Explanation of Terms

Resolution

The pulse count of an incremental signal output when the shaft revolves once, or the absolute address count.

Output Phase

The output signal count for an Incremental Encoder. There are 1-phase models (phase A), 2-phase models (phase A, phase B), and 3-phase models (phase A, phase B, and phase Z). The phase Z is an origin signal that is output once a revolution.

Output Phase Difference

When the shaft is rotated, this is the time difference between the rise or fall of the phase A and phase B signals, expressed as a proportion of the period of one signal, or as an electrical angle where one signal period equals 360°.
The difference between phase A and phase B as an electrical angle is normally 90°.
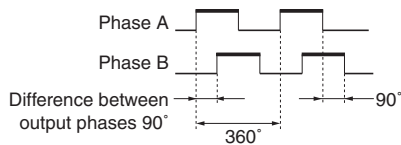

CW

The clockwise direction of rotation. Viewed from the end of the shaft, the shaft rotates clockwise. With an Incremental Encoder, phase A normally leads phase B in this rotation direction. With an Absolute Encoder, this is the direction of code increase.
The reverse of CW rotation is counterclockwise (CCW) rotation.
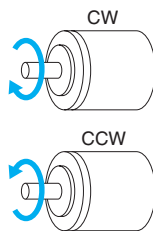
Output Duty Ratio

This is the ratio of the duration of high level during one period to the average period of pulse output when the shaft is rotated at a constant speed.
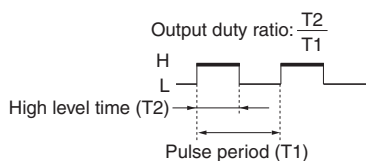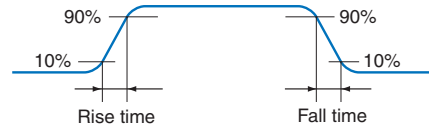

Maximum Response Frequency

The maximum frequency at which the signal can respond.

Rise and Fall Times of Output

The elapsed time from a 10% to 90% change in the output pulse.

Output Circuit

(1) Open-collector Output
An output circuit where the emitter of the output circuit transistor is the common and the collector is open.

(2) Voltage Output
An output circuit where the emitter of the output circuit transistor is the common and a resistor is inserted between the collector and the power supply to convert the output from the collector to a voltage.

(3) Line-driver Output
An output method that uses a special IC for high-speed, long-distance data transmission that complies with the RS-422A standard. The signal is output as a differential secondary signal, and thus is strong with respect to noise.
A special IC called a line receiver is used to receive the signal output from a line driver.

(4) Complementary Output
An output circuit with two output transistors (NPN and PNP) on the output.
These two output transistors alternately turn ON and OFF depending on the high or low output signal. When using them, pull up to the positive power supply voltage level or pull down to 0 V. The complementary output allows flow-in or flow-out of the output current and thus the rising and falling speeds of signals are fast. This allows a long cable distance.
They can be connected to open-collector input devices (NPN, PNP).

Starting Torque

The torque needed to rotate the shaft of the Rotary Encoder at startup.
The torque during normal rotation is normally lower than the starting torque. A shaft that has a waterproof seal has a higher starting torque.

Moment of Inertia

This expresses the magnitude of inertia when starting and stopping the Rotary Encoder.

Shaft Capacity

This is the load that can be applied to the shaft. The radial load is the load that is perpendicular to the shaft, and the thrust load is the load in the direction along the shaft. Both are permitted on the shaft during rotation, and the size of the load affects the life of the bearings.

Ambient Operating Temperature

The ambient temperature that meets the specifications, consisting of the permitted values for the external air temperature and the temperature of the parts that contact the Rotary Encoder.

Ambient Storage Temperature

The ambient temperature when the power is OFF that does not cause functional deterioration, consisting of the permitted values for the external air temperature and the temperature of the parts that contact the Rotary Encoder.

Degree of Protection

The level of protection against penetration of foreign objects from outside the Rotary Encoder. This is defined in the IEC60529 standard and expressed as IPXX.

The degree of protection against oil is specified by OMRON standards, and is expressed as oil-proof construction or oil resistance.

Absolute Code

(1) Binary Code

A pure binary code, expressed in the format 2^n. Multiple bits may change when an address changes.

