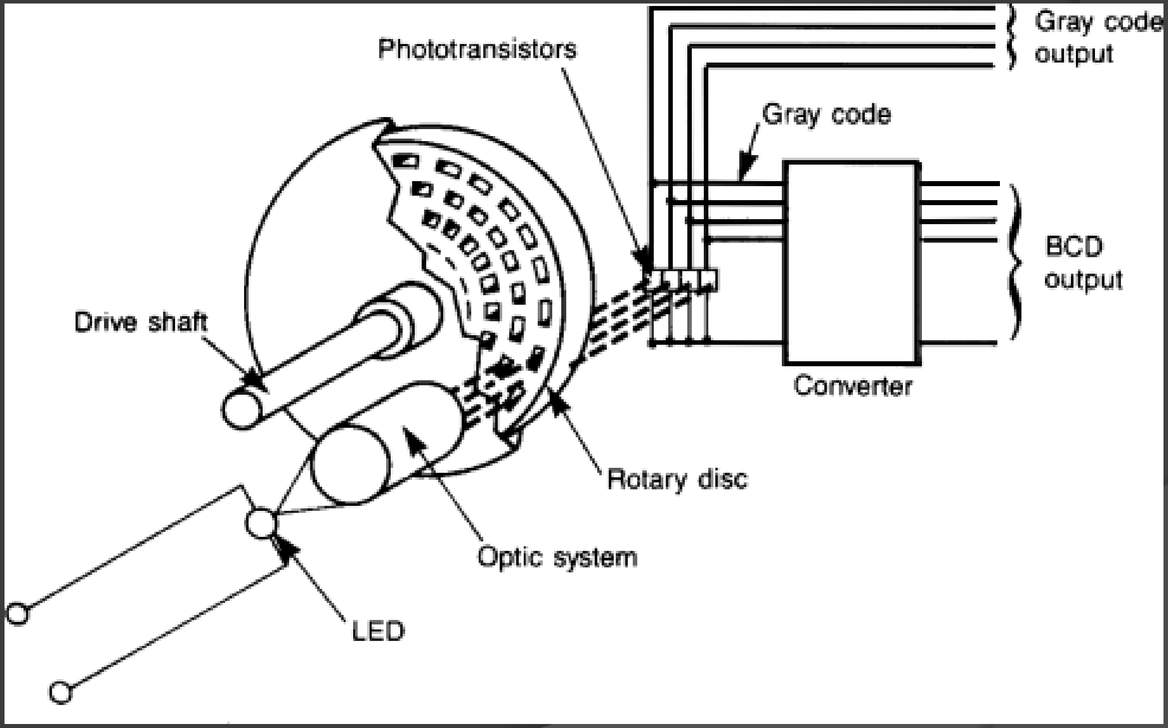
ENCODERS

Encoder

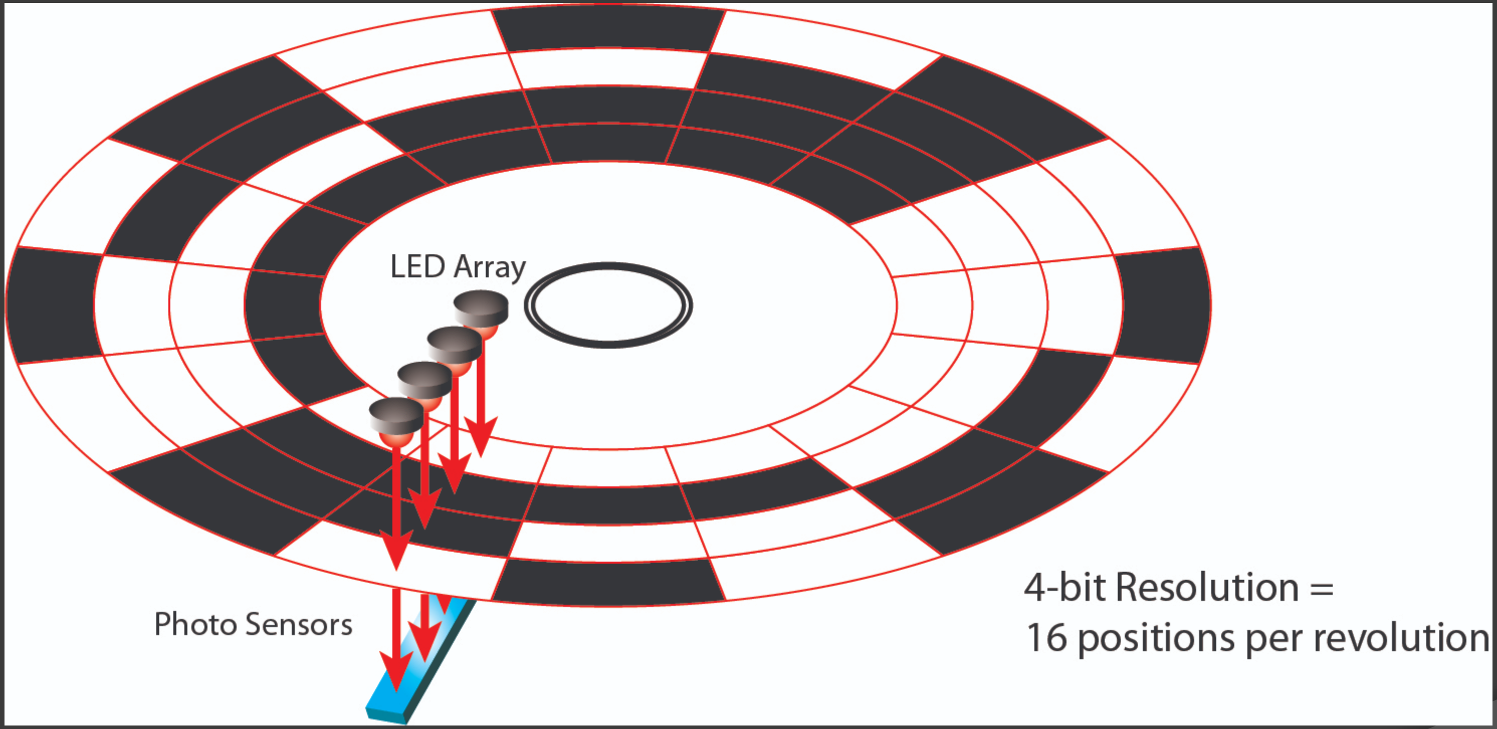
An encoder is a device which converts mechanical position or speed information into an electrical signal.

Different Ways to Sense the Bits

- Optically (most common)
- Capacitively
- Magnetically



Another Image of Sensing



2 Types of Encoders

There are two types of encoders: Linear and Rotary

Linear Encoders convert linear distance to an electrical signal.

Rotary Encoders convert angular position into an electrical signal.

Linear Encoders

Linear encoders typically use two methods: Wiredraw and With Scale.

Wiredraw converts a pulled wire length (up to 50 m or so) into a signal. Typically, these encoders wrap a wire around a shaft and convert the number of rotations of the shaft to a linear measurement (so it’s really like a rotational encoder). Uses incremental or absolute encoding.

With Scale reads in a code (like a barcode) to determine its position (up to 1700 m or so). Uses absolute encoding.

