Quantum Devices, Inc.

"Improving the Quality of Life through the Power in Light"

Quantum Facts

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OPTICAL ERROR COMPONENTS...

IN AN OPTICAL ENCODER SYSTEM AND THEIR EFFECTS ON SIGNAL QUALITY WITH INTERLACED SENSING SCHEMES.

THERE ARE FOUR MAJOR POTENTIAL SOURCES OF INCONSISTENCY IN AN OPTICAL ENCODER SENSING SYSTEM. *These items are:* ***(1) light transfer variability through the rotating disc**, **(2)rotational flatness of the disc while in motion, (3)concentricity of the disc pattern to the centerline of the shaft and (4) rotational error of the reticule pattern relative to the disc pattern**. Encoder manufacturers day in and day out strive to control these variables in order to provide the best possible output signals from their product. The effect of these variables become much more difficult to control as encoder resolutions increase toward the 10 micron window region.*

...HOW DO ENCODER MANUFACTURERS CONTROL OPTICAL ERROR COMPONENTS?

Typically, they either limit the product resolution to a point such that they can economically control each optical variable or invest in manufacturing time and variable control systems to obtain high resolutions. In either case product resolution is limited or costs increase greatly with ever increasing resolution.

Optical error components always exist to some extent in an encoder design, therefore, the practical way to control error effects is to make error components appear as common mode noise to a differential sensing system. The more an error appears like common mode noise the more effective the common mode noise rejection ratio (CMMR) of the differential system eliminates the error. By interlacing a, a not, b and b not signals of an optical sensor, the four optical inconsistencies can be eliminated with the CMMR of the differential sensing system.

Figure 1

Figure 1 illustrates an opaque spot produced by an indelible marker on the clock channel of an encoder disc.

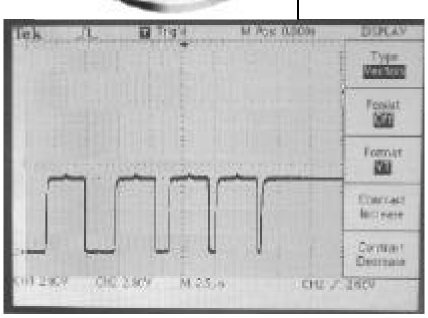

Figure 2

Figure 2 illustrates the resultant output duty cycle errors typical to light transfer variations.

Optical error number one, consistent light transfer through the rotating disc. As resolutions increase the demand on the constancy of light transfer through the disc increases as well. Manufacturers regularly strive to purchase or produce the "perfect disc". A good test for susceptibility of an optical system to inconsistent disc light transfer is to place an opaque spot in the center of the A and B clock channels and look for encoder output variation during operation.

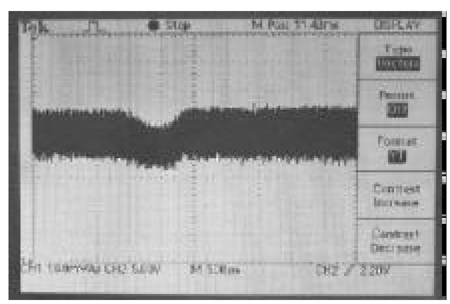

Figure 3

Figure 3 illustrates the drop in analog signal of the "a"output from the sensor.

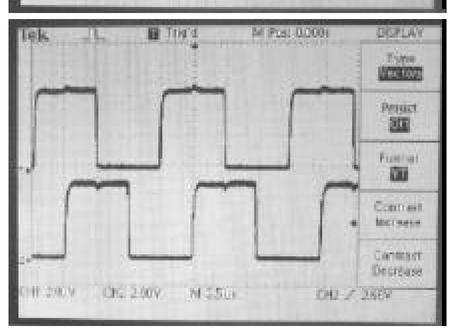

Figure 4

Figure 4 illustrates the encoder output signal quality with the same optical error using an interlaced sensor.

As the illustrations show, the interlaced sensor "sees" the optical error as common mode noise and nicely rejects it while maintaining output signal quality. The opaque spot is a gross error to prove a point about interlaced sensing but in reality even small errors can cause output variations with typical encoder sensing systems.

Rotational flatness error of the rotating disc causes similar errors as seen with error number one.

