# Technical Explanation for Rotary Encoders

## Introduction

### What Is a Rotary Encoder?

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. (Refer to *Operating Principles* on page 2.)
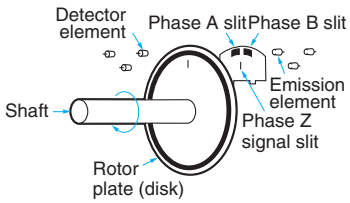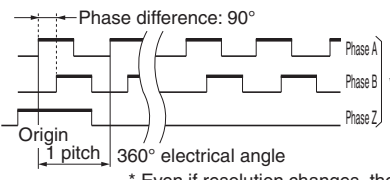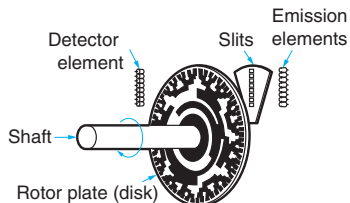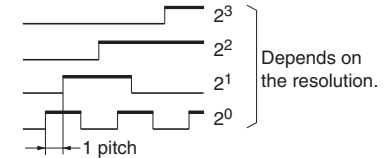
**3. The rotation direction can also be detected.**
The rotation direction is determined by the output timing of phases A and B with an Incremental Encoder, and by the code increase or decrease with an Absolute Encoder. (Refer to *Operating Principles* on page 2.)

**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.

Sensors

Switches

Safety Components

Relays

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Automation Systems

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Power Supplies / In Addition

Others

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**1**

## Operating Principles

| Item Classification | Features | Structure | Output waveform |
|---|---|---|---|
| **Incremental Encoders**<br><br>**E6A2-C**<br>**E6B2-C**<br>**E6C2-C**<br>**E6C3-C**<br>**E6D-C**<br>**E6F-C**<br>**E6H-C** | • 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.<br>• 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.<br>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.*<br>Also, the phase-Z signal, which is generated once a revolution, can be used as the origin within a revolution.<br><br>✽ 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.) | Detector element  Phase A slit Phase B slit<br>Emission element<br>Shaft  Phase Z signal slit<br>Rotor plate (disk)<br><br>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.<br>The two slits are positioned so that the phase difference between the square wave outputs is 1/4 pitch. | Phase difference: 90°<br>Phase A<br>Phase B  *<br>Phase Z<br>Origin<br>1 pitch  360° electrical angle<br>* Even if resolution changes, the number of phases does not change. |
| **Absolute Encoders**<br><br>**E6CP-A**<br>**E6C3-A**<br>**E6F-A** | • This type of encoder outputs in parallel the rotation angle as an absolute value in $2^n$ code.<br>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.<br>• 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.<br>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. | Detector element  Slits  Emission elements<br>Shaft<br>Rotor plate (disk)<br><br>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. | $2^3$<br>$2^2$  Depends on the resolution.<br>$2^1$<br>$2^0$<br>1 pitch |

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# Classification

For details, refer to *Operating Principles* on page 2.
**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, oilresistant)
• 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.

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# 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°.
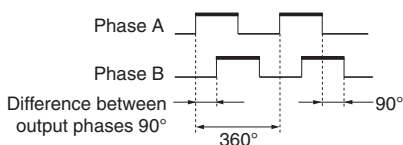


## CW

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.
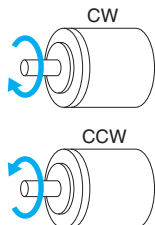


## Output Duty Ratio

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.
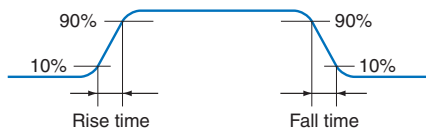


Output duty ratio: $\dfrac{T2}{T1}$

High level time (T2)

Pulse period (T1)
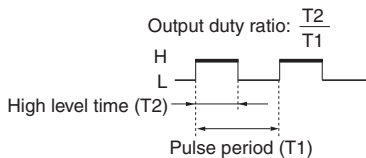
## Maximum Response Frequency

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.