(2) Gray Code

A code in which only one bit changes when an address changes. The code plate of the Rotary Encoder uses gray code.

(3) Remainder Gray Code

This code is used when expressing resolutions with gray code that are not 2^n, such as 36, 360, and 720. The nature of gray code is such that when the most significant bit of the code changes from 0 to 1 and the same size of area is used for both the larger value and the smaller value of objects, the signal only changes by 1 bit within this range when changing from the end to the beginning of a code. This enables any resolution that is an even number to be set with gray code. In this case, the code does not begin from 0, but from an intermediate code, and thus when actually using a code it must first be shifted so that it starts from 0.

The example in the code table shows 36 divisions. For the change from address 31 to 32, the code extends from address 14 to 49 when 18 addresses each are taken for the objects. When changing from address 49 to 14, only one bit changes, and we can see that the characteristic of gray code is preserved. By shifting the code 14 addresses, it can be converted to a code that starts from address 0.

(4) BCD

Binary Coded Decimal Code.

Each digit of a decimal number is expressed using a binary value.

Serial Transmission

In contrast to parallel transmission where multiple bits of data are simultaneously output, this method outputs data serially on a single transmission line, enabling the use of fewer wires. The receiving device converts the signals into parallel signals.

Hollow Shaft

The rotating shaft is hollow, and the drive shaft can be directly connected to the hole in the hollow shaft to reduce the length along the direction of the shaft. A leaf spring is used as a buffer to absorb vibration from the drive shaft.

Metal Disk

The rotating slit disk in the Encoder is made of metal for higher shock tolerance than glass. Due to slit machining limitations, the metal disk cannot be used for high-resolution applications.

Servo Mount

A method of mounting the Encoder in which a Servo Mounting Bracket is used to clamp down the flange of the Encoder. The position of the Encoder in the direction of rotation can be adjusted, and thus this method is used to temporarily mount the Encoder to adjust the origin. Refer to *Accessories*.

