Self-Diagnostic Encoders Find Problems Before They Stop Your Machinery

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Encoders are the mystery machine of the industrial landscape: A mechanical device at heart, but with electronic outputs. Encoders are often installed by motor companies or outside integrators, then connected to both PLCs and drives. They frequently fall in the “all other” scope of job responsibility and troubleshooting. Most encoders are a “black box” with no diagnostic features at all, not even a power light! Troubleshooting an encoder requires an oscilloscope and some engineering knowledge, or a dedicated encoder diagnostic device. Both are typically in short supply at 3AM when a problem arises and production comes to an abrupt halt.

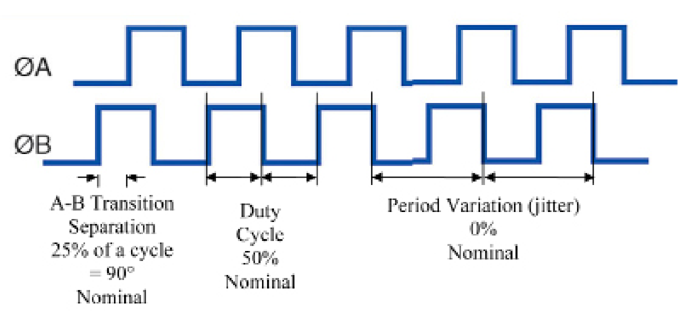
Worse yet, once customers have seen a few encoder failures, everything looks like an encoder failure. Encoder manufacturers report over 50% of their returns have no detectable problem. The customer, conditioned by many previous failures, has removed a perfectly good encoder, often at great expense and replaced it unnecessarily. Then the customer must spend more time to find the real problem!

A better approach to troubleshooting is to have the encoder diagnose and tune itself continuously. The encoder should warn machine operators and remote diagnostic systems of impending problems, before the problems cause the machine to be shut down.

The key to self-diagnostic encoders is a digital signal processor (DSP) imbedded within the unit. Older optical and magnetic encoders didn’t need this horsepower to provide their basic output functions, so manufacturers didn’t include them. This kept costs low but meant diagnostics and self-tuning were not possible. However modern encoder designs include these processors so adding diagnostics as well as self-adjustment is a natural improvement.

How do the diagnostics work? First, let’s examine a standard incremental encoder signal, with quadrature output, (A, A NOT, B, B NOT = A Quad B). There are a few important characteristics of the signal that help the receiving device (drive or PLC) correctly interpret the encoder pulses (see figure 1):

Figure 1: Encoder Output Signals



Duty Cycle: The signal should consist of pulses with equally sized negative and positive-going portions (50%/50% = 180º/180º, where one cycle = 360º). Drives are relatively tolerant of duty cycle variations.

Phase/Transition Separation: The A and B signal transitions should be separated by exactly 1⁄4 of an entire cycle (25% = 90º). Drives are likely to trip if phase separation is less than 15% (54º).

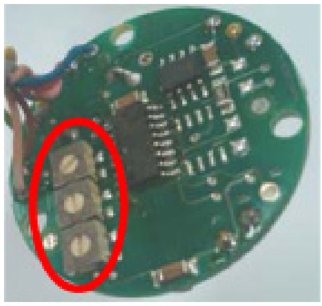
Period Variation (jitter): At constant speed, each cycle should be exactly the same width (0% jitter). Drives are often extremely tolerant of jitter; often jitter over 50% has no visible impact on drive performance! (But the results may drive up motor current.)

If there are serious defects in the pulse output signals, this will cause an error at the PLC or drive that causes the process to stop. Most common is the “Tach Loss” signal indicated in most variable speed drives. Poorly named, this error does not typically mean the pulses from the encoder are entirely lost; instead, it means the signals are not acceptable to the drive. This may range from a complete loss of all input to the drive or a phase separation problem in the encoder signal. Waiting for the PLC or drive to trip or stop the machine, and then replacing or troubleshooting the encoder is a very costly process.

Some vendors took the initial step of providing a power light, and/or signal output lights to show phase A and B changing. However, neither the encoder itself, nor a technician attempting to use these lights, could detect the quality of the output signal, and there was no prediction of problems. Failure = no light = no operation. Not very helpful. Worse yet, often the lights would be green and blinking away merrily, but the controller would trip with a “tach loss” error!

What Causes Encoder Signal Problems?

There are a wide range of causes, but common problems are changes in the environment (temperature), or mechanical changes over time (bearings, mounting). All encoders start with analog signal sensing: these signals are subject to variation over time. Without a processor, these changes go unnoticed until they make the encoder signal unacceptable to the PLC or drive. Older encoders use potentiometers “pots” set at the factory. With repeated temperature cycles and time these drift, and so do the analog electronics of the encoder causing poor quality signal outputs and drive tripping.

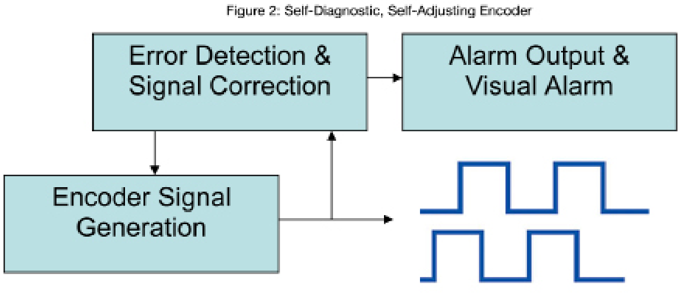

Encoder with “pots”

A self-tuning encoder continuously monitors its output signals for quality. If the signals start to drift away from ideal, the encoder self-adjusts to correct the signal. This makes the encoder very tolerant of temperature changes. Some models can operate from -40°C to +85°C or even +100°C. This self-tuning also guarantees extremely long encoder life; the encoder will self-adjust as mechanical conditions change.

If the signals in the processor-controlled encoder cannot be corrected, this is a warning sign that the encoder is experiencing problems. For example, if the duty cycle is changing from the nominal 50%/50%, and is now 40%/60%, the drive may not yet have “tripped”. Before the condition reaches a point that would cause a drive trip, the encoder can provide an alarm output. The alarm can be both a visual indicator (LED) for the operator, and an alarm contact for the controller. Now corrective action can be taken at the next convenient shutdown. The encoder can be diagnosed or replaced, and the process resumes as normal, without unscheduled downtime.

This diagnostic notification can be local, at the machine, or half a world away for remote site dispatch.

Figure 2: Self-Diagnostic, Self-Adjusting Encoder



As an added benefit, customers who have installed self-diagnostic encoders report hugely lower replacement rates; they have stopped replacing working encoders. (Remember the old 50% return rate of working encoders?) Instead, they look elsewhere and find the true problem the first time, instead of replacing the encoder, then discovering they had not resolved the issue.

For even greater up-time performance, manufacturers have added diagnostics to magnetic encoders. (ex: magnetic encoder white paper). These units seal all of the active electronics inside a potted area, ensuring ideal protection and durability.

In summary, self-diagnostic encoders which include self-adjusting circuits offer customers a great way to reduce machine downtime, reduce mean-time-to-repair and ensure the longest encoder life possible.

Example: Self-Diagnostic Encoder (AV56, AV67 & AV85 from Nidec-Avtron) Note Green Diagnostic LEDs with Remote Alarm Contact

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