Overview

What Are Rotary Encoders?

Rotary Encoders are sensors that detect position and speed by converting rotational mechanical displacements into electrical signals and processing those signals. Sensors that detect mechanical displacement for straight lines are referred to as Linear Encoders.

Features

(1) The output is controlled according to the rotational displacement of the shaft.
Linking to the shaft using a coupling enables direct detection of rotational displacement.

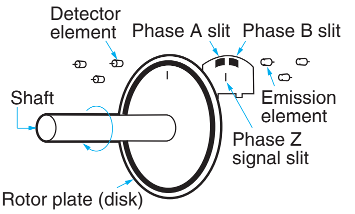
(2) Returning to the origin is not required at startup for Absolute Encoders.
With an Absolute Encoder, the rotational angle is output in parallel as an absolute value.

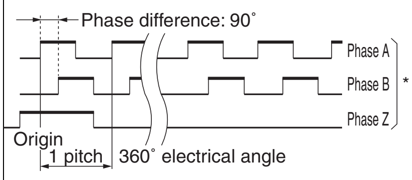
(3) The rotation direction can also be detected.
The rotation direction is determined by the output timing of phases A and B with an Incremental Encoder, and by the code increase or decrease with an Absolute Encoder.

(4) Choose the optimal Sensor from a wide lineup of resolutions and output types.
Select the Sensor to match the requirements for precision, cost, and connected circuits.

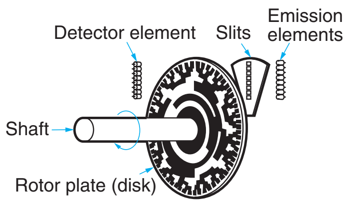
Operating Principles

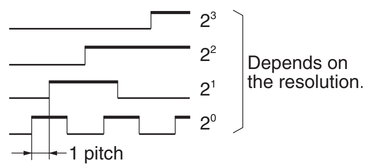
<table>
<tr><th>Item
Classification</th><th>Features</th><th>Structure</th><th>Output waveform</th></tr>
<tr>
<td>Incremental Encoders

E6J-C
E6A2-C
E6B2-C
E6C2-C
E6C3-C
E6D-C
E6F-C
E6H-C</td>
<td>• This type of encoder outputs a pulse string in response to the amount of rotational displacement of the shaft. A separate counter counts the number of output pulses to determine the amount of rotation based on the count.
• To detect the amount of rotation from a certain input shaft position, the count in the counter is reset at the reference position and the number of pulses from that position is added cumulatively by the counter. For this reason, the reference position can be selected as desired, and the count for the amount of rotation can be unlimited.
Another important feature is that a circuit can be added to generate twice or four times the number of pulses for one signal period, for heightened electrical resolution.*
Also, the phase-Z signal, which is generated once a revolution, can be used as the origin within a revolution.
*When high resolution is necessary, a 4-multiplier circuit is generally used. (4x output is obtained by differentiating the rise and fall waveforms of phase A and phase B, resulting in four times the resolution.)</td>
<td>

When a disk with an optical pattern revolves along with the shaft, light passing through two slits is transmitted or blocked accordingly. The light is converted to electrical currents in the detector elements, which correspond to each slit, and is output as two square waves. The two slits are positioned so that the phase difference between the square wave outputs is 1/4 pitch.</td>
<td>

* Even if resolution changes, the number of phases does not change.</td>
</tr>
<tr>
<td>Absolute Encoders

E6J-A
E6CP-A
E6C3-A
E6F-A</td>
<td>• This type of encoder outputs in parallel the rotation angle as an absolute value in 2^n code.
It therefore has one output for each output code bit, and as the resolution increases, the value of outputs increases. Rotation position detection is accomplished by directly reading the output code.
• When the Encoder is incorporated into a machine, the zero position of the input revolution shaft is fixed, and the rotation angle is always output as a digital value with the zero position as the coordinate origin.
Data is never corrupted by noise, and returning to the zero position at startup is not necessary.
Furthermore, even when code reading becomes impossible due to high-speed rotation, correct data can be read when the rotation speed slows, and correct rotation data can even be read when the power is restored after a power failure or other interruption in the power supply.</td>
<td>

When a disk with a pattern rotates, light passing through the slits is transmitted or blocked according to the pattern. The received light is converted to electrical currents in the detector elements, takes the form of waves, and becomes digital signals.</td>
<td>
</td>
</tr>
</table>

Classification

Selection Guidelines

1 Incremental Encoder or Absolute Encoder?

Select a type that is suitable in terms of the cost vs. capacity, returning (or not) to the origin at startup, the maximum speed, and noise tolerance.

2 How much resolution is needed?

Select the optimal model in view of required precision and cost of machine equipment. We recommend selecting a resolution of from 1/2 to 1/4 of the precision of the machine with which the Encoder will be used.

