WP-2011: The Basics Of How An Encoder Works

### *What is an encoder?*

Before you can fully understand how an encoder works, you should first understand what an encoder is and what it does. An encoder is a sensing device that provides feedback from the physical world-- it converts motion to an electrical signal which can be read by some type of control device, such as a counter or PLC. The control device can then use that signal to control a conditional event, such as activating a print head to create a mark at a specific location.

 Encoders use different types of technologies to create a signal. Some common encoder technologies are mechanical, magnetic, resistive and optical. Currently, the most common technology employed by encoders is optical. Encoders may produce either incremental or absolute signals. Incremental signals provide a series of high and low waves which indicate movement from one position to the next; there is no special indication provided by the encoder to show the specific position, only an indication that the position has changed. Absolute encoders, on the other hand, use a unique "word" for each position, meaning that an absolute encoder provides both the indication that the position has changed and an indication of the absolute position of the encoder. Each encoder type has its advantages, however, for the sake of this article, our discussion will be limited to the most common type of encoder used today-- optical incremental encoders.

Incremental encoders are available in two basic output types, single channel and quadrature.
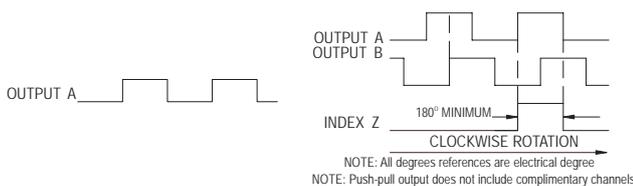
A single channel encoder, often called a tachometer, is normally used in systems that rotate in only one direction and require simple position and velocity information. Quadrature encoders have dual channels (A and B), phased 90 electrical degrees apart. These two output signals determine the direction or rotation by detecting the leading or lagging signal in their phase relationship. Quadrature encoders provide very high speed bi-directional information for very complex motion control applications.

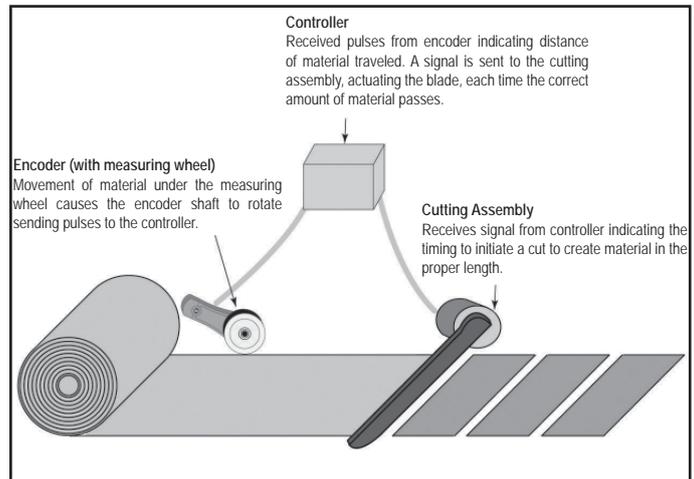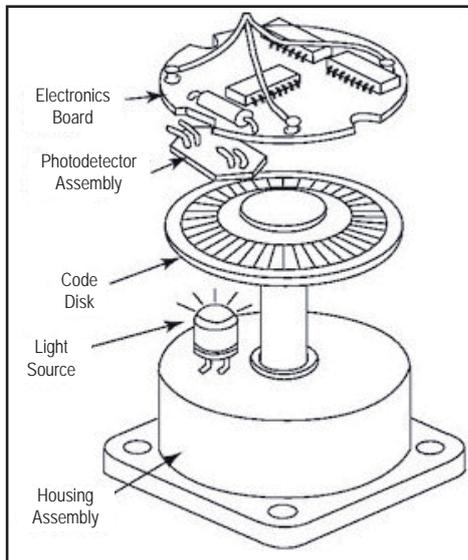### *How an Incremental Encoder Square Wave Is Produced*
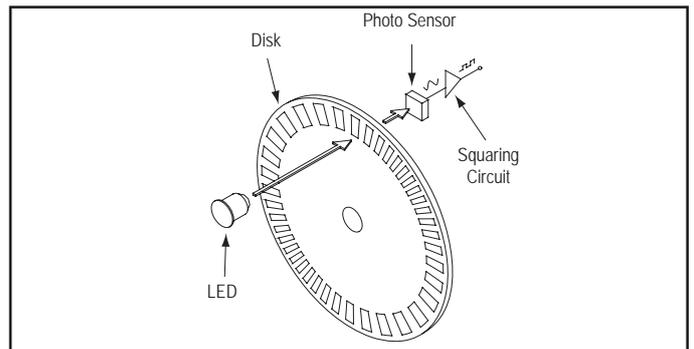
The diagram above outlines the basic construction of an incremental encoder. A beam of light emitted from an LED passes through a transparent disk patterned with opaque lines. The light beam is picked up by a photodiode array, also known as a photosensor. The photosensor responds to the light beam, producing a sinusoidal wave form, which is transformed into a square wave or pulse train. This pulse signal is then sent to the counter or controller which will then send the signal to produce the desired function. The diagram is for a typical rotary encoder. Incremental encoders can provide a once-per-revolution pulse (often called the index, marker, or reference) that occurs at the same mechanical point of the encoder shaft revolution. This pulse is on a separate output channel (Z) from the signal channel or quadrature outputs. The index pulse is often used to position motion control applications to a known mechanical reference.

Resolution is a term used to describe the Pulses Per Revolution (PPR) for incremental encoders. Each incremental encoder has a defined number of cycles that are generated for each 360 degree revolution of the shaft. These cycles are monitored by a counter or motion controller and converted to counts for position or velocity control. The diagram below is how the whole encoder comes together.

There are many applications that use encoders. Below is just one example of how an encoder is used in a typical motion control application. Cut-to-length, plotters, robotics, packaging and conveying, automation and sorting, filling, imaging, are all examples of applications that would use an encoder. The process is still the same. A count is generated by the encoder, sent to the controller, which then sends a signal to the machine to perform a function. Encoder basics -- simple.

Electronics Board
Photodetector Assembly
Code Disk
Light Source
Housing Assembly

Controller
Received pulses from encoder indicating distance of material traveled. A signal is sent to the cutting assembly, actuating the blade, each time the correct amount of material passes.

Encoder (with measuring wheel)
Movement of material under the measuring wheel causes the encoder shaft to rotate sending pulses to the controller.

Cutting Assembly
Receives signal from controller indicating the timing to initiate a cut to create material in the proper length.

If you still have questions as to how an encoder works in your specific application, please feel free to call a Customer Service Representative for Technical Support.