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## 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.

## 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 0 |
| 1 | 0 0 0 0 0 1 | 0 0 0 0 0 1 | | 0 0 0 | 0 0 0 1 |
| 2 | 0 0 0 0 1 0 | 0 0 0 0 1 1 | | 0 0 0 | 0 0 1 0 |
| 3 | 0 0 0 0 1 1 | 0 0 0 0 1 0 | | 0 0 0 | 0 0 1 1 |
| 4 | 0 0 0 1 0 0 | 0 0 0 1 1 0 | | 0 0 0 | 0 1 0 0 |
| 5 | 0 0 0 1 0 1 | 0 0 0 1 1 1 | | 0 0 0 | 0 1 0 1 |
| 6 | 0 0 0 1 1 0 | 0 0 0 1 0 1 | | 0 0 0 | 0 1 1 0 |
| 7 | 0 0 0 1 1 1 | 0 0 0 1 0 0 | | 0 0 0 | 0 1 1 1 |
| 8 | 0 0 1 0 0 0 | 0 0 1 1 0 0 | | 0 0 0 | 1 0 0 0 |
| 9 | 0 0 1 0 0 1 | 0 0 1 1 0 1 | | 0 0 0 | 1 0 0 1 |
| 10 | 0 0 1 0 1 0 | 0 0 1 1 1 1 | | 0 0 1 | 0 0 0 0 |
| 11 | 0 0 1 0 1 1 | 0 0 1 1 1 0 | | 0 0 1 | 0 0 0 1 |
| 12 | 0 0 1 1 0 0 | 0 0 1 0 1 0 | | 0 0 1 | 0 0 1 0 |
| 13 | 0 0 1 1 0 1 | 0 0 1 0 1 1 | | 0 0 1 | 0 0 1 1 |
| 14 | 0 0 1 1 1 0 | 0 0 1 0 0 1 | 0 0 | 0 0 1 | 0 1 0 0 |
| 15 | 0 0 1 1 1 1 | 0 0 1 0 0 0 | 0 1 | 0 0 1 | 0 1 0 1 |
| 16 | 0 1 0 0 0 0 | 0 1 1 0 0 0 | 0 2 | 0 0 1 | 0 1 1 0 |
| 17 | 0 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 0 1 1 |

Sensors

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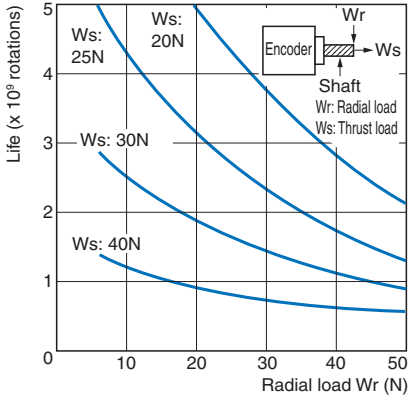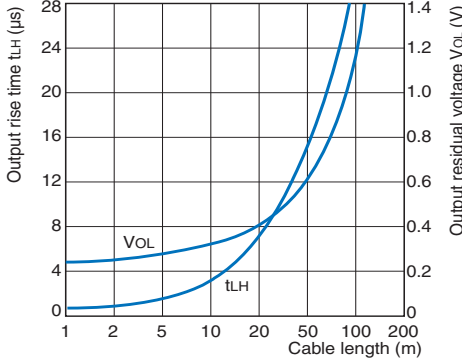Energy Conservation Support / Environment Measure Equipment