Absolute Code Table

Decimal	Binary	Gray	Gray remainder 14	BCD 10	BCD 1
0	0 0 0 0 0	0 0 0 0 0 0		0 0 0	0 0 0 0
1	0 0 0 0 1	0 0 0 0 0 1		0 0 0	0 0 0 1
2	0 0 0 1 0	0 0 0 0 1 1		0 0 0	0 0 1 0
3	0 0 0 1 1	0 0 0 0 1 0		0 0 0	0 0 1 1
4	0 0 1 0 0	0 0 0 1 1 0		0 0 0	0 1 0 0
5	0 0 1 0 1	0 0 0 1 1 1		0 0 0	0 1 0 1
6	0 0 1 1 0	0 0 0 1 0 1		0 0 0	0 1 1 0
7	0 0 1 1 1	0 0 0 1 0 0		0 0 0	0 1 1 1
8	0 1 0 0 0	0 0 1 1 0 0		0 0 0	1 0 0 0
9	0 1 0 0 1	0 0 1 1 0 1		0 0 0	1 0 0 1
10	0 1 0 1 0	0 0 1 1 1 1		0 0 1	0 0 0 0
11	0 1 0 1 1	0 0 1 1 1 0		0 0 1	0 0 0 1
12	0 1 1 0 0	0 0 1 0 1 0		0 0 1	0 0 1 0
13	0 1 1 0 1	0 0 1 0 1 1		0 0 1	0 0 1 1
14	0 1 1 1 0	0 0 1 0 0 1	0 0	0 0 1	0 1 0 0
15	0 1 1 1 1	0 0 1 0 0 0	0 1	0 0 1	0 1 0 1
16	1 0 0 0 0	0 1 1 0 0 0	0 2	0 0 1	0 1 1 0
17	1 0 0 0 1	0 1 1 0 0 1	0 3	0 0 1	0 1 1 1
18	0 1 0 0 1 0	0 1 1 0 1 1	0 4	0 0 1	1 0 0 0
19	0 1 0 0 1 1	0 1 1 0 1 0	0 5	0 0 1	1 0 0 1
20	0 1 0 1 0 0	0 1 1 1 1 0	0 6	0 1 0	0 0 0 0
21	0 1 0 1 0 1	0 1 1 1 1 1	0 7	0 1 0	0 0 0 1
22	0 1 0 1 1 0	0 1 1 1 0 1	0 8	0 1 0	0 0 1 0
23	0 1 0 1 1 1	0 1 1 1 0 0	0 9	0 1 0	0 0 1 1
24	0 1 1 0 0 0	0 1 0 1 0 0	1 0	0 1 0	0 1 0 0
25	0 1 1 0 0 1	0 1 0 1 0 1	1 1	0 1 0	0 1 0 1
26	0 1 1 0 1 0	0 1 0 1 1 1	1 2	0 1 0	0 1 1 0
27	0 1 1 0 1 1	0 1 0 1 1 0	1 3	0 1 0	0 1 1 1
28	0 1 1 1 0 0	0 1 0 0 1 0	1 4	0 1 0	1 0 0 0
29	0 1 1 1 0 1	0 1 0 0 1 1	1 5	0 1 0	1 0 0 1
30	0 1 1 1 1 0	0 1 0 0 0 1	1 6	0 1 1	0 0 0 0
31	0 1 1 1 1 1	0 1 0 0 0 0	1 7	0 1 1	0 0 0 1
32	1 0 0 0 0 0	1 1 0 0 0 0	1 8	0 1 1	0 0 1 0
33	1 0 0 0 0 1	1 1 0 0 0 1	1 9	0 1 1	0 0 1 1
34	1 0 0 0 1 0	1 1 0 0 1 1	2 0	0 1 1	0 1 0 0
35	1 0 0 0 1 1	1 1 0 0 1 0	2 1	0 1 1	0 1 0 1
36	1 0 0 1 0 0	1 1 0 1 1 0	2 2	0 1 1	0 1 1 0
37	1 0 0 1 0 1	1 1 0 1 1 1	2 3	0 1 1	0 1 1 1
38	1 0 0 1 1 0	1 1 0 1 0 1	2 4	0 1 1	1 0 0 0
39	1 0 0 1 1 1	1 1 0 1 0 0	2 5	0 1 1	1 0 0 1
40	1 0 1 0 0 0	1 1 1 1 0 0	2 6	1 0 0	0 0 0 0
41	1 0 1 0 0 1	1 1 1 1 0 1	2 7	1 0 0	0 0 0 1
42	1 0 1 0 1 0	1 1 1 1 1 1	2 8	1 0 0	0 0 1 0
43	1 0 1 0 1 1	1 1 1 1 1 0	2 9	1 0 0	0 0 1 1
44	1 0 1 1 0 0	1 1 1 0 1 0	3 0	1 0 0	0 1 0 0
45	1 0 1 1 0 1	1 1 1 0 1 1	3 1	1 0 0	0 1 0 1
46	1 0 1 1 1 0	1 1 1 0 0 1	3 2	1 0 0	0 1 1 0
47	1 0 1 1 1 1	1 1 1 0 0 0	3 3	1 0 0	0 1 1 1
48	1 1 0 0 0 0	1 0 1 0 0 0	3 4	1 0 0	1 0 0 0
49	1 1 0 0 0 1	1 0 1 0 0 1	3 5	1 0 0	1 0 0 1
50	1 1 0 0 1 0	1 0 1 0 1 1		1 0 1	0 0 0 0
51	1 1 0 0 1 1	1 0 1 0 1 0		1 0 1	0 0 0 1
52	1 1 0 1 0 0	1 0 1 1 1 0		1 0 1	0 0 1 0
53	1 1 0 1 0 1	1 0 1 1 1 1		1 0 1	0 0 1 1
54	1 1 0 1 1 0	1 0 1 1 0 1		1 0 1	0 1 0 0
55	1 1 0 1 1 1	1 0 1 1 0 0		1 0 1	0 1 0 1
56	1 1 1 0 0 0	1 0 0 1 0 0		1 0 1	0 1 1 0
57	1 1 1 0 0 1	1 0 0 1 0 1		1 0 1	0 1 1 1
58	1 1 1 0 1 0	1 0 0 1 1 1		1 0 1	1 0 0 0
59	1 1 1 0 1 1	1 0 0 1 1 0		1 0 1	1 0 0 1
60	1 1 1 1 0 0	1 0 0 0 1 0		1 1 0	0 0 0 0
61	1 1 1 1 0 1	1 0 0 0 1 1		1 1 0	0 0 0 1
62	1 1 1 1 1 0	1 0 0 0 0 1		1 1 0	0 0 1 0
63	1 1 1 1 1 1	1 0 0 0 0 0		1 1 0	0 1 1 1

