Parity setting for data transmission.
0: None
1: Even
2: Odd</td></tr>
<tr><td>84</td><td>COM1 Communication Mode Setting</td><td>-256</td><td>1</td><td>0</td><td>-</td><td>
<table>
<tr><th>K81</th><th>K84</th><th>COM0 Communication Mode</th><th>COM1 Communication Mode</th></tr>
<tr><td rowspan="3">0</td><td>0</td><td rowspan="3">RS-232C</td><td>RS-232C</td></tr>
<tr><td>< 0</td><td>RS-232C</td></tr>
<tr><td>1</td><td>Modbus Host</td></tr>
<tr><td rowspan="3">0 ></td><td>0</td><td rowspan="3">Modbus Slave</td><td>RS-232C</td></tr>
<tr><td>< 0</td><td>RS-232C</td></tr>
<tr><td>1</td><td>Modbus Host</td></tr>
</table>
</td></tr>
<tr><td>85</td><td>Endian</td><td>3</td><td>0</td><td>0</td><td>-</td><td>
<table>
<tr><th>Value</th><th>COM0</th><th>COM1</th></tr>
<tr><td>0</td><td>Big Endian</td><td>Big Endian</td></tr>
<tr><td>1</td><td>Little Endian</td><td>Big Endian</td></tr>
<tr><td>2</td><td>Big Endian</td><td>Little Endian</td></tr>
<tr><td>3</td><td>Little Endian</td><td>Little Endian</td></tr>
</table>
</td></tr>
</table>

6.2. Data Commands

Com-mands	Function	unit	Format (n: Motor ID)	Example	Description
P	Position Data Definition	pulses	P#.n=Value #: memory No. *(1∼200) P0: direct mode (0 can be omitted)	 P.2=9000 P1.3=9000	Define the position data in Motor n's P memory #. Note) The max. values of the position data depends on the resolution setting Ex.) Motor 2's P0 is set to 9000. Define Motor 3's P1 is set to 9000. * Memory range can be changed by allocation (R type only)
	Relative Position Data Definition	pulses	P#.n+=1000 P1.3-=1000	 P.1+=1000 P1.3-=1000	The value can be defined as relative to the current position by using + or – after Motor ID. Note) In direct mode (using P0), it is relative to the current position. In program mode, it is relative to values defined as P1∼P200*. Ex.) Motor 1's P0 is set to [current position + 1000]. Define Motor 3's P1 as [current position - 1000].
S	Speed Data Definition	100pps or 10pps or 1pps	S#.n=value #: memory No. (1∼15) S0: direct mode (0 can be omitted)	 S.2=100 S13.3=150	Define an absolute speed data in Motor n's S memory #. Note) The negative value is treated as absolute value. Ex.) Define Motor 2's S0 as 100. Define Motor 3's S13 as 150.
A	Acceleration Data Definition	$kpps^2$	A#.n=value #: memory No. (1∼8) A0: direct mode (0 can be omitted)	 A.2=10 A6.3=100	Define the absolute acceleration data in Motor n's A memory #. Note) The negative value is treated as absolute value. Ex.) Define Motor 2's A0 as 10. Define Motor 3's A6 as 100.
T	Timer Data Definition	msec	T#.n=value #: memory No. (1∼8)	 T2.1=500	Define Timer data in Motor n's T memory # Ex.) Define Motor 1's T2 as 500.
M	Torque Limit Data Definition	%	M#.n=value #: memory No. (1∼8) M0: direct mode (0 can be omitted)	 M.2=50 M2.3=80	Define Torque limit data in Motor n's M memory #. (0-100% of Max. motor torque can be set) Ex.) Define Motor 2's direct mode M0 as 50. Define Motor 3's M2 as 80.

Com-mands	Function	unit	Format (n: Motor ID)	Example	Description
V	Variable Data Definition		1) V#.n=value 2) V#.n="Characters" 3) V#.n="motor's internal variables" #: memory No. (1~15) Internal variables : Px, Sx, Ix, Ux, Pe, AIN, PT, ST or CT	V1.2=1234 V1.2="ABCD" V1.2="Px"	Define Variable data in Motor n's V memory #. Up to 4 digit number or characters can be used. Note) " double quotation is needed to use characters and motor's internal variables. 1) use as a number 2) use as character 3) use as an internal state values as below Px…current position Sx…current speed Ix…current Iq Ux…current motor status Pe…position error ADIN…analog input PT…target position ST…target speed CT…external encoder counter Ex.) Define Motor 2's V1 as 1234 Define Motor 2's V1 as ABCD Define Motor 2's V1 as Px (current position)
N	Center Point data of Circle Definition		N#.n=value #: memory No.(1~200)* N0: direct mode (0 can be omitted)	N.1=100,N.2=100 N1.1=100,N1.2=100	Define center point data of circle in Motor n's N memory #. Ex.) Define center point of circle to 100 pulses for X and Y. * Memory range can be changed by allocation (R type only)
R	Radius data of Circle Definition		R#.n=value #: memory No.(1~200)* R0: direct mode (0 can be omitted)	R.1=100, R.2=100 R1.1=100, R1.2=100	Define radius data of circle in Motor n's R memory #. When the two values are set to 0, linear interpolation is executed. When the two values are different, elliptic trajectory will be drawn. Ex.) Define radius of circle to 100 pulses for X and Y. * Memory range can be changed by allocation (R type only)

6.3. Program Bank Commands

OP‥It shows if it is possible to use with operators or not.

