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A New Approach to Interpolated High Res Encoders

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Introduction - Optical Encoder Basics

The key to the successful operation of an optical encoder is the optics system, which consists of a light source, a resolution disk, and a sensor. During the operation of the encoder, the resolution disk rotates between the light source and the sensor. Resolution lines on the disk break the beam of light between the light source and the sensor as each line passes by. The output from the sensor is an analog signal called a sine wave, a series of rising and falling voltages that varies with the amount of light reaching the sensor. Each sine wave period has a duration of 360 electrical degrees.

These sine waves are input to a comparator, that generates the series of on/off states, or square wave signals, commonly associated with an encoder. For a single output "Channel A" encoder, the square wave is in phase with the original sine wave. If a second "Channel B" signal is needed, it is generated from another sinewave 90° offset from the original sine wave. An on or off state is generated based on the angle of each sine wave period. See Figure 1.

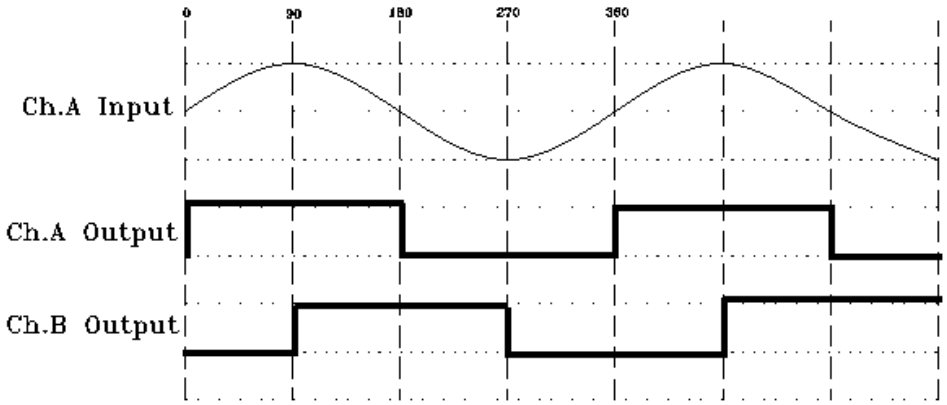

Figure 1

Interpolation Basics

Since a sine wave is an analog signal, each sine wave can theoretically be divided into an infinite number of components that represent the various positions of the encoder. To achieve an interpolated resolution, the comparator is replaced by an interpolation circuit, which performs the actual division of the sine wave generated by the optics system into the desired number of multiple interim positions. The interpolator uses the angle of the sine wave period to maintain position integrity, so a pure sine wave is a requirement for good interpolation. The interpolation circuit then generates a new square wave output at the increased resolution. See Figure 2.

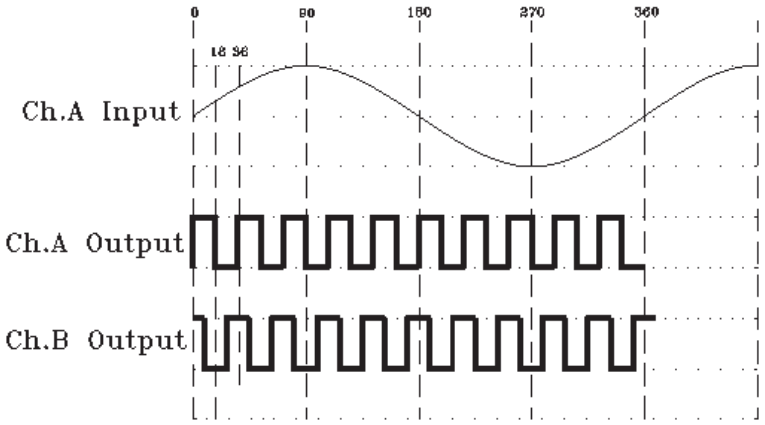

Figure 2

One on and one off position is created for each level of interpolation. For example, to achieve an interpolation level of 10X, the interpolation circuit creates 10 on and 10 off positions in each sine wave period for a total of 20 positions. This means that one position is created every 18 electrical degrees (360÷20). See Table 1.

Input Angle (within one sine wave)	Output
0-18º	ON
18-36º	OFF
36-54º	ON
54-72º	OFF
72-90º	ON
.....	.....
342-0º	OFF

Table 1

The use of interpolation allows an encoder to generate high-resolution output without increasing the size of the disk. Thereby eliminating the need to increase the overall size of the encoder.

Signal Quality
As mentioned above, the most important factor in accurately generating an interpolated output is the quality of the analog sine wave signal input to the interpolation circuit. If the shape of the sine wave signal is distorted in any way, the interpolation circuit can not accurately determine the angle of the wave. This results in pulses in the square wave that are shortened or missed altogether. BEPC's advanced optics system incorporates proprietary sensor design to ensure the cleanest possible sine wave. Using these high quality sine wave signals, BEPC's high-resolution encoders generate highly accurate and reliable interpolated outputs while virtually eliminating the phase, offset, and amplitude errors common in many other encoder designs.

Other Considerations
Once a clean interpolated square wave has been generated that accurately reflects the positional integrity of the encoder, the job is still not done. The rest of the encoder electronics must also be designed to accommodate the increased performance represented by good interpolation. For example, the 300 KHz output frequency of standard encoder electronics would only allow an interpolated encoder capable of 30,000 PPR to be used on a motor or shaft that was running at a maximum of 600 rpm (300,000 kHz/30,000 PPR*60). For that reason, higher speed drivers capable of operating to at least 1 MHz becomes a necessity. BEPC has chosen a design that allows different drivers to be inserted so performance is balanced with economics, allowing an optimal solution.

Conclusion
Someone once said about playing the guitar, "It's easy to play, but it certainly isn't easy to play well." The same thing can be said about interpolated encoders - with modern electronics, its not that hard to do, but it certainly is hard to do well. BEPC's various high-resolution encoders are just that, high resolution, and their innovative approach insures that the gains made in resolution are not lost in increased inaccuracies and poorer performance specifications.