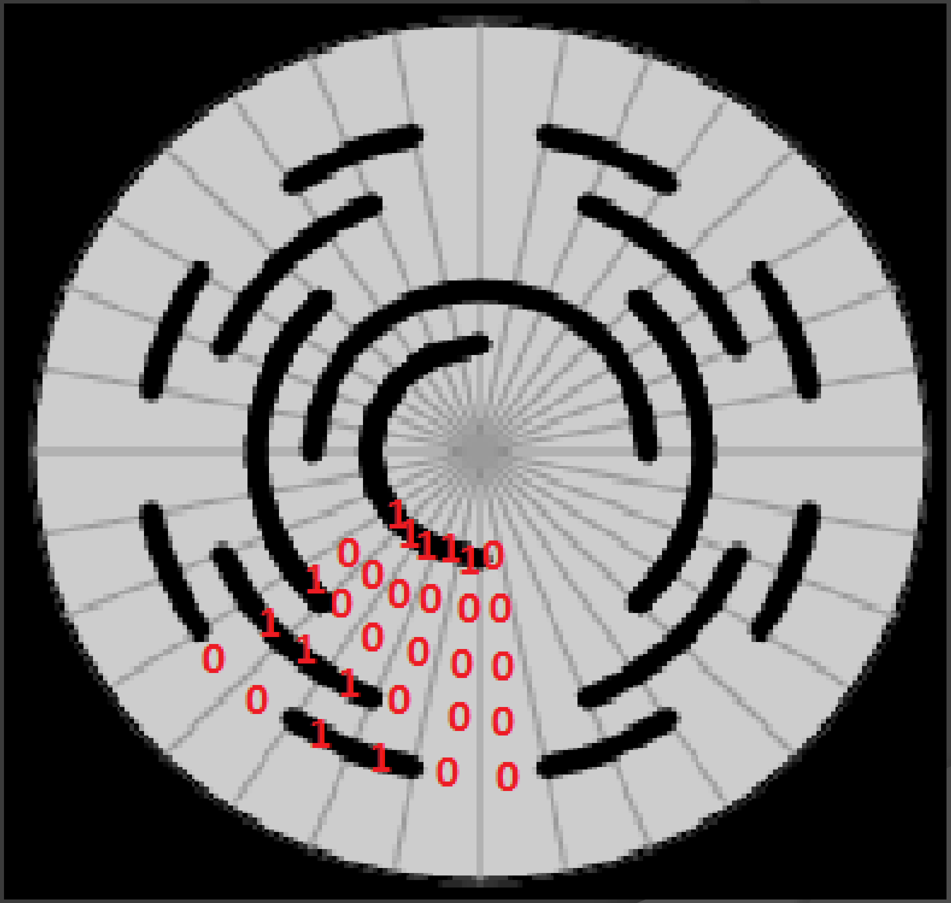
2 Types of Encoding

- Absolute
- Incremental

Absolute Rotary Encoder

An absolute rotary encoder has a unique binary number for every angular step's position. Uses Gray code: each step only changes one bit at a time.

For example, we go from 01101 to 01001 where the 3rd bit is the only bit to change.

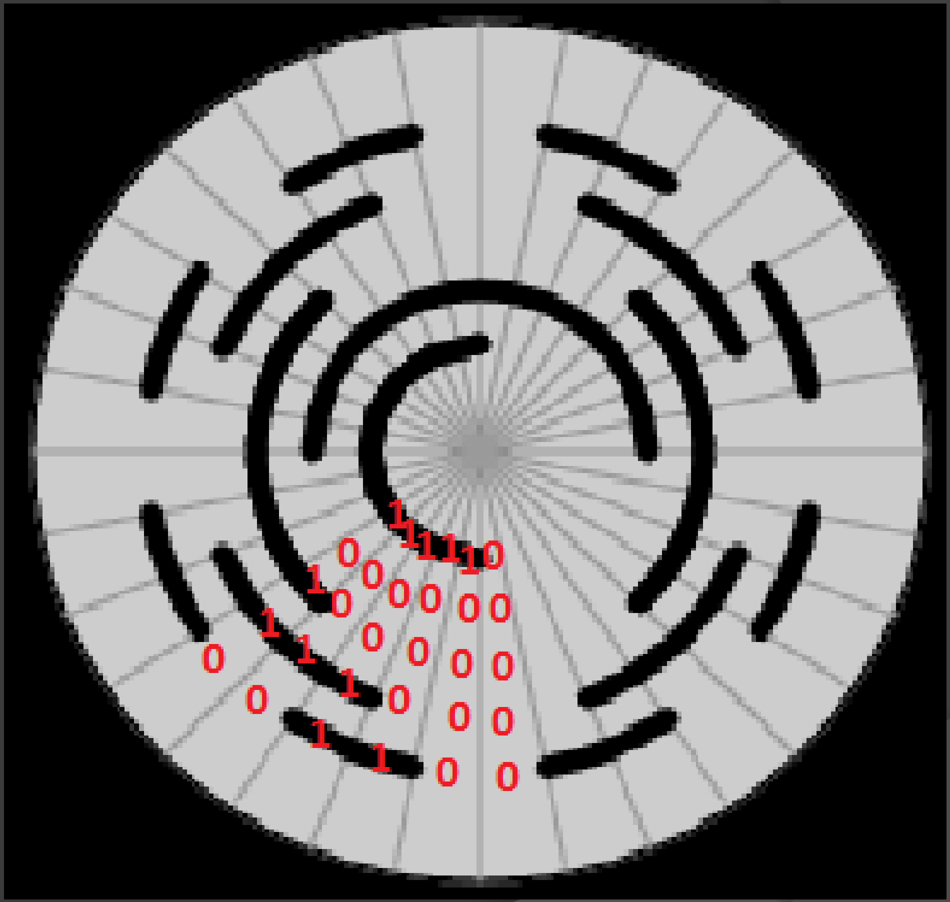


As we move counter-clockwise, we get the unique decimal numbers: 13, 9, 25, 17, 1, 0