Com-mands	Function	OP	Format (n: Motor ID)	Example	Description
S	Speed	○	S#.n #:memory No. (1~15)	S1.1 S1.1= S2.1+ V1.1	Ex.) Define the specified motion speed as S1. Define the value of S2.1+V1.1 as S1.1.
A	Acceleration	○	A#.n #:memory No. (1~8)	A1.1 A1.1= A2.1+ V2.1	Ex.) Define the specified motion acceleration as A1. Define the value of A2.1+ V2.1as A1.1.
P	Position	○	P#.n #:memory No. (1~200)*	P1.1 P1.1+ P1.1= P3.1+ V3.1	Ex.) Define target position as P1. Add or subtract P1 to or from the current position and set P1 as the next target position. Define the value of P3.1+ V3.1 as P1.1. * Memory range can be changed by allocation (R type only)
Y	Execute next line without in-position queuing	×	Y#.n #:P memory No.	A1.1,S4.1,Y1.1 A1.2,S4.2,P1.2	In Daisy Chain, by using Y command instead of P, the motors move without waiting for in-position of Motor n. Ex.) Motor 2 starts executing the next line without waiting for Motor 1's in-position at P1.
Q	Push motion	×	Q#.n #:P memory No.	A1.1,S4.1,Q10.1	Perform push motion Ex.) Motor 1 performs push motion against P10.
Z	Execute next line without push motion completion queuing	×	Z#.n #:P memory No.	A1.1,S4.1,Z1.1 A1.2,S4.2,P1.2	In Daisy Chain, by using Z command instead of Q, the motors move without waiting for completion of specified motor's push motion. Ex.) Motor 2 starts execution the next line without waiting for Motor 1's completion of push motion.
M	Torque Limit	○	M#.n #:memory No. (1~8)	M1.1 M1.1= V5.1+ V6.1	Define the max. torque in percentage as M# of Motor n. Ex.) The max. torque is set to M1.1.
B	Beginning of Program Bank	×	B#.n #: Bank No. (1~30)	B1.1 A1.1,S4.1,P12.1	Define the beginning of a Program Bank and specify the Program Bank number. Note) Program Bank should end with “End”.
C	Call other Program Bank	×	C#.n #: Bank No. (1~30)	A1.1,S4.1,P12.1 C2.1	Call the specified Program Bank, execute it and return to the next line of the original Program Bank. Note) It is impossible to call other motor's Program Banks and re-call itself.
J	Jump to other Program Bank	×	J#.n #: Bank No. (1~30)	B1.1 J2.1	Jump to the specified Program Bank, execute it and can not return to the next line of the original Program Bank. Note) It is impossible to jump to other motor's Program Banks.

Com-mands	Function	OP	Format (n: Motor ID)	Example	Description
X	Looping	×	X#.n X#.n ～ X.n- X.n- # is loop count n must be the same as Motor ID of B command.	X0.1 A1.1, S1.1, P1.1 X2.1 P1.1 P2.1 X.1- X.1-	Execute the lines between X and X- repeatedly up to loop count (1～255). When X0 is set, it loops infinitely. Note) When X-is not placed, lines after X until the end of Program Bank will be looped. · A part of Program Bank can be executed repeatedly. · Up to 10 nestings of X loop are available.
I	Conditional Branching on Input Status	○	[expression], [action 1], [action 2]		Depending on the result of operation in expression, if TRUE, execute action 1. if FALSE execute action 2.
	Branching on Condition of Single Input		I#.n,[action 1], [action 2] #:Input No.	I1.1, C2.1, C3.1	Execute a specified motion according to Input # status. Ex.) If Input 1 is ON (TRUE), Motor 1 calls Program Bank 2. If OFF (FALSE), Motor 1 calls Program Bank 3.
	Branching on Condition of 2 Inputs Operation		I#.n \ I #.n, [action 1], [action 2] \ : Logical Operator	I3.2 && I4.1,?99,?98	Ex.) If I3.2 & I4.1 are ON (TRUE), Motor 1 executes ?99. If FALSE, Motor 1 executes ?98.
V	Conditional Branching on Variable	○	[expression], [action 1], [action 2]		Depending on the result of operation in expression, if TRUE, execute action 1. if FALSE execute action 2.
	Branching on Condition of Single Variable		V#.n,[action 1], [action 2] n must be the same as Motor ID of B command.	V1.1,?99,?98	For single Variable, the operation of V>0 is applied. Ex.) If V1.1>0, Motor 1 executes ?99. Otherwise, Motor 1 executes ?98.
	Branching on Condition of 2 Variables		V#.n \ V#.n,[action 1], [action 2] \ : Operator n must be the same as Motor ID of B command.	V1.1> V2.1, ?99, ?98 V1.1== V2.1, ?99, ?98	Ex.) If V1.1>V2.1, Motor 1 executes ?99. If V1.1≦V2.1, Motor 1 executes ?98. If V1.1=V2.1, Motor 1 executes ?99. If V1.1≠V2.1, Motor 1 executes ?98.
T	Timer	○	T#.n n must be the same as Motor ID of B command.	T1.1	Wait for the time defined by T data. T0 means no action.
W	Timer in Conditional Branching	×	W#.n #:T memory No. n must be the same as Motor ID of B command.	I4.1,W1.1,?99 A1.1, S1.1, P1.1	Wait for event to happen for the time defined by T data. If set to W0, then wait continuously. Ex.) While I4.1 is TRUE, Motor 1 waits for the time set by T1. After the time is up, Motor 1 executes next line. If I4.1 turns FALSE during the time set by T1, Motor 1 executes ?99 instantly and then next line.
N	Center Point of Circle	○	N#.n,N#.n	N1.1,N1.2	Set the center point of circle to (N1.1, N1.2) (multi-axis application)
R	Radius of Circle	○	R#.n,R#.n	R1.1,R1.2	Set X axis' radius of circle to R1.1, and set Y axis' radius to R1.2. (multi-axis application)
Execution Command	Refer to 6.5 Chapter	×	Refer to 6.5 Chapter	Refer to 6.5 Chapter	Execution commands can be used within Program Bank.
END	End of Program Bank	×	END	END	Define the end of Program Bank.