Encoder manufacturers expend considerable amounts of effort to maintain a consistent air gap between the rotating disc and reticule. As resolutions increase the constancy of the air gap becomes a more important factor. The result of this type of optical system error will result in variations in the encoder output duty cycles or (jitter). As with light transfer variations, interlaced sensing systems interpret analog signal variations due to changing air gap as common mode noise and reject it thus producing jitter free output signals.

Potential error number three is the concentricity of the disc pattern to the centerline of the encoder shaft.

This type of error is double-edged in that it causes two problems. The first is the positional accuracy of encoder signals are directly proportional to the placement of the rotating pattern relative to the centerline of the disc. And, the second is encoder output signal jitter, occurring with most sensor geometry's.

The reticule pattern of an optical encoder system defines the light transfer to the sensing elements.

Reticule patterns produce the analog differential sensing and quadrature phasing relationships, which are utilized to produce the encoder output signals. Placement of a reticule pattern relative to the rotating disc is critical to the quadrature phasing relationship and slight misalignments will cause unacceptable phasing errors.

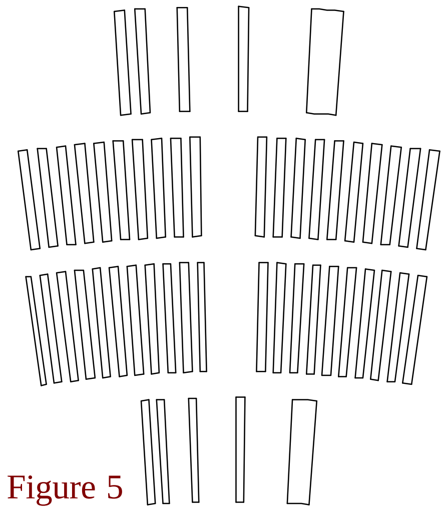

Figure 5

Figure 5 illustrates a very common encoder reticule geometry that is susceptible to disc pattern concentricity. The interlaced sensor design will provide jitter free output signals due to the fact concentricity errors appear as common mode noise. Unfortunately, rotational accuracy still suffers with a single interlaced sensing system, but add multiple interlaced sensing "read heads" and accuracy can be improved while eliminating jitter.

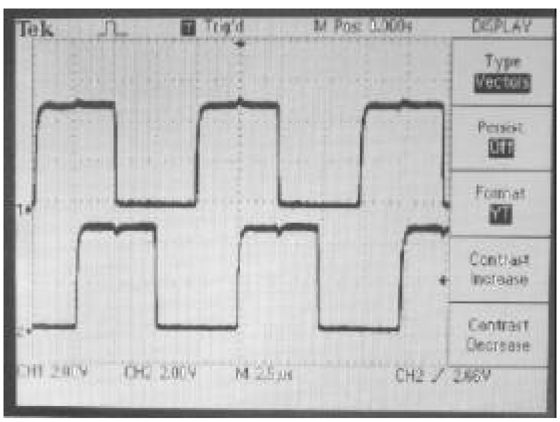

Figure 6

Figure 6 illustrates a typical quadrature encoder output waveform.

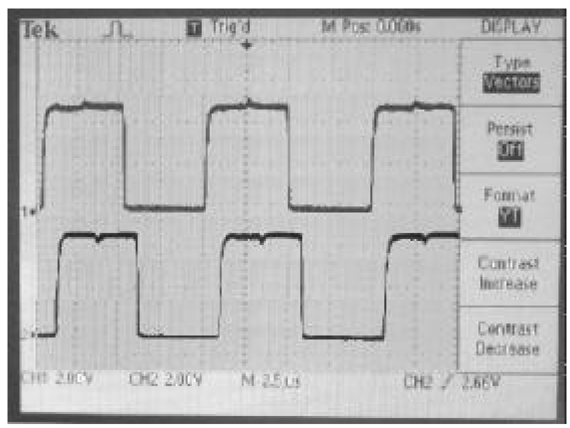

Figure 7

Figure 7 illustrates the waveform error caused by misalignment of a reticule.

The design of interlaced sensors places sensing elements relative to a disc pattern in silicon to produce differential sensing and quadrature relationships. Interlaced sensors provide the function of the reticule and thus eliminate the need for a separate reticule component. The relationship of the interlaced sensing elements maintain differential sensing and quadrature phasing of all analog signals over a wide range of rotational sensor positioning. Interlaced sensors will maintain phasing relationships up to one disc pitch before significant output signal errors occur.

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