3 Dimensions

Also take into consideration the type of shaft that is required (hollow shaft or regular shaft) in relation to mounting space.

4 Permitted Shaft Loading

When selecting, take into consideration how the mounting method affects the load on the shaft and mechanical life.

5 Maximum Permissible Speed

Base your selection on the maximum mechanical speed during use.

6 Maximum Response Frequency

Base your selection on the maximum shaft speed when the device in which the Encoder is used is in operation.
Maximum response frequency = (Revolutions (RPM) /60) x Resolution.
There are deviations in the actual signal periods, so the specifications of the selected model should provide a certain amount of leeway with respect to the above calculated value.

7 Degree of Protection

Select the model based on how much dust, water, and oil there is in the application environment.

- Dust only: IP50
- Water or oil also present: IP52(f), IP64(f) (water-resistant, oil-resistant)
- Oil present: Oil-proof construction

8 Startup Torque of Shaft

How much torque does the drive have?

9 Output Circuit Type

Select the circuit type based on the device to be connected, the frequency of the signal, transmission distance, and noise environment.
For long distance transmission, a line-driver output is recommended.

Explanation of Terms

Resolution

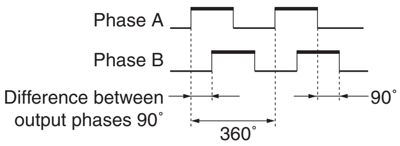
The pulse count of an incremental signal output when the shaft revolves once, or the absolute address count.

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.

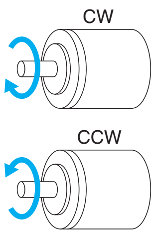
Output Phase Difference

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°.



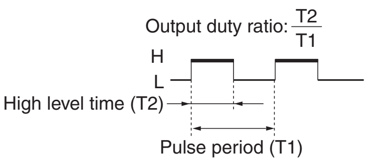
CW

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.

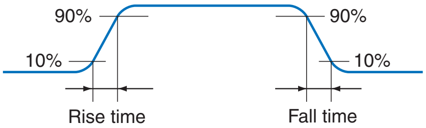


Maximum Response Frequency

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

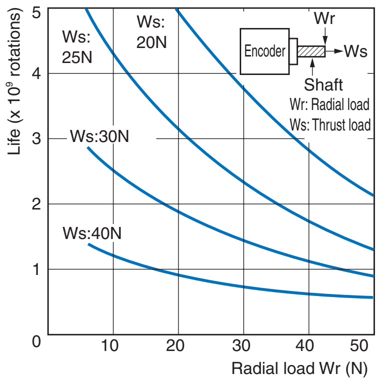
Dec-imal	Binary						Gray						Gray re-mainder 14		BCD						
															10			1			
0		0	0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0
1		0	0	0	0	1	0	0	0	0	0	1			0	0	0	0	0	0	1
2		0	0	0	1	0	0	0	0	0	1	1			0	0	0	0	0	1	0
3		0	0	0	1	1	0	0	0	0	1	0			0	0	0	0	0	1	1
4		0	0	1	0	0	0	0	0	1	1	0			0	0	0	0	1	0	0
5		0	0	1	0	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

Interpreting Engineering Data

Bearing Life	Cable Extension Characteristics
E6B2-C	E6B2-CWZ6C

Bearing Life

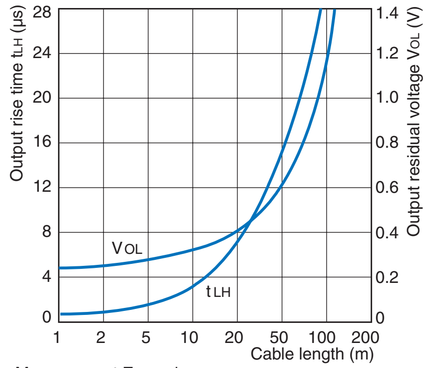
E6B2-C



- This graph shows the relationship between mechanical life and the load applied to the shaft.
- The size of the load during rotation affects the life of the bearings.

Cable Extension Characteristics

E6B2-CWZ6C



Measurement Example
Power supply voltage: 5 VDC
Load resistance: 1 kΩ (Output residual voltage is measured at a 35 mA load current.)
Cable: Special Cable

- This graph shows the effect of the output waveform if the cable is extended.
- Extending the cable length not only changes the startup time, but also increases the output residual voltage.

Operating Procedure and Data

Peripheral Device Connectability

Yes: Connection possible. No: Connection not possible.