Symbol	Function	Format (n: Motor ID)	Example	Description
//	Comment	Command line // Comment	B1.1//comment	Comments can be written after "//" by English one byte character.
, (comma)	Command Concatenation / Merge Motion / Simultaneous Motion Execution	Command, Command	A1.1, S1.1, P1.1 A1.1, S1.1, P1.1, S2.1, P2.1 P1.1, P3.2	Command concatenation : Multiple commands can be described in a single line. Merge motion : Motor 1 moves to P2 without stopping at P1 smoothly, with speed change to S2 when passing P1. Simultaneous motion : Motor 1 and 2 will start their motion at the same time.
; (semi colon)	Command Concatenation in Multiple Lines	Command; Command	A1.1,S1.1,P1.1; S2.1,P2.1	By using semicolon instead of comma, multiple commands and merge motion can be described in multiple lines.
: (colon)	Command Concatenation in Branching	Command:Command	V1>V2, ?99.1: O1.1, ?96.1: F1.1	Colon allows the use of multiple commands in branching processing. Ex.) If V1>V2, Motor 1 executes ?99 and O1.1. If V1<=V2, motor 1 executes ?96 and F1.1.

6.4. Ladder Logic Bank Commands

OP ··· It shows if it is possible to use with operators or not.

Com-mands	Function	OP	Format (n: Motor ID)	Example	Description
L	Begging of Ladder Logic Bank	×	L#.n #: Bank No. (1~30)	L1.1	Define the beginning of a Ladder Logic Bank and specify Ladder Logic Bank number. Note) Ladder Logic Bank should end with "End".
CL	Call other Ladder logic Bank	×	CL#.n #: Bank No. (1~30)	CL2.1	Call the specified Ladder Logic Bank, execute it and return to the next line of the original Ladder Logic Bank. Note) It is impossible to call other motor's Ladder Logic Banks and re-call itself.
JL	Jump to other Ladder Logic Bank	×	JL#.n #: Bank No. (1~30)	JL2.1	Jump to the specified Ladder Logic Bank, execute it and can not return to the next line of the original Ladder Logic Bank. Note) It is impossible to jump to other motor's Ladder Logic Banks.
I	Conditional Branching on Input Status	○	[expression], [action 1], [action 2]		Depending on the result of operation in expression, if TRUE, execute action 1. if FALSE execute action 2.
	Branching on Condition of Single Input		I#.n,[action 1], [action 2] #:Input No.	I1.1, CL2.1, CL3.1	Execute a specified motion according to Input # status. Ex.) If Input 1 is ON (TRUE), Motor 1 calls Ladder Logic Bank 2. If OFF (FALSE), Motor 1 calls Ladder Logic Bank 3.
	Branching on Condition of 2 Inputs Operation		I#.n \ I #.n, [action 1], [action 2] \ : Logical Operator	I3.2 && I4.1,?99,?98	Ex.) If I3.2 & I4.1 are ON (TRUE), Motor 1 executes ?99. If FALSE, Motor 1 executes ?98.
V	Conditional Branching on Variable	○	[expression], [action 1], [action 2]		Depending on the result of operation in expression, if TRUE, execute action 1. if FALSE execute action 2.
	Branching on Condition of Single Variable		V#.n,[action 1], [action 2] n must be the same as Motor ID of L command.	V1.1,?99,?98	For single Variable, the operation of V>0 is applied. Ex.) If V1.1>0, Motor 1 executes ?99. Otherwise, Motor 1 executes ?98.
	Branching on Condition of 2 Variables		V#.n \ V#.n,[action 1], [action 2] \ : Operator n must be the same as Motor ID of L command.	V1.1> V2.1, ?99, ?98 V1.1== V2.1, ?99, ?98	Ex.) If V1.1>V2.1, Motor 1 executes ?99. If V1.1≦V2.1, Motor 1 executes ?98. If V1.1=V2.1, Motor 1 executes ?99. If V1.1≠V2.1, Motor 1 executes ?98.
T	Timer	○	T#.n n must be the same as Motor ID of L command.	T1.1	Wait for the time defined by T data. T0 means no action.
W	Timer in Conditional Branching	×	W#.n #:T memory No. n must be the same as Motor ID of L command.	I4.1,W1.1,?99 CL3.1	Wait for event to happen for the time defined by T data. If set to W0, then wait coutinuously. Ex.) While I4.1 is TRUE, Motor 1 waits for the time set by T1. After the time is up, Motor 1 executes next line. If I4.1 turns FALSE during the time set by T1, Motor 1 executes ?99 instantly and then next line.
#	Capture Position Data	○	#x.n x is P memory No.	#2.1	Capture the current position value and store it to the specified motor's specified P memory.
Execution Command	Refer to 6.5 Chapter	×	Refer to 6.5 Chapter	Refer to 6.5 Chapter	Execution commands can be used within Ladder Logic Bank.
END		×	END	END	Define the end of Ladder Logic Bank.