Operating Procedure and Data

Peripheral Device Connectability   Yes: Connection possible. No: Connection not possible.
#### Incremental Encoders

Peripheral device / Rotary Encoder model (Model)	Digital Counter (H7BR)	Self-powered Tachometer (H7ER)	Frequency/ Rate Meter (K3NR)	Up/Down Counting Meter (K3NC)	Period Meter (K3NP)	Direction Detection Unit (E63-WF5C)	Built-in Counter in SYSMAC PLC (CJ1M-CPU2□)	High-speed Counter Unit (C□-CT□)
E6D-CWZ1E E6J-CWZ1E	Yes Requires separate power supply for Encoder.	Yes	No	No	No	No	No	Yes
E6D-CWZ2C	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
E6F-CWZ5G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
E6A2-CS3E E6A2-CW3E E6A2-CWZ3E E6B2-CWZ3E E6H-CWZ3E E6C2-CWZ3E E6C3-CWZ3EH	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
E6A2-CS3C E6A2-CW3C E6A2-CWZ3C E6A2-CS5C E6A2-CW5C E6B2-CWZ6C E6H-CWZ6C E6C2-CWZ6C E6C3-CWZ5GH	Yes	Yes	Yes	Yes	Yes	Yes	No Yes	Yes
E6B2-CWZ1X E6H-CWZ3X E6C2-CWZ1X E6C3-CWZ3XH	No	No	No	No	No	No	Yes	Yes
E6B2-CWZ5B E6C2-CWZ5B	Yes Requires external load connection resistor.	No	Yes	No	Yes	No	No	No

Absolute Encoders

| Peripheral device	Cam Positioner		SYSMAC Programmable Controller		
Rotary Encoder model Model	H8PS	H8PR	CPM1A	CQM1H-CPU51 +CQM1H-ABB21	DC Input Unit
E6CP-AG5C E6C3-AG5C	No	No	Yes — Requires separate power supply for Encoder.	Yes — Requires separate power supply for Encoder.	Yes — Requires separate power supply for Encoder.
E6CP-AG5C-C E6C3-AG5C-C E6F-AG5C-C	Yes	No	No	Yes — Requires E69-DC5 Connection Cable.	No
E6F-AB3C	No	No	Yes — Requires separate power supply for Encoder.	No	Yes — Requires separate power supply for Encoder.
E6F-AB3C-C	No	Yes	No	No	No
E6C-NN5C E6C-NN5CA	No	No	Yes	No	Yes — Requires separate power supply for Encoder.
E6C-NN5C-C E6C-NN5CA-C	No	No	Yes — Requires PS-26PE-D4☐ Connector manufactured by Japan Aviation Electronics Industry, Ltd.	No	Yes — Requires PS-26PE-D4☐ Connector manufactured by Japan Aviation Electronics Industry, Ltd., and separate power supply for Encoder.

Example of Connection with H7ER Self-powered Tachometer

Example of Applicable Models	E6A2-CS3E 10P/R, 60P/R E6C2-CWZ3E, E6F-CWZ5G 600P/R E6C3-CWZ3EH 10P/R, 60P/R, 600P/R

E6A2 — Brown / Black / 5 to 12 VDC / Blue — H7ER Self-powered Tachometer
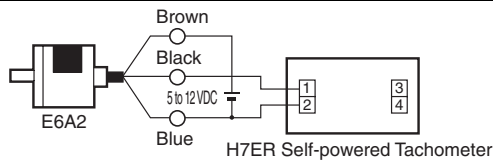
Example of Connection with H7BR Digital Counter

Example of Applicable Models	E6A2-CW3E E6C2-CWZ3E, E6C3-CWZ3EH, E6F-CWZ5G

E6A2-CW3 — Brown / Black / White / Shield / Blue / 0V / +12V — H7BR Digital Counter
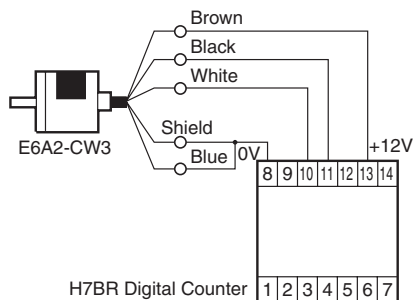
Example of Connection with K3NC Up/Down Counting Meter