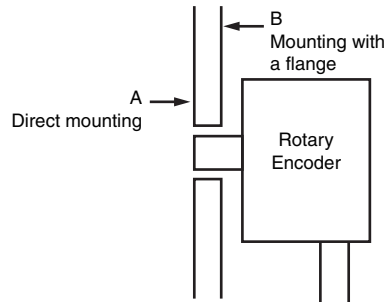Power Supplies / In Addition

Others

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# Further Information

## Interpreting Engineering Data

| Bearing Life | Cable Extension Characteristics |
|---|---|
| E6B2-C | E6B2-CWZ6C |

E6B2-C



Life (x $10^9$ rotations) vs Radial load Wr (N)

Ws: 20N, Ws: 25N, Ws: 30N, Ws: 40N

Wr: Radial load
Ws: Thrust load

E6B2-CWZ6C



Output rise time $t_{LH}$ (µs) / Output residual voltage $V_{OL}$ (V) vs Cable length (m)

$V_{OL}$, $t_{LH}$

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 relationship between mechanical life and the load applied to the shaft.
• The size of the load during rotation affects the life of the bearings.

• 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.

## Mounting

To mount the Rotary Encoder directly, secure it with screws from direction A. If a servo mount is used, attach a Flange to the Rotary Encoder and mount the Rotary Encoder from direction B.



B
Mounting with a flange

A
Direct mounting

Rotary Encoder

Example: Attaching an E69-FCA02 Flange to the E6C2-C
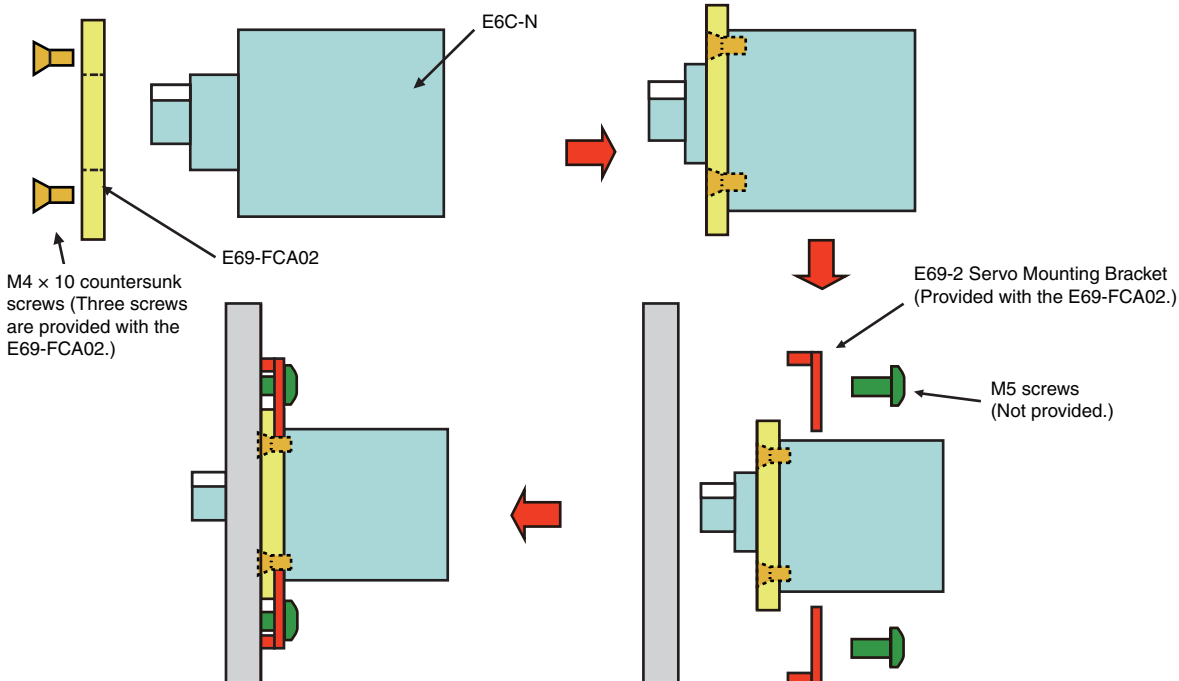


E6C-N

E69-FCA02

M4 × 10 countersunk screws (Three screws are provided with the E69-FCA02.)