Symbol	Function	Format (n: Motor ID)	Example	Description
//	Comment	Command line // Comment	B1.1//comment	Comments can be written after "//" by English one byte character.
, (comma)	Command Concatenation	Command, Command	V2.1>V3.1, V2.1=V3.1, T0.1	Command concatenation : Multiple commands can be described in a single line.
; (semi colon)	Command Concatenation in Multiple Lines	Command; Command	V2.1>V3.1; V2.1=V3.1, T0.1	By using semicolon instead of comma, multiple commands can be described in multiple lines.
: (colon)	Command Concatenation in Branching	Command:Command	V1>V2,?99.1:O1.1,?96.1: F1.1	Colon allows the use of multiple commaxnds in branching processing. Ex.) If V1>V2, Motor 1 executes ?99 and O1.1. If V1<=V2, motor 1 executes ?96 and F1.1.

6.5. Execution Commands

P ··· Program Bank, L ··· Ladder Logic Bank, D ··· Direct Mode, indicate the availability of command.

Com-mands	Function	P	L	D	Format (n: Motor ID)	Example	Description
|	Origin Search	O	O	O	|.n	|.1	Origin Search starts.
|1	Move to Position 0	O	O	O	|1.n	|1.2	Move to position 0 with the speed and acceleration set by K42 and K43.
|2	Assign Current Position to 0	O	O	O	|2.n	|2.3	Assign current position to 0. Set Motor 3's current position to 0.
(	Enable Motor	O	O	O	(.n	(.1	Enable motor (Servo ON).
)	Motor Free	O	O	O	).n	).1	Motor free.
[	Execute Program Bank	O	O	O	[#.n #: Bank #	[1.2	Execute the specified Program Bank. Only [resumes the execution of the Program Bank paused right before.
]	Pause Program Bank	O	O	O	]	]CR : pause]CR]CR : stop	This command stops all motors and pauses Program Bank in operation. Send the command twice to terminate the Program Bank.
]1	Pause Specified Motor	×	×	O	]1.n	]1.2	Pause only specified motor in Daisy Chain connection. In direct mode, pause only Motor 2 in Daisy Chain connection.
[L	Execute Ladder Logic Bank	×	O	O	[L#.n #: Bank #	[L1.1	Execute the specified Ladder Logic Bank. Only [L restarts the execution of the paused Ladder Logic Bank.
]L	Pause Ladder Logic Bank	×	O	O	]L.n	]L.1CR : pause]L.1CR]L.1CR : stop	Pause specified Ladder Logic Bank. Send the command once to pause the Ladder Logic Bank. Send the command twice to stop the Ladder Logic Bank.
*	Emergency Stop	O	O	O	*	*	Emergency stop of operation with the max. deceleration. Send the command once to pause the Program Bank. Send the command twice to terminate the Program Bank.
*1	Cancel Emergency Stop	O	O	O	*1	*1	Cancel emergency stop
^	Execute the Direct Mode Motion	×	×	O	^.n	^.1	Execute the motion in Direct Mode.
O	Output Signal ON	O	O	O	O#.n #: Output #	O2.1	Turn the specified output signal ON. Output signal 2 of Motor 1 is turned ON.
F	Output Signal OFF	O	O	O	F#.n #: Output #	F2.1	Turn the specified output signal OFF. Output signal 2 of Motor 1 is turned OFF.
>	Execute Next Line	×	×	O	>.n	>.2	Execute the next line of Program Bank in pause.
<	Execute Previous Line	×	×	O	<.n	<.2	Execute the previous line of Program Bank in pause.
}	Stop after Completing Current Line	×	×	O	}.n	}.1	Stop motor after completing the current line in Program Bank.
$	Save data	×	×	O	$.n	$.1	Save the data into a specified motor's memory.
?	Query	O	O	O	?No.	?96	Please refer to section 6.6
#	Capture Position Data	O	O	O	#x.n x is P memory No.	#2.1	Capture the current position value and store it to the specified motor's specified P memory.
@	Execute Circular and Linear Interpolation	O	O	O	@#.n,@#.n	@1.1,@1.2	Motors execute interpolation motion target to the points (P1.1,P1.2). Only interpolation type can be used.
\ (¥or₩)	Allocation of Data Area	×	×	O	\P numeric \N numeric	\P300 \N200	The area for 600 data in total is allocated for P, N and R. Only interpolation type can be used.

6.6. Query

Queries can be used in Direct Mode, Program Bank and Ladder Logic Bank.