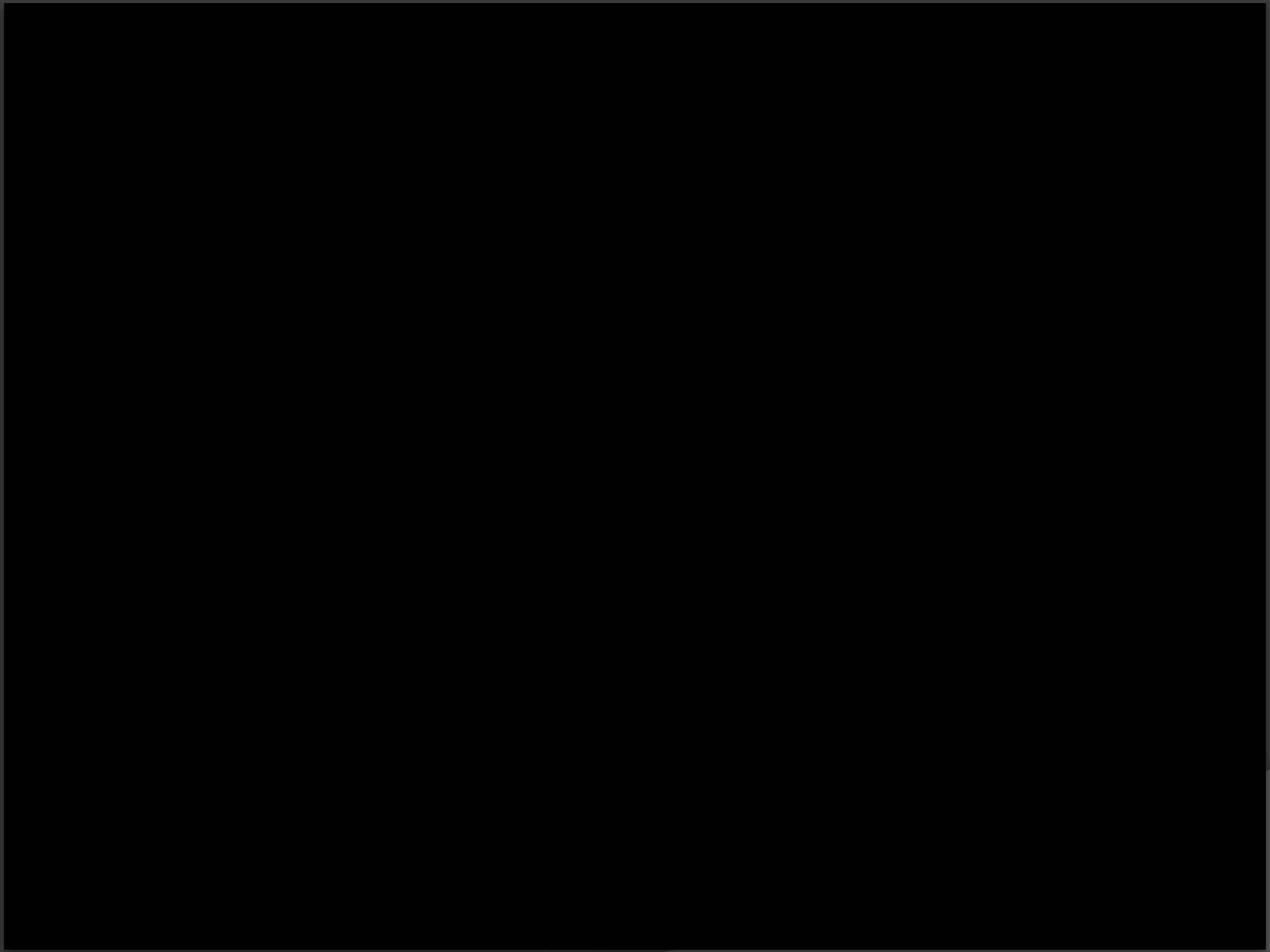
Absolute Encoder

It's important that we only change one number for each step so that we don't see glitches. If we change 2 numbers at a time, then there's a chance that one bit will be slower than the other changing bit creating race conditions and we'll get a false number in between the two.

For example: if we go from 00000 to 00011, then there's a chance we'll see 00010 if the least significant bit is slower to change than the other changing bit.