Incremental Encoders

Peripheral device	Digital Counter	Self-powered Tachometer	Frequency/ Rate Meter	Up/Down Counting Meter	Period Meter	Direction Detection Unit	SYSMAC Pulse I/O Module *	High-speed Counter Unit	EtherCAT-compatible Encoder Input Terminal
Rotary Encoder model / Model	H7BX-A H7CX-A□-N	H7BX-AW H7CX-R□-N H7ER-N	K3HB-R	K3HB-C	K3HB-P	E63-WF5C	CJ2M-CPU1□/ CPU3□ + CJ2M-MD21□	C□-CT□	GX-EC02□□
E6D-CWZ1E E6J-CWZ1E	No	No	No	No	No	No	No	Yes	No
E6D-CWZ2C	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
E6F-CWZ5G	Yes	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	No
E6A2-CS3C E6A2-CW3C E6A2-CWZ3C E6A2-CS5C E6A2-CW5C E6B2-CWZ6C E6H-CWZ6C E6C2-CWZ6C E6C3-CWZ5GH	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
E6B2-CWZ1X E6H-CWZ3X E6C2-CWZ1X E6C3-CWZ3XH	No	No	No	No	No	No	Yes	Yes	Yes
E6B2-CWZ5B E6C2-CWZ5B	No	No	Yes	No	Yes	No	No	No	No

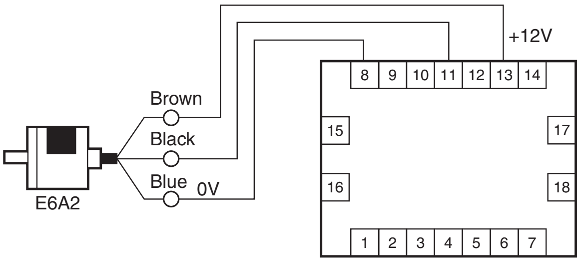
* Supported by CJ2M CPU Unit with unit version 2.0 or later.

Absolute Encoders

Peripheral device / Rotary Encoder model / Model	Cam Positioner	SYSMAC Programmable Controller						
	H8PS	CPM1A		CP1H	CP1L	CP1E	DC Input Unit	
E6CP-AG5C E6C3-AG5C	No	Yes	Requires separate power supply for Encoder.	Yes	Yes	Yes	Yes	Requires separate power supply for Encoder.
E6CP-AG5C-C E6C3-AG5C-C E6F-AG5C-C	Yes	No		No	No	No	No	
E6F-AB3C	No	Yes	Requires separate power supply for Encoder.	Yes	Yes	Yes	Yes	Requires separate power supply for Encoder.
E6F-AB3C-C	No	No		No	No	No	No	

Example of Connection with H7BX-AW Self-powered Tachometer

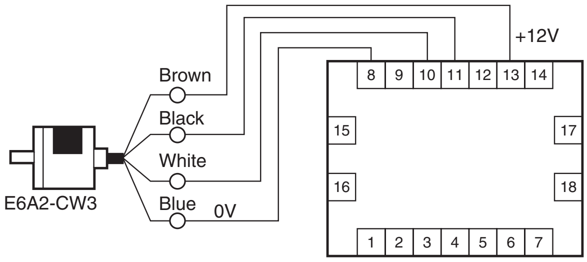
Example of Applicable Models	E6A2-CS3E 10P/R, 60P/R E6C2-CWZ3E, E6F-CWZ5G 600P/R E6C3-CWZ3EH 10P/R, 60P/R, 600P/R



