ENCODER

An **encoder** is a sensor of mechanical motion that generates digital signals in response to motion. As an electro-mechanical device, an encoder is able to provide motion control system users with information concerning position, velocity and direction. There are two different types of encoders: linear and rotary. A linear encoder responds to motion along a path, while a rotary encoder responds to rotational motion. An encoder is generally categorized by the means of its output. An incremental encoder generates a train of pulses which can be used to determine position and speed. An absolute encoder generates unique bit configurations to track positions directly.

Types of Encoders

- Linear Encoder
- Rotary Encoder
- Magnetic Rotary Encoder
- Communication Encoder

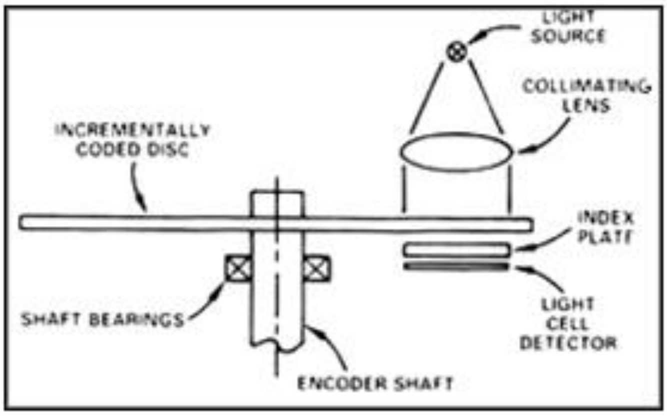
These two have main types: absolute encoder and incremental encoder.

Incremental Encoder

An **Incremental rotary encoder** is also referred to as a quadrature encoder. This type of encoder utilizes sensors that use optical, mechanical or magnetic index counting for angular measurement.

WORKING

Incremental rotary encoders utilize a transparent disk which contains opaque sections that are equally spaced to determine movement. A light emitting diode is used to pass through the glass disk and is detected by a photo detector. This causes the encoder to generate a train of equally spaced pulses as it rotates. The output of incremental rotary encoders is measured in pulses per revolution which is used to keep track of position or determine speed.



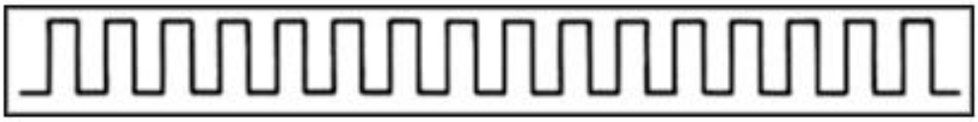


Fig1: Pulse Train Produced from Incremental Encoder

A single-channel output is commonly implemented in applications in which direction of movement is not significant. Instances in which direction sensing is important, a 2-channel, quadrature, output is used. The two channels, A and B, are commonly 90 electrical degrees out of phase and the electronic components determine the direction based off the phase relationship between the two channels. The position of an incremental encoder is done by adding up all the pulses by a counter.

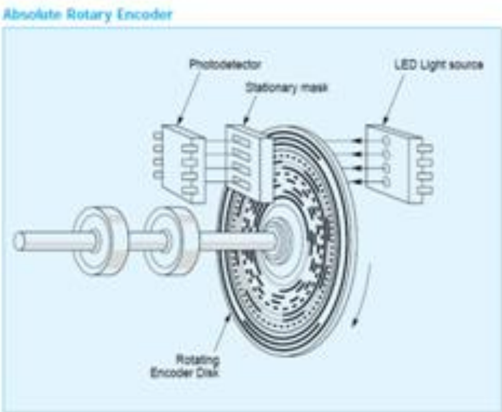
A setback of the incremental encoder is count loss which occurs during power loss. When restarting, the equipment must be referenced to a home position to reinitialize the counter. The index channel produces a single signal pulse per revolution of the encoder shaft and is often used as a reference marker. The reference marker is then denoted as a starting position which can resume counting or position tracking.