E69-2 Servo Mounting Bracket (Provided with the E69-FCA02.)

M5 screws (Not provided.)

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# Technical Explanation for Rotary Encoders (Connection Example)

## Example of Connection

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

**Incremental Encoders**

| Peripheral device | Counter | | Digital Panel Meter | | | Rotary Encoder | Programmable Controller | | Machine Automation Controller | Network Device |
|---|---|---|---|---|---|---|---|---|---|---|
| | Multifunction Counter | Tachometer | Rotary Pulse Indicator | Up/Down Counting Pulse Indicator | Timer Interval Indicator | Direct Discrimination Unit | CJ2M CPU Unit, Pulse I/O Module* | High-speed Counter Unit | NX-series Incremental Encoder Input Unit | EtherCAT 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□ | CJ1W-CT021 CS1W-CT021/ 041 C200H-CT021 | NX-EC0□□□ | GX-EC02□□ |
| E6D-CWZ1E | No | No | No | No | No | No | No | Yes | No | No |
| E6D-CWZ2C | Yes | Yes | Yes | Yes | Yes | Yes | No | Yes | No | No |
| E6F-CWZ5G | Yes | 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 | 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 | Yes |
| E6B2-CWZ1X E6H-CWZ3X E6C2-CWZ1X E6C3-CWZ3XH | No | No | No | No | No | No | Yes | Yes | Yes | Yes |
| E6B2-CWZ5B E6C2-CWZ5B | No | No | Yes | No | Yes | No | No | No | No | No |

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

**Absolute Encoders**

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

For details, refer to the datasheets and manuals for each product.

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# Technical Explanation for Rotary Encoders (Connection Example)

## Example of Connection with H7BX-AW Self-powered Tachometer

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



H7BX-AW Self-powered Tachometer
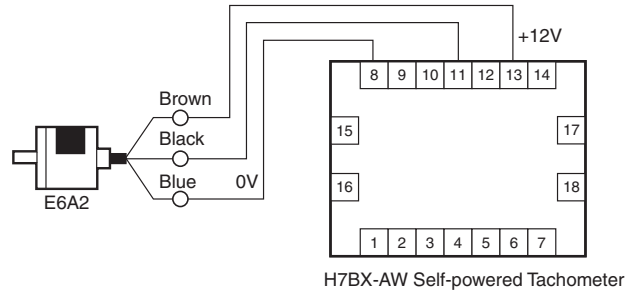
## Example of Connection with H7BX-A Digital Counter

| Example of Applicable Models | E6A2-CW3E<br>E6C2-CWZ3E, E6C3-CWZ3EH,<br>E6F-CWZ5G |
| --- | --- |



H7BX-A Digital Counter
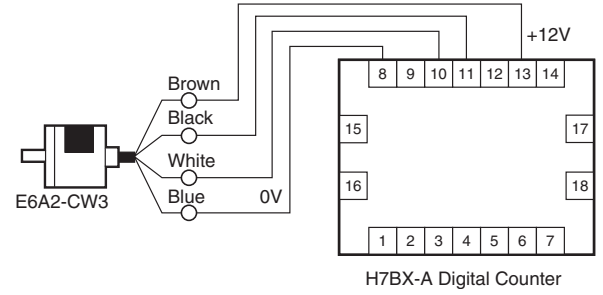
## Example of Connection with K3HB-C Up/Down Counting Meter