H7BX-AW Self-powered Tachometer

Example of Connection with H7BX-A Digital Counter

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

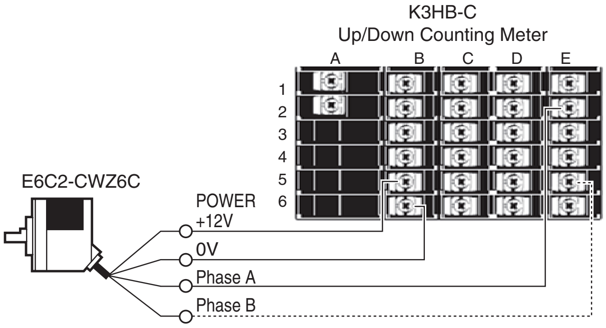


H7BX-A Digital Counter

Example of Connection with K3HB-C Up/Down Counting Meter

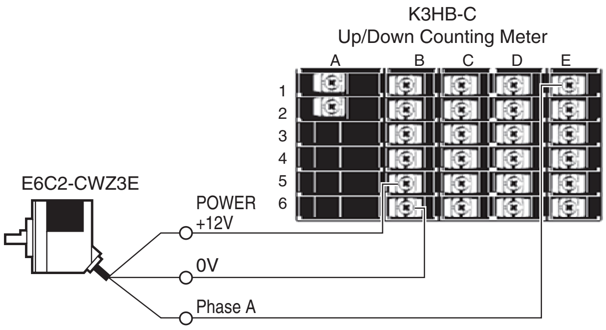
• NPN Open-collector Outputs

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



• Voltage Outputs

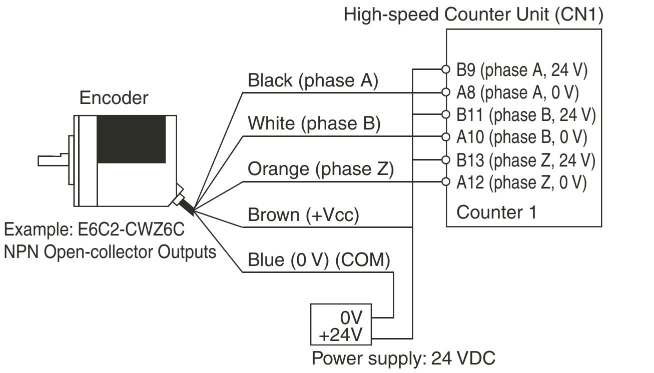
Example of Applicable Models	E6A2-CS3E, E6A2-CW3E E6C2-CWZ3E



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)

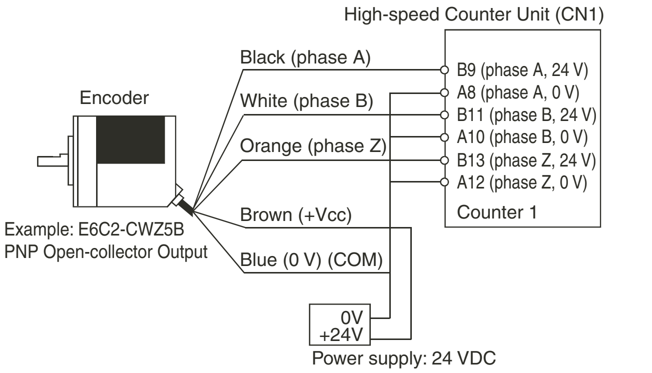
Encoder with NPN Open-collector Output (5/12/24 VDC)



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

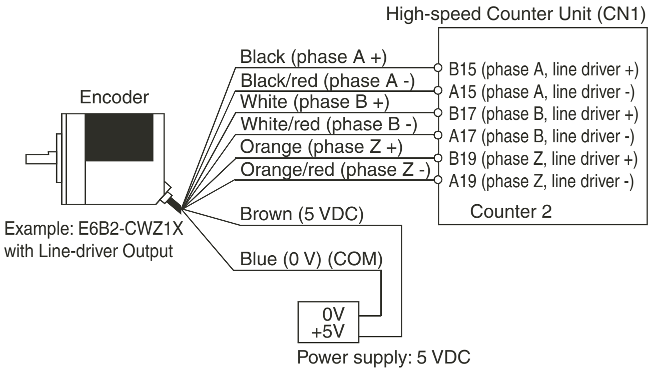
Encoder with PNP Open-collector Output (5/12/24 VDC)



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

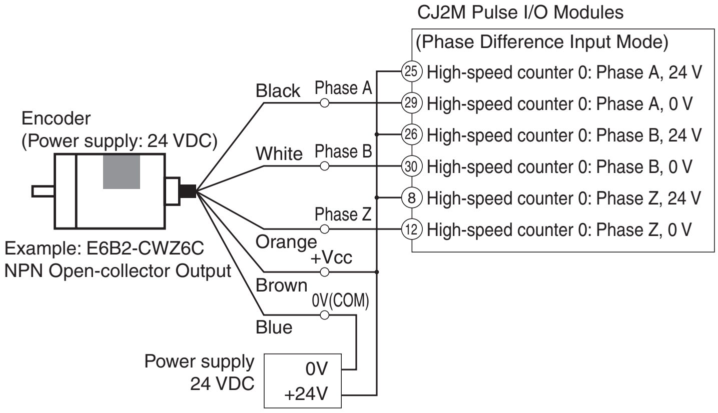
Example of Applicable Models (3)	E6B2-CWZ1X, E6C2-CWZ1X E6C3-CWZ3XH, E6H-CWZ3X

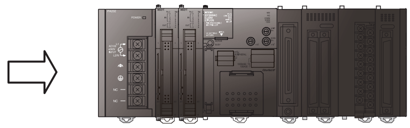
Encoder with Line-driver Output (RS-422)



Example of Connection with CJ2M-CPU1□/CPU3□ + CJ2M-MD21□ SYSMAC Pulse I/O Module

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





CJ2M-CPU1□/CPU3□ + CJ2M-MD21□

- Up to two Pulse I/O Modules can be mounted to a CJ2M CPU Unit with unit version 2.0 or later. Each Pulse I/O Module allows you to use six inputs (IN8, IN9, IN3, IN6, IN7, and IN2) to directly input pulses from rotary encoders for application in built-in high-speed counters.
- 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.