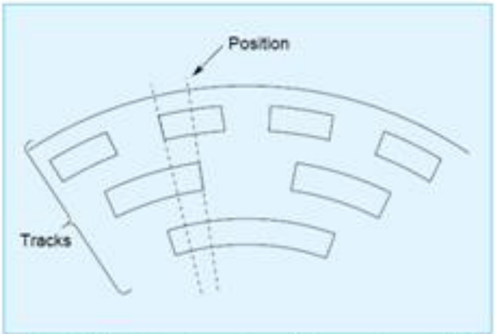
Absolute Encoder

An **absolute encoder** contains components also found in incremental encoders. They implement a photodetector and LED light source but instead of a disk with evenly spaced lines on a disc, an absolute encoder uses a disk with concentric circle patterns.

WORKING

Absolute encoders utilize stationary mask in between the photodetector and the encoder disk as shown below. The output signal generated from an absolute encoder is in digital bits which correspond to a unique position. The bit configuration is produced by the light which is received by the photodetector when the disk rotates. The light configuration received is translated into gray code. As a result, each position has its own unique bit configuration.





Typical disk pattern showing radial scanning method used to read position.

Fig2.1: Component of Absolute Encoder

Fig2.2: Absolute Encoder Disk with Concentric Circle pattern

Linear Encoder

A **linear encoder** is a sensor, transducer or reading-head linked to a scale that encodes position. The sensor reads the scale and converts position into an analog or digital signal that is transformed into a digital readout. Movement is determined from changes in position with time. Both optical and magnetic linear encoder types function using this type of method. However, it is their physical properties which make them different.

Working: Optical Linear Encoder

The light source and lens produce a parallel beam of light which pass through four windows of the scanning reticle. The four scanning windows are shifted 90 degrees apart. The light then passes through the glass scale and is detected by photosensors. The scale then transforms the detected light beam when the scanning unit moves. The detection of the light by the photosensor produces sinusoidal wave outputs. The linear encoder system then combines the shifted signals to create two sinusoidal outputs which are symmetrical but 90 degrees out of phase from each other. A reference signal is created when a fifth pattern on the scanning reticle becomes aligned with an identical pattern on the scale.

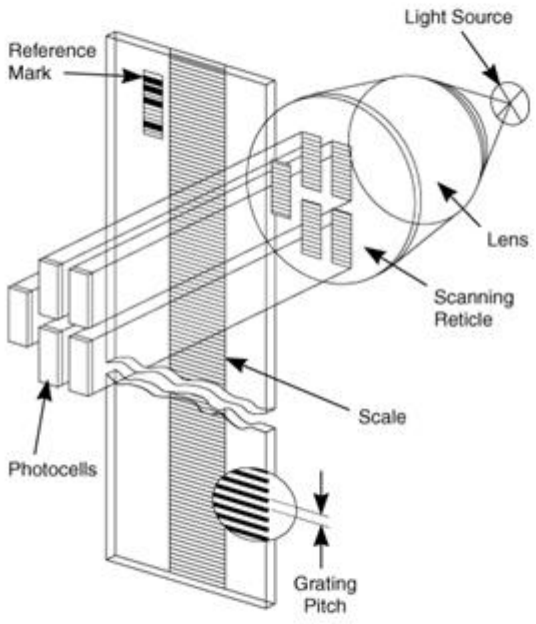


Fig3: Linear Encoder Component

Working: Magnetic Linear Encoder

A Linear Encoder system uses a magnetic sensor readhead and a magnetic scale to produce TTL or analog output for Channel A and B. As the magnetic sensor passes along the magnetic scale, the sensor detects the change in magnetic field and outputs a signal. This output signal frequency is proportional to the measuring speed and the displacement of the sensor. Since a linear encoder detects change in the magnetic field, the interference of light, oil, dust, and debris have no effect on this type of system; therefore they offer high reliability in harsh environments.