• NPN Open-collector Outputs

| Example of Applicable Models | E6A2-CS3C, E6A2-CS5C<br>E6A2-CW3C, E6A2-CW5C<br>E6C2-CWZ6C, E6F-CWZ5G |
| --- | --- |
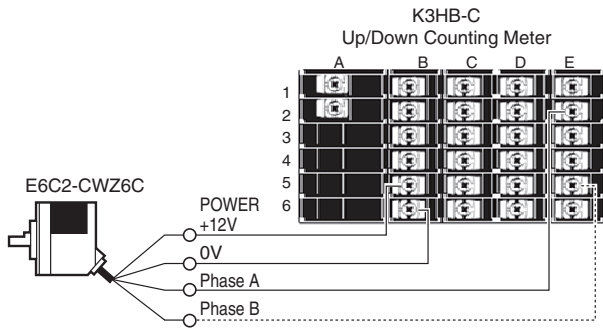


• Voltage Outputs

| Example of Applicable Models | E6A2-CS3E, E6A2-CW3E<br>E6C2-CWZ3E |
| --- | --- |

# Technical Explanation for Rotary Encoders (Connection Example)

## Example of Connection with CJ1W-CT021 High-speed Counter Unit in Programmable Controller

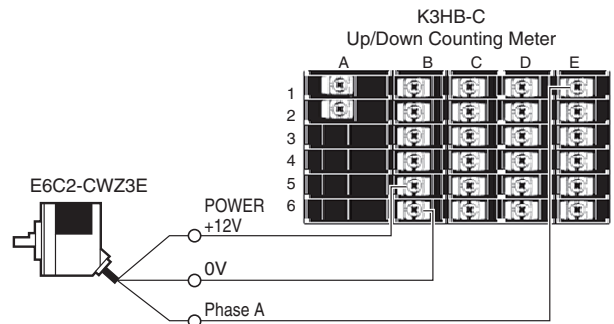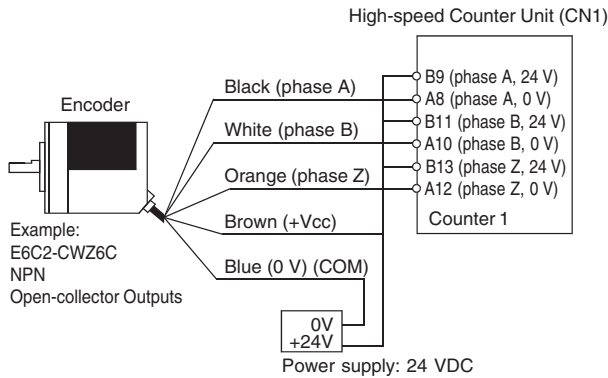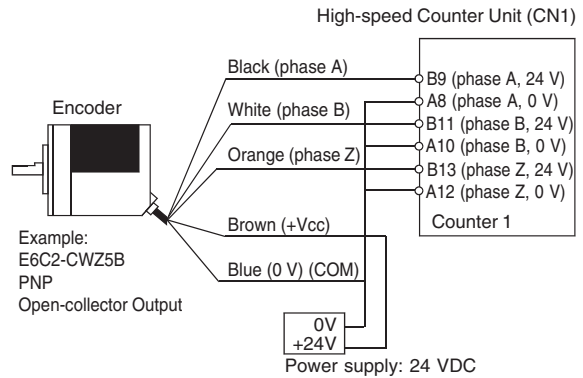| Example of Applicable Models (1) | E6A2-C, E6B2-C, E6C2-C, E6H-C E6F-CWZ5G, E6D (open-collector output) |
|---|---|

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:** 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