- NPN Open-collector Outputs

Example of Applicable Models	E6A2-CS3C, E6A2-CS5C E6A2-CW3C, E6A2-CW5C E6C2-CWZ6C, E6F-CWZ5G

E6C2-CWZ6C — 0V / POWER / +12V / Phase A / Phase B — K3NC Up/Down Counting Meter
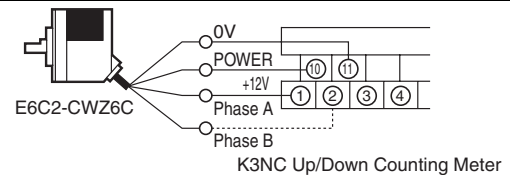
- Voltage Outputs

Example of Applicable Models	E6A2-CS3E, E6A2-CW3E E6C2-CWZ3E

E6C2-CWZ3E — 0V / POWER 0V / +12V / Phase A / INA INB — K3NC Up/Down Counting Meter
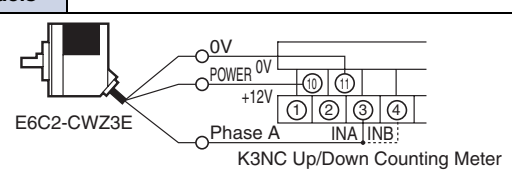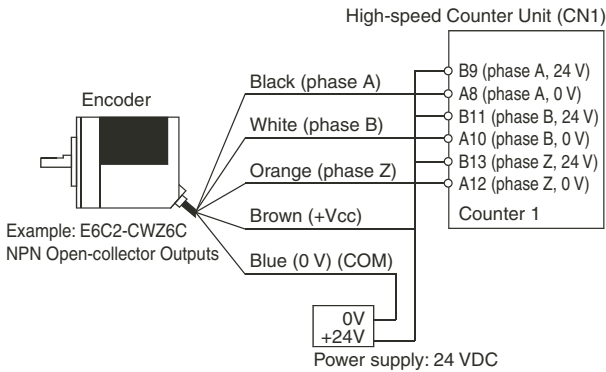
Example of Connection with CJ1W-CT021 High-speed Counter Unit in Programmable Controller

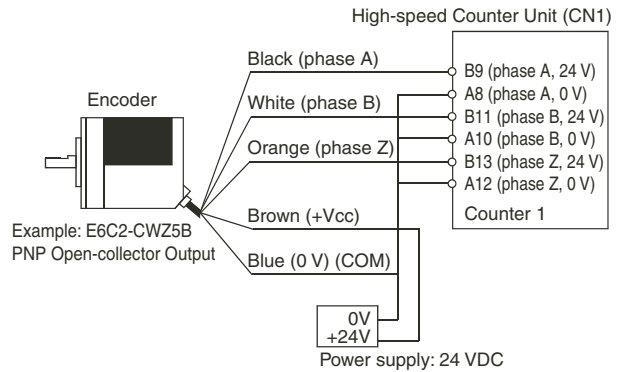| Example of Applicable Models (1)	E6A2-C, E6B2-C, E6C2-C, E6H-C E6F-CWZ5G, E6D (open-collector output)

Encoder with NPN Open-collector Output (5/12/24 VDC)

High-speed Counter Unit (CN1)

Encoder

Black (phase A) — B9 (phase A, 24 V)
— A8 (phase A, 0 V)
White (phase B) — B11 (phase B, 24 V)
— A10 (phase B, 0 V)
Orange (phase Z) — B13 (phase Z, 24 V)
— A12 (phase Z, 0 V)

Counter 1

Example: E6C2-CWZ6C
NPN Open-collector Outputs

Brown (+Vcc)

Blue (0 V) (COM)

0V
+24V

Power supply: 24 VDC

Note: Connections are as follows if the Encoder power supply is 5 V or 24 V.
Phase A + 5-V power supply → A19, 24 V → B20
Phase B + 5-V power supply → A17, 24 V → B18