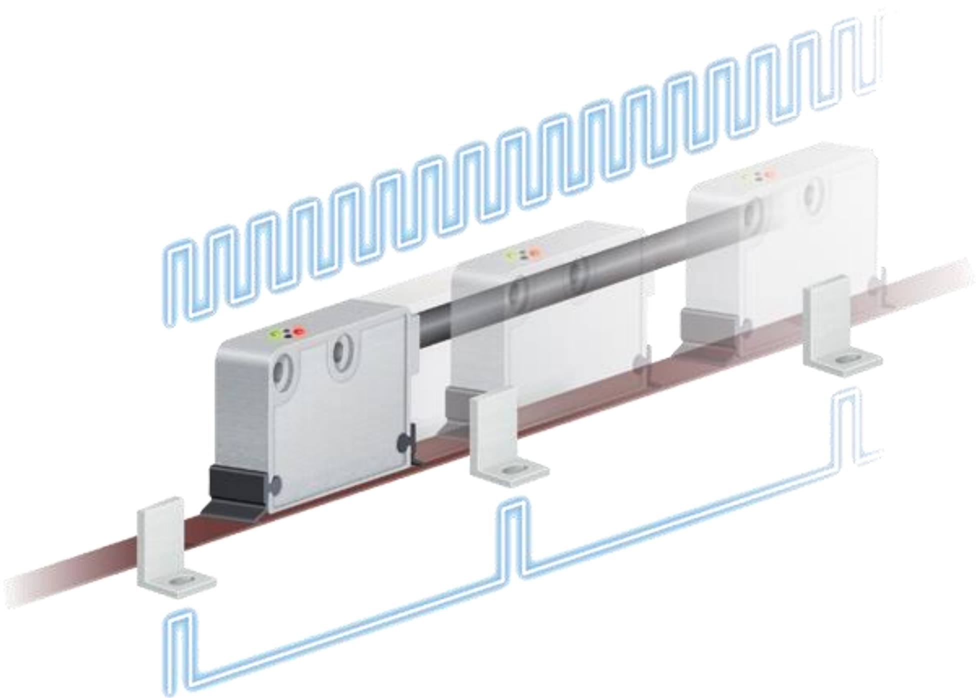


Fig4: Linear Encoder System uses Magnetic Sensor

Magnetic Rotary Encoder

A **magnetic encoder** consists of two parts: a rotor and a sensor. The rotor turns with the shaft and contains alternating evenly spaced north and south poles around its circumference. The sensor detects these small shifts in the position N>>S and S>>N. There many methods of detecting magnetic field changes, but the two primary types used in encoders are: Hall Effect and Magneto resistive. Hall Effect sensors work by detecting a change in voltage by magnetic deflection of electrons. Magneto resistive sensors detect a change in resistance caused by a magnetic field.

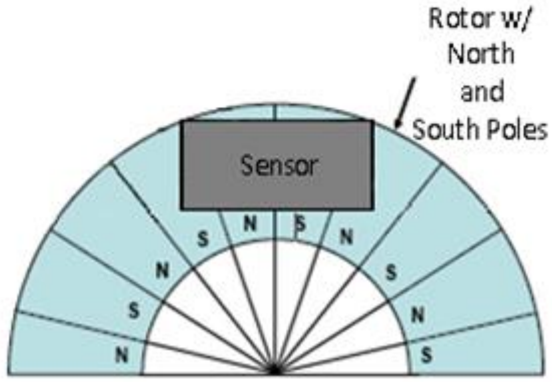


Fig 5: Rotor and Sensor

Hall-Effect sensing

The Sensor produces and processes Hall-Effect signals producing a quadrature signal as is common with optical encoders. The output is generated by measuring magnetic flux distributions across the surface of the chip. The output accuracy is dependent on the radial placement of the IC with respect to the target magnet. The chip face should be parallel to the magnet so the magnet to sensor air gap is consistent across the sensor face.

Magnetic encoders avoid the three vulnerabilities that optical encoders face:

- Seal failures which permit the entry of contaminants.
- The optical disk may shatter during vibration or impact
- Bearing failures

Magnetic devices designed effectively eliminate the first two failure modes and offer an opportunity to reduce bearing failures as well. Magnetic encoders do not make errors due to contamination because their sensors detect variations in magnetic fields imbedded in the rotor and oil, dirt and water do not affect these magnetic fields.

Commutation Encoders

A **commutation encoder** contains the same fundamental components as incremental encoders but with the addition of commutation tracks alongside the outer edge of the disk for U/V/W output.

Working

Commutation encoders utilize a transparent disk which includes opaque sections that are equally spaced to determine movement. A light emitting diode is used to pass through the glass disk and is detected by a photo detector. This causes the encoder to generate a train of equally spaced pulses as it rotates. The output of incremental rotary encoders is measured in pulses per revolution which is used to keep track of position or determine speed.