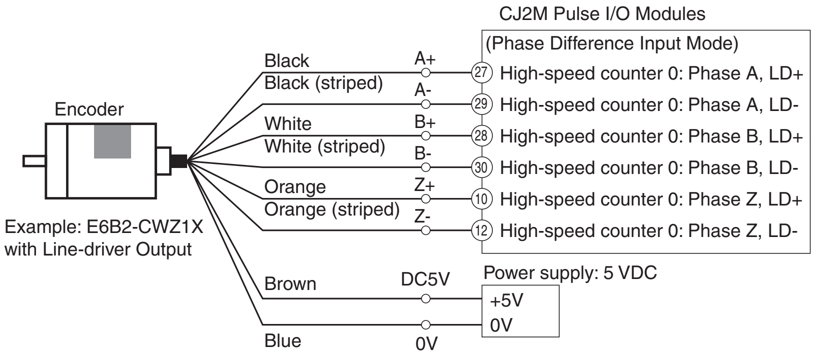
<Reset Method>

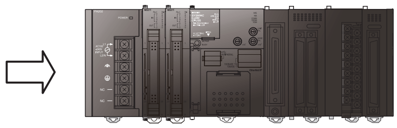
Phase Z and software reset	If software reset is ON, the present value will be reset when the phase-Z input turns ON.
Software reset	The present value will be reset when software reset turns ON.

<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





CJ2M-CPU1□/CPU3□ + CJ2M-MD21□

General Precautions

For precautions on individual products, refer to *Safety Precautions* in individual product information.

⚠ WARNING

These products cannot be used in safety devices for presses or other safety devices used to protect human life. These products are designed for use in applications for sensing workpieces and workers that do not affect safety.

Precautions for Correct Use

- Do not use a voltage that exceeds the rated voltage range. Applying a voltage that is higher than the rated voltage range may cause explosion or burning.
- Be sure that the power supply polarity and other wiring is correct. Incorrect wiring may explosion or burning.
- Do not short-circuit the load. Doing so may cause explosion or burning.
- Make sure the power is OFF before performing wiring work. If the power is ON and an output wire contacts the power supply, the output circuit may be damaged.
- Wire high-voltage lines or power lines separately from Encoder wiring. If high-voltage lines are wired in parallel with Encoder wiring, induction may cause malfunction or damage.

Precautions for Correct Use

●Mounting

Mounting Procedure

1 Fit the coupling onto the shaft. — **Do not secure the coupling to the shaft with screws.**

2 Secure the Encoder.

Do not insert the shaft into the coupling beyond the value indicated at right.

Coupling	Amount of insertion
E69-C02B	3.2mm
E69-C04B	5.2mm
E69-C06B	5.5mm
E69-C08B	6.8mm
E69-C10B	7.1mm
E69-C68B	6.8mm
E69-C610B	7.1mm
E69-C06M	8.5mm
E69-C10M	10.5mm

3 Secure the coupling.

Coupling	Tightening torque
E69-C02B	0.08N•m
E69-C04B	0.2N•m
E69-C06B	0.25N•m
E69-C08B	0.44N•m
E69-C10B	
E69-C68B	
E69-C610B	
E69-C06M	0.7N•m
E69-C10M	3.5N•m

4 Connect the power supply and I/O wires. — **Always turn OFF the power supply before wiring.**

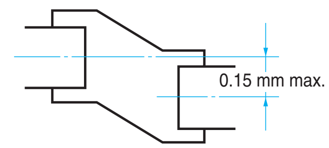
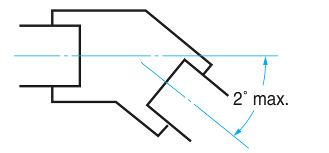
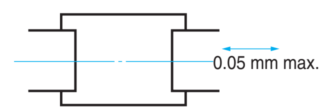
5 Turn ON power and check output.

Mounting

- When connecting with a chain timing belt and gears, hold the shaft with a bearing and use a coupling to join to the Encoder.

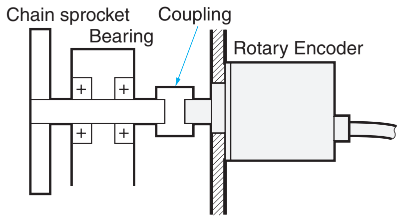
Mounting

- Do not allow water or oil to splash on the Encoder.
- The Rotary Encoder consists of high-precision components. Dropping the Encoder may damage it. Exercise sufficient caution when handling the Encoder.
- When using reverse rotation, check the Encoder mounting direction and the increment/decrement directions before mounting.
- When aligning phase Z of the Encoder with the origin of the machine in which the Encoder is installed, be sure to verify phase Z output while mounting the Encoder.
- Make sure that an excessive load is not placed on the shaft when the gears engage.
- When securing the Rotary Encoder with screws, tighten the screws to a torque of 0.49 N•m.
- When using a coupling, do not exceed the following permitted values.