Example of Applicable Models (2)	E6B2-CWZ5B E6C2-CWZ5B, E6C3-CWZ5GH

Encoder with PNP Open-collector Output (5/12/24 VDC)

High-speed Counter Unit (CN1)

Encoder

Black (phase A) — B9 (phase A, 24 V)
— A8 (phase A, 0 V)
White (phase B) — B11 (phase B, 24 V)
— A10 (phase B, 0 V)
Orange (phase Z) — B13 (phase Z, 24 V)
— A12 (phase Z, 0 V)

Counter 1

Example: E6C2-CWZ5B
PNP Open-collector Output

Brown (+Vcc)

Blue (0 V) (COM)

0V
+24V

Power supply: 24 VDC

Note: Note: Connections are as follows if the Encoder power supply is 5 V or 24 V.
Phase A + 5-V power supply → A19, 24 V → B20
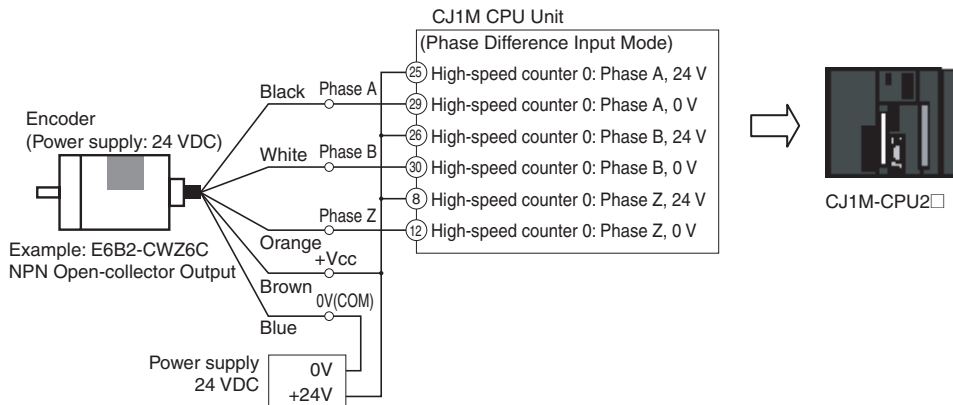Phase B + 5-V power supply → A17, 24 V → B18

Example of Applicable Models (3)	E6B2-CWZ1X, E6C2-CWZ1X E6C3-CWZ3XH, E6H-CWZ3X

Encoder with Line-driver Output (RS-422)

High-speed Counter Unit (CN1)

Encoder

Black (phase A +) — B15 (phase A, line driver +)
Black/red (phase A -) — A15 (phase A, line driver -)
White (phase B +) — B17 (phase B, line driver +)
White/red (phase B -) — A17 (phase B, line driver -)
Orange (phase Z +) — B19 (phase Z, line driver +)
Orange/red (phase Z -) — A19 (phase Z, line driver -)

Counter 2

Example: E6B2-CWZ1X
with Line-driver Output

Brown (5 VDC)

Blue (0 V) (COM)

0V
+5V

Power supply: 5 VDC

OMRON

9
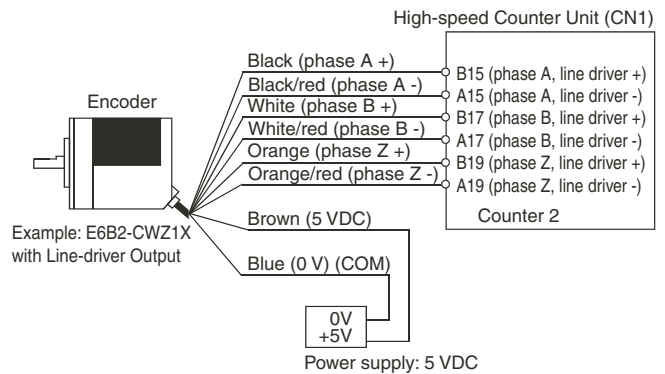
Example of Connection with CJ1M-CPU2☐ Programmable Controller

Example of Applicable Models	E6A2-CWZ5C, E6C2-CWZ6C, E6C3-CWZ5GH, E6F-CWZ5G

CJ1M CPU Unit
(Phase Difference Input Mode)

Encoder (Power supply: 24 VDC)