Absolute Encoder Example



Link

You can purchase rotary encoders like the one shown in this slide. Notice that this encoder has at least 9 pins if we count them (8 for data and 1 for ground) so it can record $2^8 = 256$ unique angular positions.

Absolute Rotary Encoders

Come in two varieties:

Single turn and multi-turn

Single turn just outputs the absolute rotational position whereas multi-turn encoders measures and outputs the number of revolutions as well.

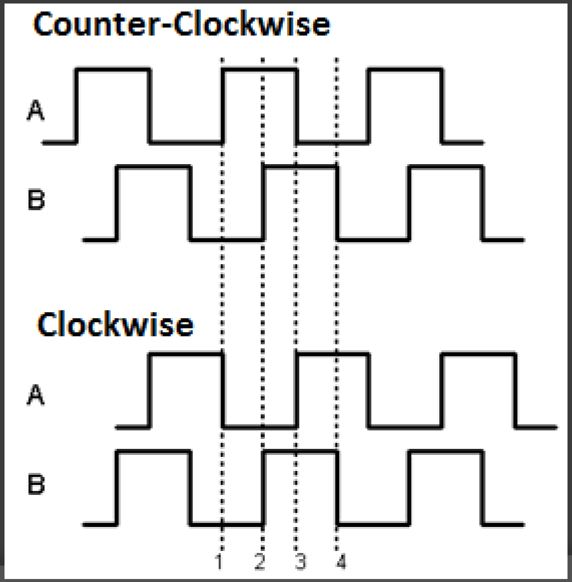
Absolute Encoder Problems

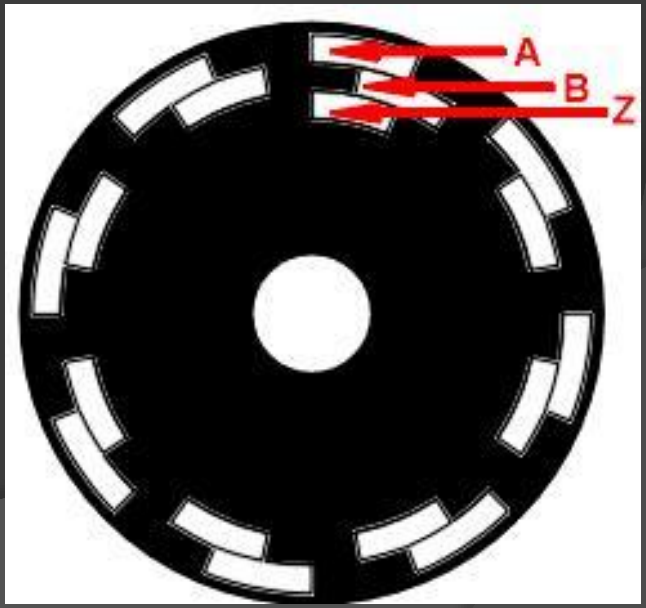
- Expensive and harder to implement since you have to deal with a bunch of pins

One common way that manufacturers create absolute encoders and don't have to deal with so many pins is for the encoder to transmit it's position serially. This will be slower and possibly more complicated, but it may be worth it depending on the application.

Incremental Rotary Encoder

A less expensive, less complicated, and more common encoder is the incremental encoder. It uses bi-phase encoding. It needs two signals to operate: A & B. In this example: If A leads B, then the disc is spinning counter-clockwise. If B leads A, then the disc is spinning clockwise. This is known as quadrature encoding since there's 4 edges (as shown in the figure).
Z is used as a zero position. The computer can count then number of A or B pulses after the zero position to determine the absolute position. For example: If the computer counts 4 pulses after the zero position from the picture below, then the computer can determine that the disc has rotated ~180 degrees.