Command	Query item	Format (n: Motor ID)	Response
?	Direct Mode Data	?.n	The predefined A,S and P data for Direct mode. Example: ?.1 Predefined data of Direct mode of Motor 1? Response data example: S.1=500, A.1=2000, P.1=100000
?1～30	Program Bank	?#.n #: Program Bank No. 1～30	Predefined program banks 1-30. Example: ?1.1 Predefined Program Bank 1 of Motor 1? Response data example: S1.1, A1.1, P1.1 P2.1 (Only the predefined content after B#.n)
?50	Output Signal	?50.n	Current status of all outputs in hexadecimal. Example: ?50.1 All the output current status of Motor 1? Response data example: OUT.1=03 * 03 means 0011 in binary number and 0 (OFF) or 1 (ON) is responded by one column of unit in order of Out4, 3, 2, 1.
?51	Output Signal 1	?51.n	Current status of output signal 1 by 0 (OFF) or 1 (ON). Example: ?51.1 Response data example: OUT1.1=0
?52	Output Signal 2	?52.n	Current status of output signal 2 by 0 (OFF) or 1 (ON). Example: ?52.1 Response data example: OUT2.1=0
?53	Output Signal 3	?53.n	Current status of output signal 3 by 0 (OFF) or 1 (ON). Example: ?53.1 Response data example: OUT3.1=0
?54	Output Signal 4	?54.n	Current status of output signal 4 by 0 (OFF) or 1 (ON). Example: ?54.1 Response data example: OUT4.1=0

Command	Query item	Format (n: Motor ID)	Response
?70	Input Signal	?70.n	Current status of all inputs in hexadecimal. Example: ?70.1 All the input current status of Motor 1? Response data example: IN.1=1C * 1C means 011100 in binary number and 0 (OFF) or 1 (ON) is responded by one column of unit in order of In6, 5, 4, 3, 2, 1.
?71	Temperature in Driver Case	?71.n	Temperature inside the driver case Example: ?71.1 Temperature inside the driver case of Motor 1? Response data example: Temp.1=40 (Unit : ℃)
?72	Power Supply Voltage	?72.n	Current power supply voltage level Example: ?72.1 Current power supply voltage level of Motor 1? Response data example: VSEN.1=1400 (Unit : 0.1V)
?74	Analog Input	?74.n	Analog input voltage value 0-5V is divided by 1024 and respond 0 when 0V and 1023 when 5V is applied. Example: ?74.1 Analog input voltage value of Motor 1? Response data example: ADI0.1=512 (represents 2.5V) (Unit : 5/1023V)
?76	External Encoder Counter	?76.n	Value of counter for an external encoder. Example: ?76.1 Response data example: Ecnt.1=100
?85	Version Title	?85.n	Version title Example: ?85.1 Version title of Motor 1? Response data example ID1 : CM2v3.10R.1 #0802A12345 Serial No. Hardware No. Type Firmware Version Series Name ID No.

Command	Query item	Format (n: Motor ID)	Response
?90	User Parameter	?90.n	User parameter K20 ~K89 Example: ?90.1 User parameter's of Motor 1? Response data example: K20.1=0, K21.1=0, K22.1=200, K23.1=1 …….. K88.1=0, K89.1=0 4 parameters in 1 line, each is separated with a comma(,).
?95	Position Error	?95.n	Position error value Example: ?95.1 Position error value of Motor 1? Response data example: Pe.1=0 (Unit : pulse)
?96	Current position	?96.n	Current position Example: ?96.1 Current position of Motor 1? Response data example: Px.1=10000 (Unit : pulse)
?97	Current speed	?97.n	Current speed Example: ?97.1 Current speed of Motor 1? Response data example: Sx.1=100 (Unit : 100pps/10pps/1pps)
?98	Current torque	?98.n	Current torque Example: ?98.1 Current torque of Motor 1? Response data example: Ix.1=20
?99	Motor Status	?99.n	Current status Example: ?99.1 Response data example: Ux.n=0 motor is running Ux.n=1 position error over flow Ux.n=2 over speed/regenerative voltage Ux.n=4 overload Ux.n=8 In-position Ux.n=16 motor free Ux.n=32 push motion Ux.n=40 push motion completed Ux.n=64 power module over current Ux.n=128 temperature alarm Ux.n=256 push motion error Ux.n=512 emergency stop Multiple status can be responded by addition of above numbers.
V1~15	Specified Variable Data	V#.n #:memory No.	Value of specified V (Variables) memory

The commands below can not be used in Program Bank and Ladder Logic Bank.

