

Square Waves And Pulses: A Clarification

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The term "pulses/rev" is sometimes used to describe the output of incremental encoders, even when the output is in square-waves rather than pulse format. This indiscriminate usage creates confusion among encoder users. Square-waves are not the same as pulses, and it is important that the distinction be made.

The most common format for incremental encoder output is "quadrature square-waves," a term that denotes two square-waves that are phase-shifted with respect to each other by 90 degrees electrical, or one-quarter of a cycle. Their spatial frequency is best-expressed in "cycles per revolution." Usually, this is the same as the number of lines on the encoder disc. However, some manufacturers offer interpolated square-waves at many times the line count on the disc, but that is another subject. For purposes of this discussion, there is no difference between 1X square-waves, read directly from the disc, and interpolated square-waves, which are at some multiple of the line count on the disc.

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Since each square-wave has two transition or edges per cycle, quadrature square-waves contain 4 edges per cycle. Simple circuitry can be used to detect 1, 2, or 4 of these edges. Additionally, the edge detection circuitry determines direction of travel by looking at the relative phase of the two square-waves.

The edge-detection circuitry generates electrical pulses. Although they look "square" on an oscilloscope, pulse output differs from square-wave output in two vital ways:

1. With square-wave output, each square-wave has a 50% duty cycle (motion corresponding to ON = motion corresponding to OFF), and the location of any given edge is a function of encoder position. In other words, in an encoder with N cycles/rev square-wave output, the transitions on each square-wave are $1/2N$ rev apart; considering both square-waves together, the distance between any two adjacent edges is $1/4N$ rev. With pulse output, "one-shots" generate short duration pulses. Hence, the distance between the leading edges is a function of position ($1/N$, $1/2N$, or $1/4N$ rev, depending on whether the edge-counting circuitry is 1X, 2X, or 4X), but each pulse is of a fixed time duration, independent of encoder speed.
2. With square-wave output, square-wave 'A' appears on one terminal and square-wave 'B' on another. Both A and B are always present regardless of direction. The user must determine direction based on whether A leads or lags B. With pulse output, the pulses appear one terminal for CW rotation and on another terminal for CCW rotation. Only one terminal is "live" at any particular instant. (With oscillating motion, the pulses will appear alternately on one terminal and then the other.)

Because of these important distinctions between square-wave and pulse outputs, the quantifier "pulses/rev" (PPR) should be reserved only for those encoders that provide true pulse output; it should not be used with square-wave output, nor should it be used to describe the information on the disc ("lines/rev.") "Cycles/rev" should be used for square-wave output; the abbreviation "CPR" should be avoided unless the context makes it clear whether cycles/rev or counts/rev is intended.

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