The outer part of the encoder disk includes commutation tracks which provide a controller with information on the exact position of the motor poles, so that the proper controller input can be supplied to the motor. The commutation tracks of the encoder read the motor position and instruct the controller as to how to provide efficient and proper current to the motor to cause rotation. Commutation output for U/V/W can be in the form of differential output or open-collector (manufacturer dependent).

How to Select an Encoder

There are several important criteria involved in selecting the proper encoder:

1. Output
2. Desired Resolution (CPR)
3. Noise and Cable Length
4. Index Channel
5. Cover/Base

Output

The output is dependent on what is required by the application. There are two output forms which are incremental and absolute. Incremental output forms take form of squarewave outputs. For an application requiring an incremental encoder, the output signal is either zero or the supply voltage. The output of an incremental encoder is always a squarewave due to the switching of high (input voltage value) and low (zero) signal value. Absolute encoders operate in the same manner as incremental encoders, but have different output methods. The resolution of an absolute encoder is described in bits. The output of absolute encoders is relative to its position in a form of a digital word. Instead of a continuous flow of pulses as seen by incremental encoders, absolute encoders output a unique word for each position in form of bits. Equivalent to 1,024 pulses per revolution, an absolute encoder is described to have 10 bits (210 = 1024).

Desired Resolution (CPR)

The resolution of incremental encoders is frequently described in terms of cycles per revolution (CPR). Cycles per revolution are the number of output pulses per complete revolution of the encoder disk. For example, an encoder with a resolution of 1,000 means that there are 1,000 pulses generated per complete revolution of the encoder.

Noise and Cable Length

When selecting the proper encoder for any application, the user must also take into account noise and cable length. Longer cable lengths are more susceptible to noise. It is crucial to use proper cable lengths to ensure the system functions correctly. It is recommended to use shielded, twisted-pair cables with preferably low capacitance value. The rating for capacitance value is normally in capacitance per foot. The importance of this rating is for well-defined squarewave pulse outputs from the encoder rather than "jagged" or "saw-toothed" like pulses due to the interference of noise.

Index Channel

The index channel is an optional output channel which provides a once per revolution output pulse. This pulse allows for the user to keep track of position and establishes a reference point. This output channel is extremely valuable for incremental encoders when an interruption of power occurs. In instances with a power failure, the last sustained index channel can be used as a reference marker for a restarting point. Therefore, when such an occurrence takes place, an index channel can prove to be quite valuable in applications utilizing incremental encoders.

Absolute encoders do not have an issue with losing track of position in power loss situations, because every position is assigned a unique bit configuration.

Cover/Base

Cover and base options are considerations for specific application requirements. Enclosed cover options help protect the encoder from dust particles. Base options play a significant role in large vibration environments. Such mounting options are transfer adhesives which stick directly on the back of the encoder to the mounting surface, moulded ears for direct mounting. Anaheim Automation also offers various base options for mounting purposes.

Applications

Encoders have become a vital source for many applications requiring feedback information. Whether an application is concerned with speed, direction or distance, an encoders vast capability allow users to utilize this information for precise control. With the emergence of higher resolutions, ruggedness, and lower costs, encoders have become the preferred technology in more and more areas. Today, encoder applications are all around us. They are utilized in printers, automation, medical scanners, and scientific equipment.

Encoders are used in Many Industries

Encoders have become an essential component to applications in many different industries. The following is a partial list of industries making use of encoders:

• **Automotive** – The automotive industry utilize encoders as sensors of mechanical motion may be applied to controlling speed.
• **Consumer Electronics and Office Equipment** – In the consumer electronics industry, encoders are widely used office equipment such as PC-based scanning equipment, printers, and scanners.
• **Industrial** – In the industrial industry, encoders are used in labeling machines, packaging and machine tooling with single and multi-axis motor controllers. Encoders can also be found in CNC machine control.
• **Medical** – In the medical industry, encoders are utilized in medical scanners, microscopic or nanoscopic motion control of automated devices and dispensing pumps.
• **Military** - The military also utilizes encoders in their application of positioning antennas.
• **Scientific Instruments** – Scientific equipment implement encoders in the positioning of an observatory telescope.

For more information go to (References):

- https://www.thomasnet.com/articles/automation-electronics/types-of-encoders
- http://www.anaheimautomation.com/manuals/forms/encoder-guide.php#sthash.IUgJj9nK.dpbs