Command	Query item	Format (n: Motor ID)	Response
?L1～30	Ladder Logic Bank	?L#.n #: Ladder Logic Bank No.	Predefined Ladder Logic Banks. Example: ?L1.1 Predefined Ladder Logic Bank 1 of Motor 1? Response data example: I1.1&&I2.1, O1.1, O2.1 I3.1||I4.1, O3.1, O4.1 (Only predefined content after L#.n)
A1～8	Specified Acceleration Data	A#.n #: memory No.	Value of specified A (Acceleration) memory No. Example: A1.1 Predefined acceleration data 1 of Motor 1? Response data example: A1.1=100
S1～15	Specified Speed Data	S#.n #: memory No.	Value of specified S (Speed) memory No. Example: S1.1 Predefined speed data 1 of Motor 1? Response data example: S1.1=500
M1～8	Specified Torque Limit Data	M#.n #: memory No.	Value of specified M (Torque Limit) memory No. Example: M1.1 Predefined torque limit data 1 of Motor 1? Response data example: M1.1=10000
T1～8	Specified Timer Data	T#.n #: memory No.	Value of specified T (Timer) memory No. Example: T1.1 Predefined timer data 1 of Motor 1? Response data example: T1.1=1000
P1～200	Specified Position Data	P#.n #: memory No.	Value of specified P (Position) memory No. Example: P1.1 Predefined position data 1 of Motor 1? Response data example: P1.1=100 Only R type, P data up to P600 is available by allocation.
N1～200	Specified Center Point of Circle Data	N#.n #: memory No.	Value of specified N (Center Point of Circle) memory No. Example: N1.1 Predefined center point of circle data 1 of Motor 1? Response data example: N1.1=100 Only R type, N data up to N600 is available by allocation.

Command	Query item	Format (n: Motor ID)	Response
R1~200	Specified Radius of Circle Data	R#.n #: memory No.	Value of specified R (Radius of Circle) memory No. Example: R1.1 Predefined radius of circle data 1 of Motor 1? Response data example: R1.1=100 Only R type, R data up to R600 is available by allocation.
?A	All Acceleration Data	?A.n	All acceleration data 4 parameters in 1 line, each is separated with a comma(,).
?S	All Speed Data	?S.n	All speed data 4 parameters in 1 line, each is separated with a comma(,).
?M	All Torque Limit Data	?M.n	All torque limit data 4 parameters in 1 line, each is separated with a comma(,).
?T	All Timer Data	?T.n	All timer data 4 parameters in 1 line, each is separated with a comma(,).
?V	All Variable Data	?V.n	All variable data 4 parameters in 1 line, each is separated with a comma(,).
?P	All Position Data	?P.n	All position data 4 parameters in 1 line, each is separated with a comma(,).
?N	All Center Point of Circle Data *Available with R type only	?N.n	All center point of circle data 4 parameters in 1 line, each is separated with a comma(,).
?R	All Radius of Circle Data *Available with R type only	?R.n	All radius of circle data 4 parameters in 1 line, each is separated with a comma(,).
?999	All Data List	?999.n	All data of P, S, A, T, M, N, R, V
?1000	All Banks	?1000.n	All Program Banks and Ladder Logic Banks

6.7. Arithmetic Operators

These operators perform mathematical calculations.

Any number is required to be integer and defined value as in P(positio data) or V(variable).

Operator	Functions	Format	Examples	Description
=	Sets value	[variable] = [expression]	V1.1=V2.1 P1.1=P2.1+P3.1	= Operator assigns the value on its right to the variable on its left. Ex.) When V2.1=50, V1.1is assigned to 50 When P2.1=1000, P3.1=2000, then P1.1=3000
+	Addition	[number1] + [number2]	P1.1=P2.1 + V1.1	+ Operator adds two numbers. The result is their arithmetic sum. Ex.) When P2.1=1000, V1.1=300, then P1.1=1300
-	Subtraction	[number1] - [number2]	P1.1=P2.1 - V1.1	- Operator returns the difference between two numbers. The result is calculated by subtracting number2 from number1. Ex.) When P2.1=1000, V1.1=300, then P1.1=700
*	Multiplication	[number1] * [number2]	P1.1=P2.1 * V1.1	* Operator multiplies two numbers. The result is the product of number1 and number2. Ex.) When P2.1=100, V1.1=30, then P1.1=3000
/	Division	[number1] / [number2]	P1.1=P2.1 / V1.1	/ Operator divides two numbers. The result is the quotient of number1 divided by number2, not including any remainder. The decimal fraction part is truncated. Ex.) When P2.1=6000, V1.1=20, then P1.1=300
U1	Sine	U1([number])	P1.1=U1(V1.1)	U1 Operator returns 10000 times value of sine operation result in integer as following expression. The decimal fraction part is truncated. $U1(\theta) = 10000 \times \sin(2\pi \times \frac{\theta}{36000})$ θis data as V value (Unit:0.01degrees) Ex.) When V1.1=3000 (30 degrees), P1.1= U1(V1.1) = 10000*sin(2π×100/36000) = 5000
U2	Cosine	U2([number])	P2.1=U2(V1.1)	U2 Operator returns 10000 times value of cosine operation result in integer as following expression. The decimal fraction part is truncated. $U2(\theta) = 10000 \times \cos(2\pi \times \frac{\theta}{36000})$ θis data as V value (Unit:0.01degrees) Ex.) When V1.1=3000 (30 degrees), P2.1=U2(V1.1) = 10000*cos(2π×100/36000) = 8660
U3	Square Root	U3([number])	P3.1=U3(V1.1)	U3 Operator returns value of square-root operation result in integer. The decimal fraction part is truncated. $U3(\chi) = \sqrt{\chi}$ χ is data as V value (Integer) Ex.) When V1.1=100, P3.1=U3(V1.1)=10