Sensors
Switches
Safety Components
Relays
Control Components
Automation Systems
Motion / Drives
Energy Conservation Support / Environment Measure Equipment
Power Supplies / In Addition
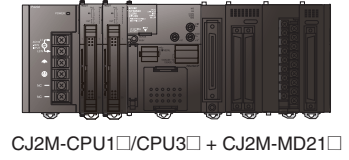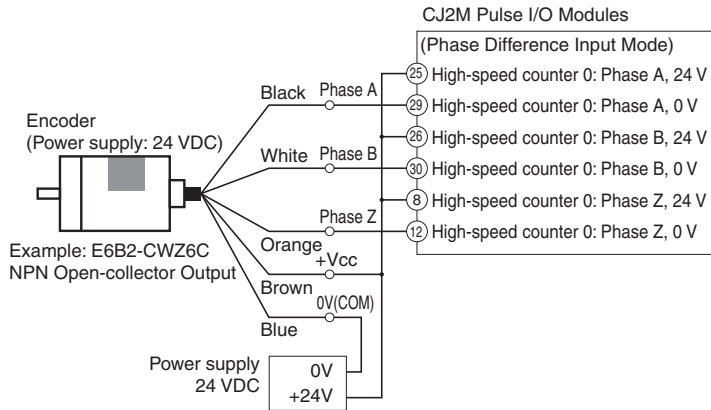Others
Common

OMRON

**3**

# Technical Explanation for Rotary Encoders (Connection Example)

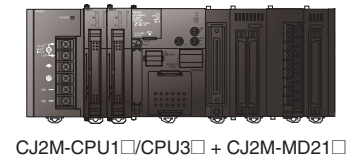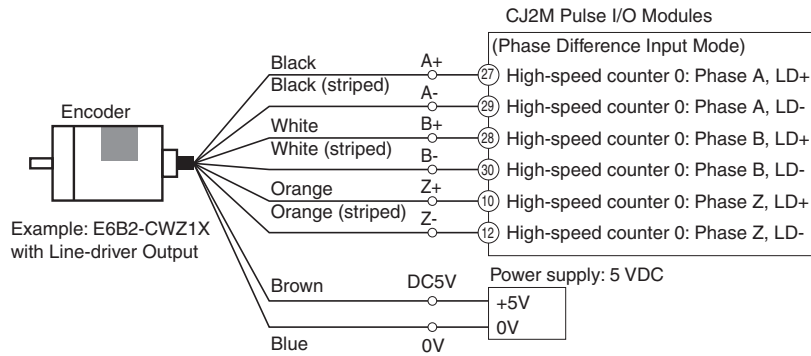## Example of Connection with CJ2M-CPU1□/CPU3□ + CJ2M-MD21□ Pulse I/O Module

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

CJ2M Pulse I/O Modules

(Phase Difference Input Mode)

Encoder
(Power supply: 24 VDC)

Black — Phase A
White — Phase B
Phase Z
Orange — +Vcc
Brown — 0V(COM)
Blue

Example: E6B2-CWZ6C
NPN Open-collector Output

25 High-speed counter 0: Phase A, 24 V
29 High-speed counter 0: Phase A, 0 V
26 High-speed counter 0: Phase B, 24 V
30 High-speed counter 0: Phase B, 0 V
8 High-speed counter 0: Phase Z, 24 V
12 High-speed counter 0: Phase Z, 0 V

Power supply
24 VDC

0V
+24V

CJ2M-CPU1□/CPU3□ + CJ2M-MD21□

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

CJ2M Pulse I/O Modules

(Phase Difference Input Mode)

Encoder

Black — A+
Black (striped) — A-
White — B+
White (striped) — B-
Orange — Z+
Orange (striped) — Z-

Example: E6B2-CWZ1X
with Line-driver Output

Brown — DC5V
Blue — 0V

27 High-speed counter 0: Phase A, LD+
29 High-speed counter 0: Phase A, LD-
28 High-speed counter 0: Phase B, LD+
30 High-speed counter 0: Phase B, LD-
10 High-speed counter 0: Phase Z, LD+
12 High-speed counter 0: Phase Z, LD-

Power supply: 5 VDC
+5V
0V

CJ2M-CPU1□/CPU3□ + CJ2M-MD21□

Sensors

Switches

Safety Components

Relays

Control Components

Automation Systems

Motion / Drives

Energy Conservation Support / Environment Measure Equipment

Power Supplies / In Addition

Others

Common

OMRON

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