Example: E6B2-CWZ6C
NPN Open-collector Output

- Black — Phase A — ㉕ High-speed counter 0: Phase A, 24 V
- Phase A — ㉙ High-speed counter 0: Phase A, 0 V
- White — Phase B — ㉖ High-speed counter 0: Phase B, 24 V
- Phase B — ㉚ High-speed counter 0: Phase B, 0 V
- Phase Z — ⑧ High-speed counter 0: Phase Z, 24 V
- Orange — Phase Z — ⑫ High-speed counter 0: Phase Z, 0 V
- Orange — +Vcc
- Brown — 0V(COM)
- Blue

Power supply 24 VDC — 0V / +24V

CJ1M-CPU2☐

- The six inputs to the CPU Unit (IN 8, 9, and 3, and IN 6, 7, and 2) can be used for the built-in high-speed counter by directly inputting the pulse input from the Rotary Encoder.
- The response speed is 60 kHz for single phase and the phase difference (multiplier of 4) is 30 kHz. Counting can be performed from 0 to 4,294,967,295 pulses in incremental mode and from -2,147,483,648 to 2,147,483,647 in incremental/decremental mode.
- Operating modes for the high-speed counter are set in the PLC Setup.

<Count Mode>

Phase difference input mode	Incremental/decremental counting is performed using the phase difference between phases A and B (4-times multiplier constant).
Incement/ decrement pulse input mode	Incremental/decremental counting is performed using phase A as the incremental pulse input and phase B as the decremental pulse input.
Pulse and direction input mode	Incremental/decremental counting is performed using phase A as the pulse input and phase B as the direction signal (i.e., incremental/ decremental).
Incremental pulse input mode	Incremental counting is performed using phase A only.

<Value range mode>

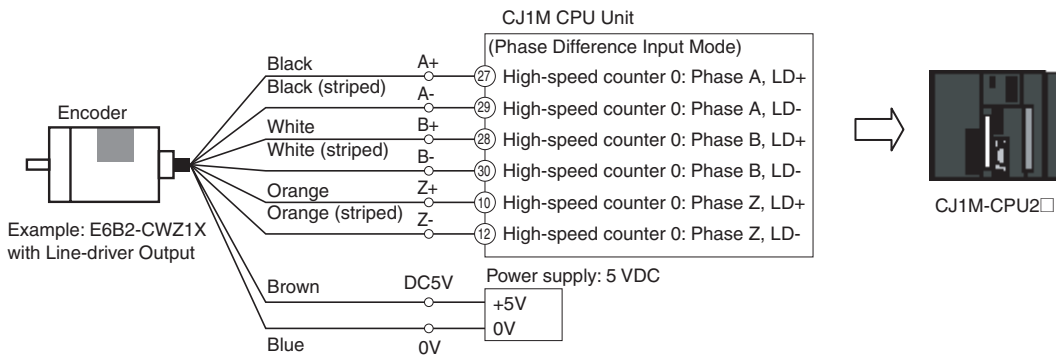|	
Linear mode	Counting is performed within the range of the upper limit and lower limit.
Ring mode	Counting is performed by looping the input pulse within the set range.

<Reset Method>

Phase Z and software reset	If software reset is ON, the present value will be reset when the phase-Z input turns ON.
Software reset	The present value will be reset when software reset turns ON.

<Output Method>

Target value comparison	Up to 48 target values can be set. When the present value reaches a target value, the specified subroutine is executed.
Range comparison	Up to 8 ranges (upper and lower limits) can be set. When the present value enters a range, the specified subroutine is executed.

Example of Applicable Models	E6B2-CWZ1X, E6C2-CWZ1X, E6C3-CWZ3XH, E6H-CWZ3X with Line-driver Output

CJ1M CPU Unit
(Phase Difference Input Mode)

Encoder

Example: E6B2-CWZ1X
with Line-driver Output

- Black — A+ — ㉗ High-speed counter 0: Phase A, LD+
- Black (striped) — A- — ㉙ High-speed counter 0: Phase A, LD-
- White — B+ — ㉘ High-speed counter 0: Phase B, LD+
- White (striped) — B- — ㉚ High-speed counter 0: Phase B, LD-
- Orange — Z+ — ⑩ High-speed counter 0: Phase Z, LD+
- Orange (striped) — Z- — ⑫ High-speed counter 0: Phase Z, LD-
- Brown — DC5V — Power supply: 5 VDC — +5V
- Blue — 0V — 0V

CJ1M-CPU2☐

Example of Connection with CQM1H-CPU51 + CQM1H-ABB21 Programmable Controller (Absolute Interface, Built-in RS-232C, Large Capacity)

Example of Applicable Models	E6F-AG5C-C, E6CP-AG5C-C E6C3-AG5C-C

Position data can be directly input from the Absolute Encoder. The absolute data input is 12-bit gray code. Position data is stored even when the power supply is interrupted, so there is no need to return to the origin when the power is restored.
The origin compensation function enables any position to be treated as the origin.