Rotational Speed

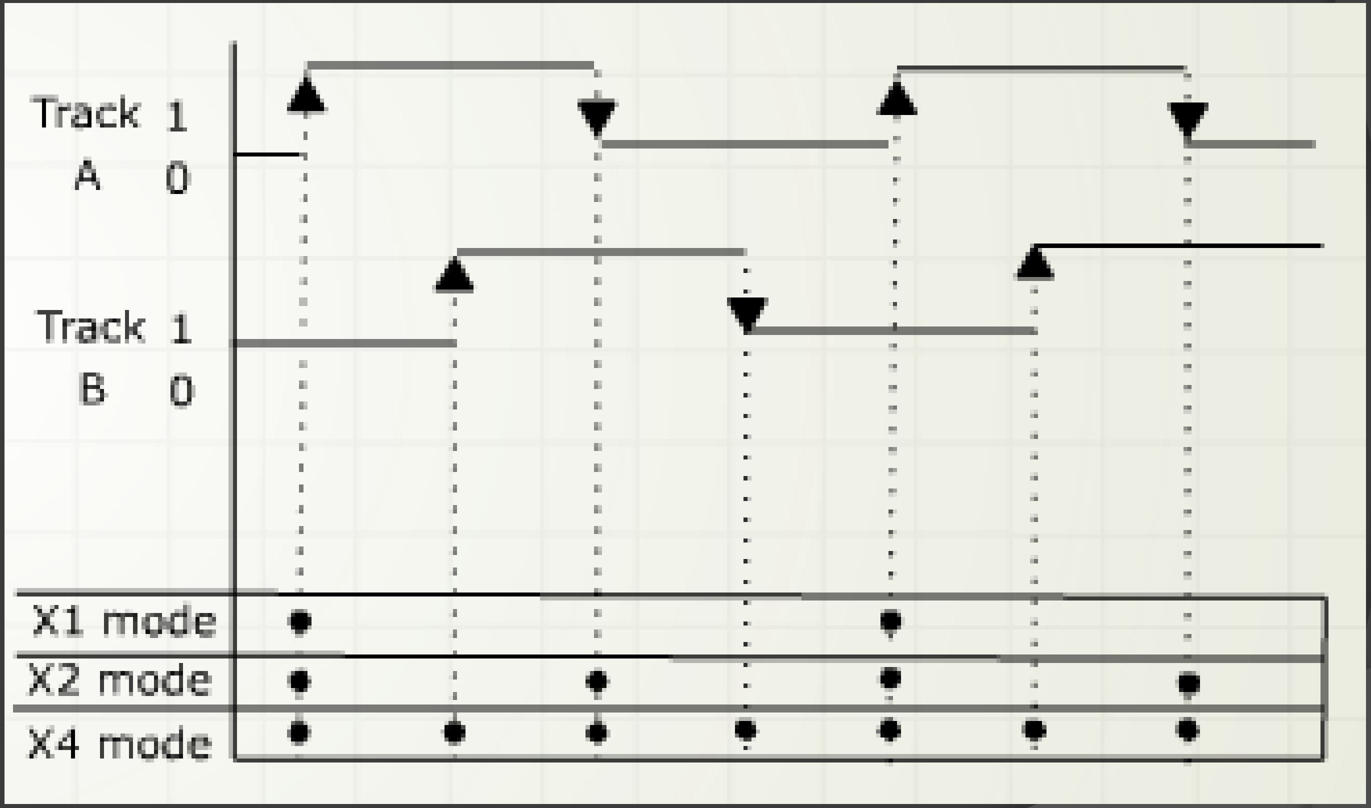
You can also determine the rotational speed with the rotary encoder if you count the number of intervals in one revolution and measure the period between pulses.

Revolutions per Minute (RPM) =

$$60\left(\frac{1}{\#\ intervals\ per\ rev. \times period\ of\ signal\ (s)}\right)$$

Three Modes for Quadrature Encoder

- X1
- X2
- X4



X1 Mode

X1 mode only looks at the rising edge on A. The resolution of the encoder is equal to the number of intervals in the decoder wheel.

12 intervals gives you 360/12 = 30 degree resolution.

By the way, ***the encoder still uses B*** *to determine the direction in which the motor is spinning.*

X2 Mode

X2 mode senses both the rising edge and the falling edge on A. This gives you greater resolution since you have 2 reference points for each interval.

12 intervals gives you $360/(12*2) = 15$ degree resolution.

X4 Mode

X4 senses both the rising edge and falling edge on A, as well as the rising and falling edge on B. This gives you 4 reference points per interval!

12 intervals gives you 360/(12*4) = 7.5 degree resolution.

Incremental Encoder Problems

Incremental encoders do not retain position information (especially if there’s a power failure) so they are typically used for applications that do not require absolute position.

Mechanical Consideration

Another consideration when choosing a encoder is that it must mechanically fit (For example: onto the motor's shaft; they must have the same shaft diameter).

If you're dealing with an application where you know you'll need an encoder, then it's easier and possibly more reliable to purchase a motor with an encoder already mounted instead of buying the two separate.