6.8. Logical Operators

<table>
<tr><th>Operator</th><th>Functions</th><th>Format</th><th>Examples</th><th>Description</th></tr>
<tr><td>&&</td><td>And</td><td>[operand1] && [operand2]</td><td>I4.1 && I3.2</td><td>And(&&) Operator performs a logical conjunction on two Boolean operands.
Result is True if and only if both operand1 and operand2 evaluate to True.
The following table illustrates how result is determined.
<table>
<tr><th>operand1</th><th>operand2</th><th>the value of result</th></tr>
<tr><td>TRUE</td><td>TRUE</td><td>TRUE</td></tr>
<tr><td>TRUE</td><td>FALSE</td><td>FALSE</td></tr>
<tr><td>FALSE</td><td>TRUE</td><td>FALSE</td></tr>
<tr><td>FALSE</td><td>FALSE</td><td>FALSE</td></tr>
</table>
Ex.) If I4.1=TRUE, I3.2=TRUE, then result is TRUE</td></tr>
<tr><td>||</td><td>Or</td><td>[operand1] || [operand2]</td><td>I4.1 || I3.2</td><td>Or(||) Operator performs an inclusive logical disjunction on two Boolean operands.
Result is False if and only if both operand1 and operand2 evaluate to False.
The following table illustrates how result is determined.
<table>
<tr><th>operand1</th><th>operand2</th><th>the value of result</th></tr>
<tr><td>TRUE</td><td>TRUE</td><td>TRUE</td></tr>
<tr><td>TRUE</td><td>FALSE</td><td>TRUE</td></tr>
<tr><td>FALSE</td><td>TRUE</td><td>TRUE</td></tr>
<tr><td>FALSE</td><td>FALSE</td><td>FALSE</td></tr>
</table>
Ex.) If I4.1=FALSE, I3.2=FALSE, then result is FALSE</td></tr>
<tr><td>!!</td><td>Negation</td><td>!!(operand)</td><td>!!(I3.2)
I4.1 && !!(I3.2)</td><td>Not(!!) Operator performs a logical negation on a Boolean operand.
The following table illustrates how result is determined.
<table>
<tr><th>operand</th><th>the value of result</th></tr>
<tr><td>TRUE</td><td>FALSE</td></tr>
<tr><td>FALSE</td><td>TRUE</td></tr>
</table>
Ex.) If I3.2=TRUE, then result is FALSE
If I4.1=TRUE, I3.2=FALSE, then result is TRUE
[Correct example]
I2.1 && I4.1 && !!(I3.1), O1.1, F1.1
If Input Signal 2 and Input Signal are ON(TRUE), and Input Signal 3 is OFF(FALSE), then Output Signal 1 turns ON(TRUE). Otherwise Output Signal 1 is OFF(FALSE).
[Incorrect example]
I2.1 && !!(I3.1) && I4.1, O1.1, F1.1
* The next character following && !!( ) strings should be "," in a statement.
I2.1 && !!(I3.1) && !!(I4.1), O1.1, F1.1
* Multiple Not(!!) Operators are not permissible in a statement.</td></tr>
</table>

6.9. Comparison Operators

These operators compare two numbers to determine whether or not they meet the conditions and return the results of comparison.

The value representing the result of the comparison is Boolean. Any number is required to be integer and defined value in V(variable)

Operator	Functions	Format	Examples	Description
==	Equal to	[number1] == [number2]	V1.1 == V2.1 V1.1 == V2.1 + V3.1	Result is TRUE if number1 is equal to number2. Otherwise FALSE. Ex.) If V1.1=100, V2.1=100, then TRUE If V1.1=100, V2.1=50, V3.1=50, then TRUE
!=	Not Equal to	[number1] != [number2]	V1.1 != V2.1 V1.1 != V2.1 + V3.1	Result is TRUE if number1 is not equal to number2. Otherwise FALSE. Ex.) If V1.1=100, V2.1=100, then FALSE If V1.1=100, V2.1=50, V3.1=50, then FALSE
>	Greater than	[number1] > [number2]	V1.1 > V2.1 V1.1 > V2.1 + V3.1	Result is TRUE if number1 is greater than number2. Otherwise FALSE. Ex.) If V1.1=110, V2.1=100, then TRUE If V1.1=100, V2.1=50, V3.1=50, then FALSE
>=	Greater than or equal to	[number1] >= [number2]	V1.1 >= V2.1 V1.1 >= V2.1 + V3.1	Result is TRUE if number1 is greater than or equal to number2. Otherwise FALSE. Ex.) If V1.1=110, V2.1=100, then TRUE If V1.1=100, V2.1=50, V3.1=70, then FALSE
<	Smaller than	[number1] < [number2]	V1.1 < V2.1 V1.1 < V2.1 + V3.1	Result is TRUE if number1 is less than number2. Otherwise FALSE. Ex.) If V1.1=110, V2.1=100, then FALSE If V1.1=100, V2.1=50, V3.1=70, then TRUE
<=	Smaller than or equal to	[number1] <= [number2]	V1.1 <= V2.1 V1.1 <= V2.1 + V3.1	Result is TRUE if number1 is less than or equal to number2. Otherwise FALSE. Ex.) If V1.1=110, V2.1=100, then FALSE If V1.1=100, V2.1=50, V3.1=50, then TRUE

The following table contains a list of the relational comparison operators and the conditions that determine whether result is TRUE or FALSE.

