Quadrature Optical Encoder Basics

Quadrature optical encoders are ubiquitous through out many technologies and industries; anytime you need to monitor or control rotating machines you need an angular sensor that provides information about the position, speed or direction of the device.

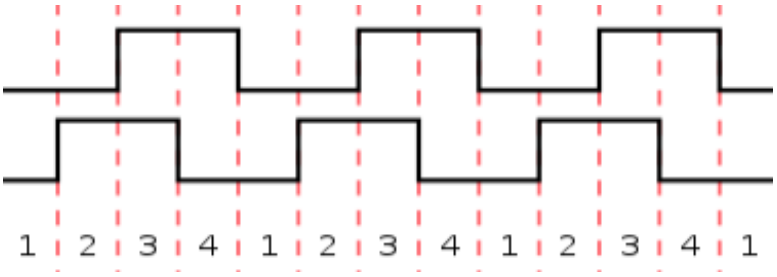
US Digital E5 Optical Kit Encoder

A rotary encoder is an angular sensor with a digital output that provides information about the position, speed or direction of motion of a rotating piece of equipment such as an axle, motor shaft, spindle or gear axis.

The two most basic classifications of encoders are absolute and incremental. Those names are not really enlightening as to the difference between them. The absolute encoder provides a unique usually digital output for each possible position. (Some provide a voltage level.) Its

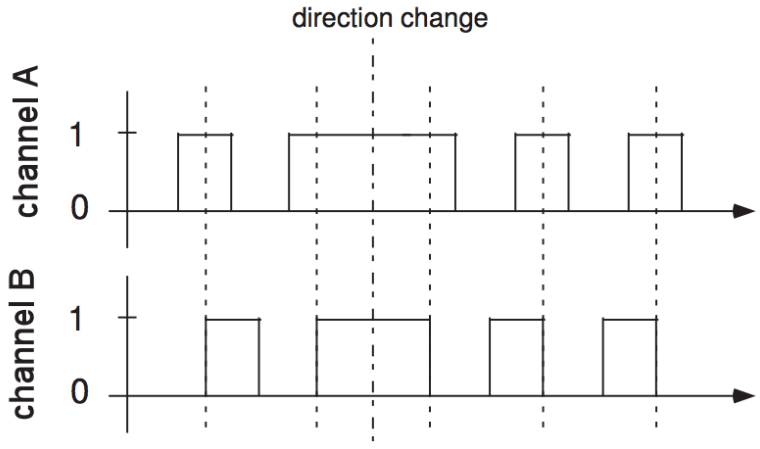
resolution is defined in number of positions per turn. For the incremental encoder the “absolute” position is not known and the resolution is measured in counts per turn. The use of an Index or Z channel that provides a signal pulse with each revolution in the incremental encoder provides a mechanism for determining absolute position. Both classifications can be optical in nature however there are many other types of encoders: Hall Effect (magnetic), mechanical, and others.
Optical Encoders are by far the most utilized because they can have high resolution, accuracy and dynamic response, function in environments with strong magnetic fields and maintain absolute position without calibration procedures.

Quadrature refers to the digital output signals. There are two outputs that are 90° out of phase with each other. Each leading and trailing edge can be counted thereby increasing the resolution by 4X per rotation.

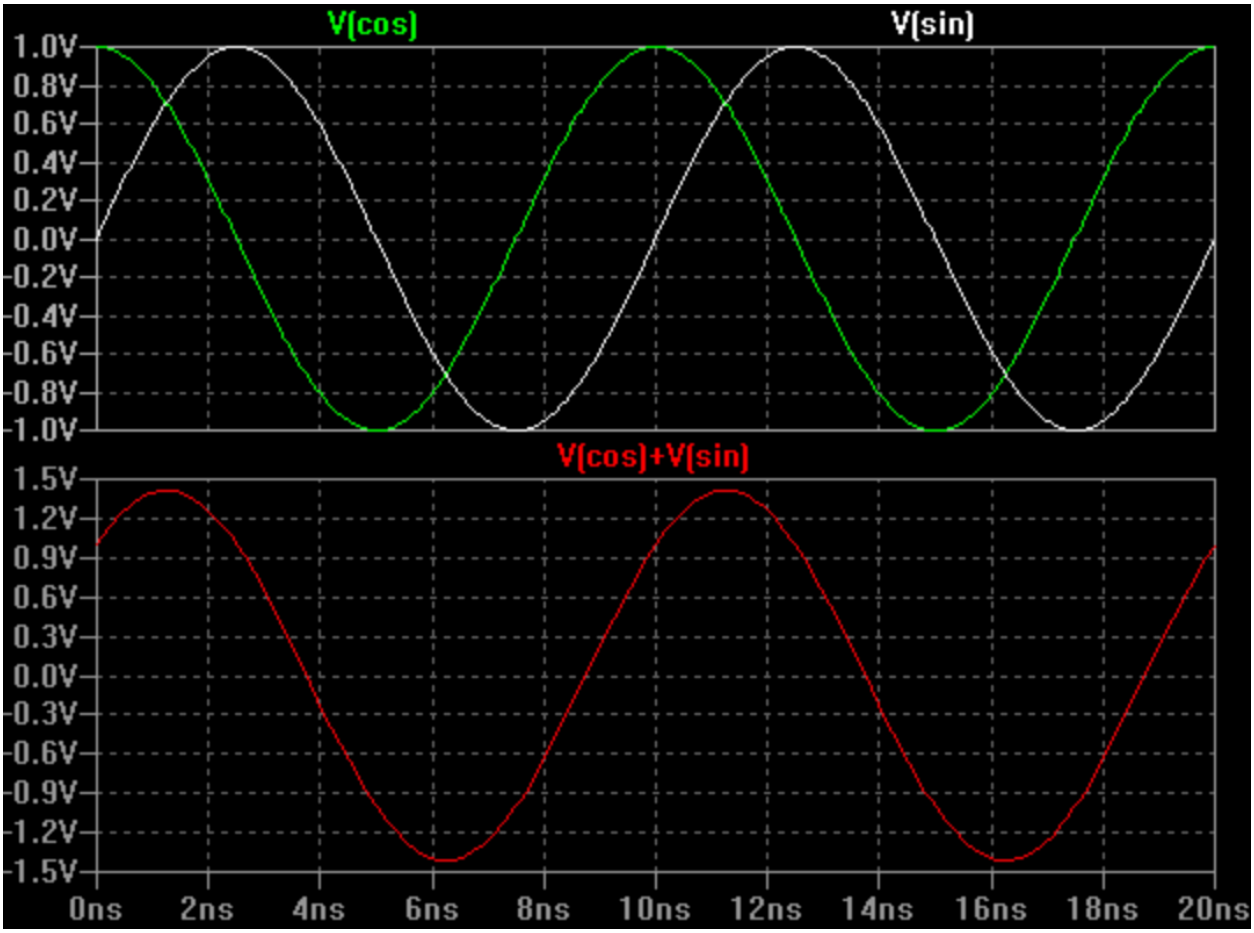


Replace with own graphic

The quadrature signal allows for the determination of direction and velocity.
A change in direction is detected by two consecutive transitions:



The neat thing about using quadrature signals is that they have mathematic properties that allow for real time digital signal processing DSP. For example if you add two sine waves in quadrature the result is a sine wave:



What is so great about this? Angular measurements have an imaginary component which are more difficult to work with in software calculations. The quadrature output also makes the output values more instantaneous because there is no need to convert from Gray code back to binary. Errors are reduced because there is an averaging element to the processing of quadrature data.