<Operation Modes>
BCD mode or 360° mode can be selected.
<Resolution>
Any of the following can be selected.
8-bit (0 to 255)
10-bit (0 to 1023)
12-bit (0 to 4095)
Set the mode according to the resolution of the Encoder.

<Input Specifications>

Input voltage	DC24V ±10%/-15%
Input impedance	5.4kΩ
Input current	4mA (TYP.)
ON voltage	16. 8 VDC min.
OFF voltage	3.0 VDC max.
Counting speed	4 KHz max.
Input code	Gray binary (8, 10, or 12 bits)

I/O capacity	128 points
User memory	3.2 Kwords
Data memory	1 Kword
Number of connected Units	7 max.
Instruction set	118 instructions
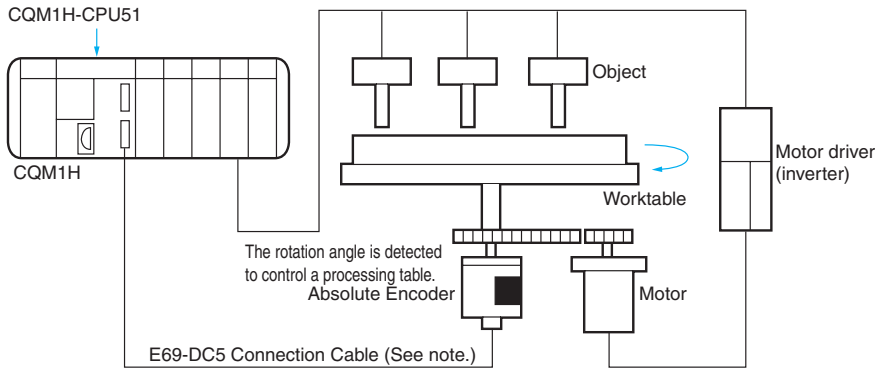
Note: When using a 256 resolution, use the E69-DC5 Connection Cable (sold separately).

Connecting Cable for CQM1H-CPU51 Programmable Controller (Sold Separately)
E69-DC5
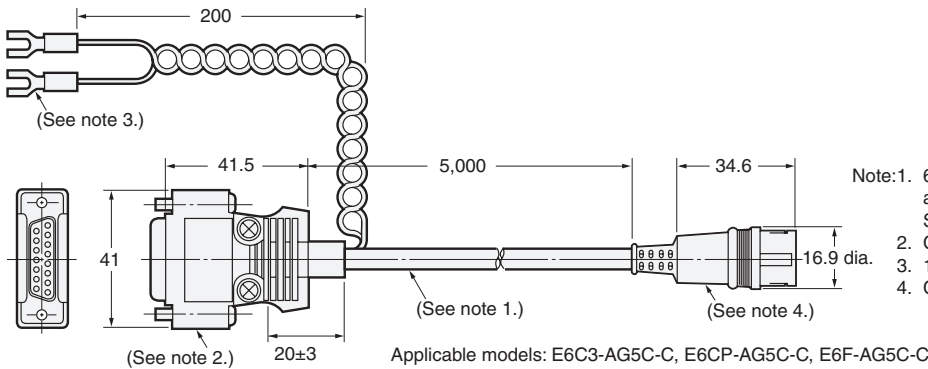
Note:
1. 6-dia. 12-conductor shielded cable (cross-section area: 0.2 mm²; insulation diameter: 1.1 mm), Standard length: 5 m
2. Connected to CQM1H-CPU51.
3. 12 to 24 VDC
4. Connect to Encoder.

Applicable models: E6C3-AG5C-C, E6CP-AG5C-C, E6F-AG5C-C

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