Operator	TRUE if	FALSE if
==	number1 == number2	number1 != number2
!=	number1 != number2	number1 == number2
>	number1 > number2	number1 <= number2
>=	number1 >= number2	number1 < number2
<	number1 < number2	number1 >= number2
<=	number1 <= number2	number1> number2

Revision History

* User's Guide No. is described in the cover of this manual.

Revised Date	User's Guide No.	Page	Object	Revised Item
May, 2007	MDUG-CML/07525E-01			New Draft
Feb., 2008	MDUG-CML/08215E-01	CH 3-31～33	K26	Parameter name and Description are changed.
		CH 3-35	K28, K31	K36=2 change to K36=2 or 3.
		CH 3-36	K29, K32	
		CH 3-40	K36	Description is changed.
		CH 3-51	K45	Function of setting unit is added.
		CH 3-54	K48	Unit is changed.
		CH 3-60	K57	"80% of peak torque" change to "Rated torque".
		CH 3-61	K58, K59	Unit is changed.
		CH 3-62	K60	Description of when set to odd No. is added.
		CH 5-96	K46, K47	K45=1 change to K45=**1, K45=0 change to K45=**0.
		CH 6-116	K26	Max value and Description are changed.
		CH 6-117, 118	K28, K29 K31, K32	K36=2 change to K36=2 or 3.
		CH 6-119	K36	Max value and Description are changed.
		CH 6-120～123	K41, K51, K60, K63, K68, K72, K77	Default value is changed.
		CH 6-120	K45	Description of 2nd digit and 3rd digit is added.
		CH 6-121	K48, K58, K59	Unit is changed. Description of setting unit is added.
			K60	Description of when set to odd No. is added.
		CH 6-133	?85	Serial No. is added.
Apr., 2008	MDUG-CML/08215E-02	CH 6-135	M	M1 ～ 7 change to M1 ～ 8.
Jan., 2009	MDUG-CML/09101E-01	CH 2-013	P	Caution is added.
		CH 2-016	P	Caution is added.
		CH 3-075	K81	Caution is added.
		CH 4-088	4.4	Description of merge motion during even at the interpolation is added.
		CH 6-120	K45	Default value is changed.
		CH 6-121	K48, K58, K59	"*Unit depends on *** digit of K45." is added.

Revised Date	User's Guide No.	Page	Object	Revised Item
May, 2014	MDUG-CML/14501E-01	CH2-005	A	Change minimum value from "-32767" to "1".
		CH2-008	[	Description is changed.
		CH2-009	>	Description is changed from "End!" to "End.n".
		CH2-013	P	A part of explanation is deleted.
			A	Change minimum value from "-32767" to "1".
		CH2-014	V	Description is corrected from "AIN" to "ADIN".
		CH2-016	P	A part of explanation is deleted.
		CH2-017	Z	Explanation is changed.
		CH2-019	//	Explanation is added.
		CH2-023	V	Function name is changed.
		CH2-024	//	Explanation is added.
		CH3-025		Caution is added.
		CH3-026		Caution is changed.
		CH3-027	K23	Explanation is added to function 4.
		CH3-028	K24	Change maximum value from "32767" to "50000".
		CH3-034	K30	Explanation is added to function 7.
		CH3-048	K41	Change minimum value from "-32767" to "-999999999".
				Change maximum value from "32767" to "999999999".
		CH3-050	K44	Change minimum value from "10" to "1".
		CH3-052	K46	Explanation is added.
		CH3-060	K57	Change maximum value from "5000" to "10000".
		CH3-061	K58,K59	Change minimum value from "-32767" to "-999999999".
				Change maximum value from "32767" to "999999999".
		CH3-072	K73	Change minimum value from "0" to "1".
		CH3-075	K80	Change minimum value from "1" to "0".
			K81	Function is changed.
		CH3-076	K84	Function is added.
			K85	Function is added.
		CH4-086	4.3.1	Section name is changed.
		CH4-087	4.3.2	Section name is changed.
		CH4-088	4.4	Explanation is added in the frame.
		CH4-090	4.4.2	Value is changed from "P2.1" to "P2.2".
		CH4-092	4.4.3	Value is changed from "P2.1" to "P2.2".
		CH4-094	5.1	Caution about parameter setting is added.
		CH4-098	5.3.2	Explanation is added.
		CH5-105	5.6	Parameter diagram is changed and explanation is added.
		CH5-107	5.6.4	"5.6.4. Broadcast Communication Function" is added.
		CH5-108	5.6.5	"5.6.5. Endian" is added.
			5.6.6	"5.6.6. Modbus Setting and How to Usee in Daisy Chain" is added.
		CH5-111	5.6.7	"5.6.7. Function Code" is changed.
		CH5-119		"ASCII Code Character Table" is added.
		CH6-121	K24	Value is changed.
		CH6-125	K41,K44	Value is changed.
		CH6-126	K57,K58	Value is changed.
			K59	Value is changed.

Revised Date	User's Guide No.	Page	Object	Revised Item
		CH6-127	K73	Value is changed.
		CH6-128	K80,81	Changed.
			K84,K85	Added.
		CH6-130	V	Corrected from "AIN" to "ADIN".
		CH6-133	//	Explanation is changed.
		CH6-135	//	Explanation is changed.