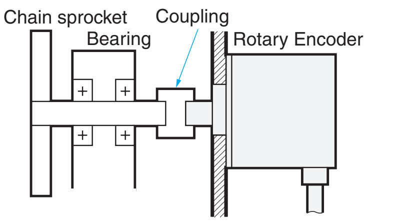
Eccentricity	
Angle deviation	
Radial displacement	

- If there are large mounting errors (eccentricity or angle deviation), an excessive load will be placed on the shaft, causing damage and an extremely shortened life.

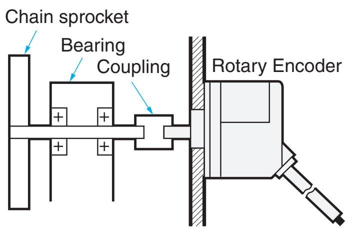
E6A2-C



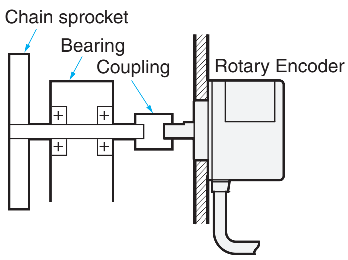
E6B2-C
E6D-C



E6C2-C



E6C3-C□H
E6C3-A

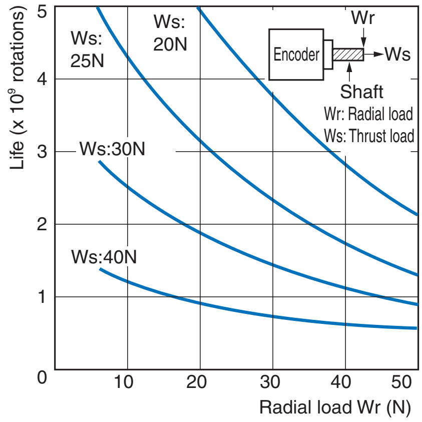


- When inserting the coupling into the shaft, do not tap it with a hammer or apply any other type of shock.
- When attaching or detaching the coupling, do not bend, compress, or pull excessively on the coupling.

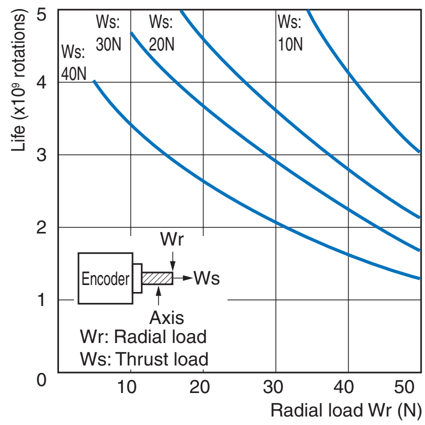
Life of Rotary Encoder Bearings

The life of bearings when a radial load and thrust load are applied are shown in the following graphs (theoretical value).

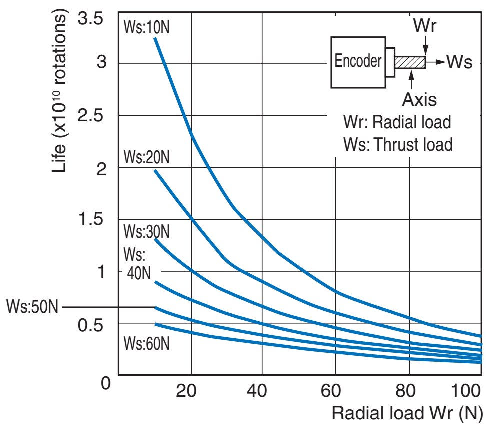
E6B2-C



E6C2-C□



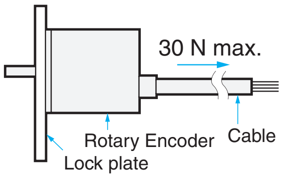
E6C3-C□H



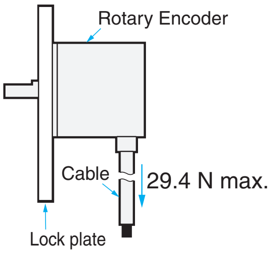
●Wiring

- If connecting the cable after securing the Encoder, do not pull on the cable with a force of 29.4 N or greater.

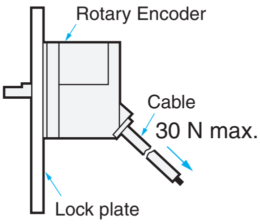
E6A2-C
E6J-A/C



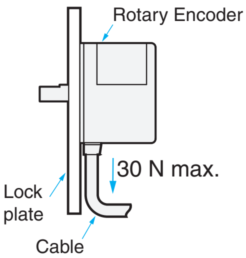
E6B2-C
E6D-C



E6C2-C



E6C3-C□H
E6C3-A



- If connecting the cable after securing the Encoder, do not pull on the cable. Also do not apply shock to the Encoder or shaft.

Connecting

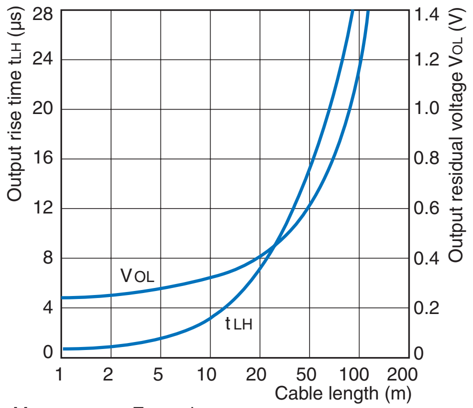
Connection

- When extending the cable, check the cable type and response frequency. Wire resistance and capacitance between wires may amplify residual voltage and cause waveform distortions. If the cable is extended, it is recommended to use a line-driver output. Regardless of the output type, only lengths of 30 m or less comply with the EMC Directive.
  To avoid inductive noise, keep the cabling as short as possible (particularly when inputting to an IC).
- If surges occur in the power supply, connect a surge absorber between the power supply and the Encoder. To reduce noise, keep the wiring as short as possible.
- Spurious pulses may be generated when the power is turned ON or OFF. Wait 0.1 s after turning ON the power before using the connected device, and stop using the connected device 0.1 s (1 s for E6CP-A) before turning OFF the power to the Encoder.
- Inrush current will flow when the power is turned ON. Take the value of the inrush current into consideration before using the power supply.

Cable Extension Characteristics

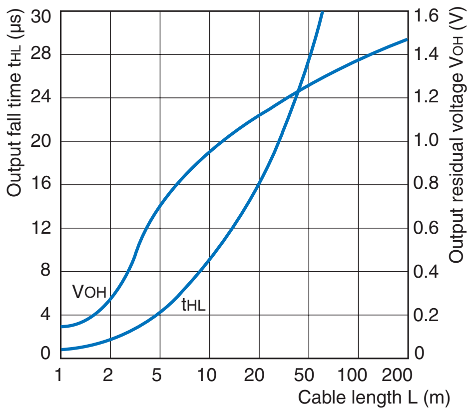
- When the cable length is extended, the output waveform startup time is lengthened and it affects the phase difference characteristics of phases A and B.
- The output waveform startup time changes not only according to the length of the cable, but also according to the load resistance and the cable type.
- Extending the cable length not only changes the startup time, but also increases the output residual voltage.

<E6B2-CWZ6C>



Measurement Example
Power supply voltage: 5 VDC
Load resistance: 1 kΩ (Output residual voltage is measured at a 35 mA load current.)
Cable: Special Cable

<E6C2-CWZ5B>



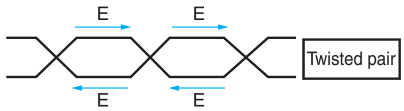
Measurement Example
Power supply voltage: 12 VDC
Load resistance: 5 mA (Output residual voltage is measured at a 35-mA load current.)
Cable: Special Cable

Preventing Counting Errors

Spurious pulses due to vibration may cause counting errors if the shaft is stationary near the rise or fall of the signal. Using an up/down counter can prevent the counting of error pulses.

Extending the Cable When Using a Line-driver Output

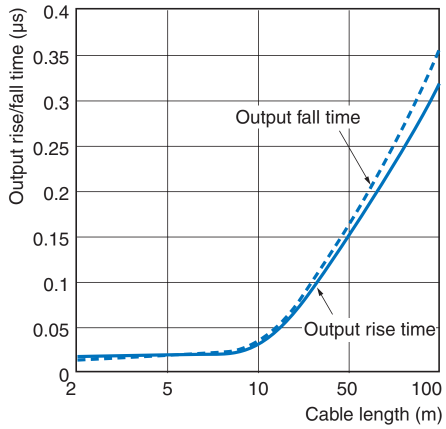
- Be sure to use shielded twisted-pair cable when extending the cable for a line-driver output. (Recommended Cable: TKVVBS4P-02T from Tachii Electric Wire Co.)
  Use an RS-422A Receiver for the receiver side.
- The structure of twisted-pair cable is suitable for RS-422A transmission. By twisting the two outputs as shown in the following diagram, electromotive force occurring in the wires is reciprocally canceled, and the noise element of normal mode is eliminated.



- When using a line-driver output, a power supply of 5 VDC is needed for the Encoder. The voltage will drop approximately 1 V per 100 m of cable.

<Using a Line Receiver IC>

Recommended IC: ICs from Texas Instruments Incorporated
AM26C32



<Connections>

To extend the line receiver, soldering or using a connector is preferred. Connection through a terminal block should be avoided to help prevent sneak noise.
There are no standards for the RS-422 connectors. Select them carefully.

● Operating Environment

Ambient Conditions

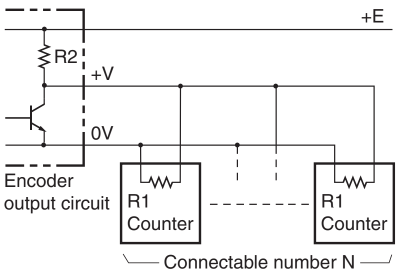
At low temperatures (0°C or less), the vinyl cable will harden and the wires may break if the cable is bent. Do not bend a Standard or Robot Cable at low temperature.

●Others

Input to More than One Counter from Encoder (with Voltage Output)

To connect multiple identical counters to one Encoder, use the following equation to determine the number of counters that can be connected.

$$\text{Number of connectable counters } N = \frac{R1(E - V)}{V \cdot R2}$$



E : Power supply voltage of Encoder
V : Input voltage of counter (min. value)
R1 : Input resistance of counter
R2 : Output resistance of Encoder

Gray Code → Binary Code Conversion

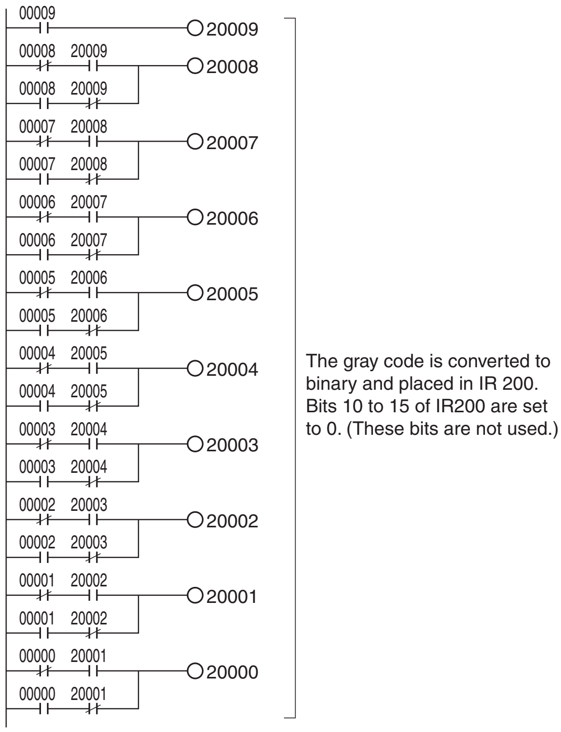
- This section explains how to convert gray code into binary values using PLC (Programmable Controller) ladder programming when the resolution is 720.

First, the following table shows a wiring example.

Encoder output signal	PLC input signal
Brown (2^0)	00000
Orange (2^1)	00001
Yellow (2^2)	00002
Green (2^3)	00003
Blue (2^4)	00004
Violet (2^5)	00005
Gray (2^6)	00006
White (2^7)	00007
Pink (2^8)	00008
Empty (2^9)	00009

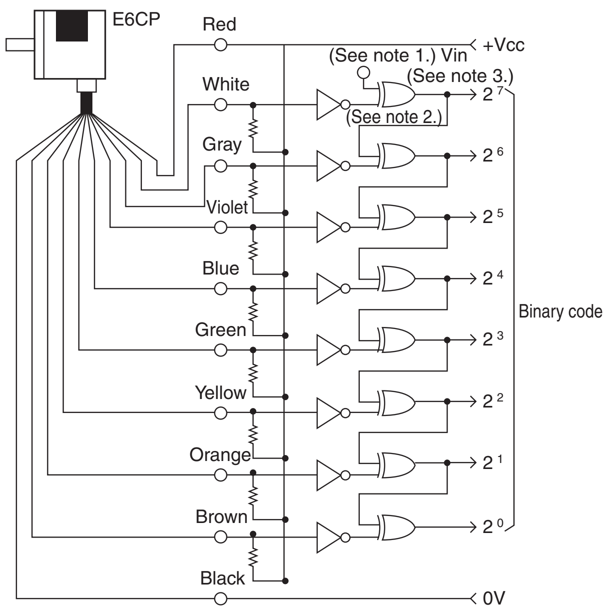
The following diagram shows converting gray code to binary using programming.

<Ladder Program Example>



Note: The ladder program example above is for a CPM1A PLC. Check the ladder programming with the model being considered for use.

- To convert gray code to binary code, refer to the circuits in the following diagram.



Note: 1. Vin can be connected to 0 V to convert to positive logic binary code.
2. Inverter
3. Exclusive OR

MEMO