Noise Suppression of Differential Signals

An encoder is an electro-mechanical transducer that converts mechanical rotary motion into digital signals for the control of machinery. The encoder produces a square wave signal as the shaft rotates. Speed, position, servo feedback, etc., can be determined through proper processing of this signal. As the electrical signal leaves the encoder, it is "clean" of electrical noise. However, by the time the signal reaches its intended counter, PLC, etc., it is degraded and may not be "clean" enough for the system to work properly.

One of the common causes of this signal degradation is the cable length. All cable has small amounts of capacitance between its adjacent conductors, and this capacitance is a direct function of the cable's length. This capacitance tends to round off the leading edge on the square wave signal. If rounding is excessive, the receiving device may begin to miscount. As a rule of thumb, use only enough cable to reach where you are going and use proper engineering practices when installing the cable (e.g. avoid routing adjacent to AC power cables, etc.).

Another common cause of signal degradation is electrical noise. The longer the cable run, the more electrically induced noise the cable picks up. If this noise becomes excessive, miscounts will occur. Electrical noise causes miscounting because the receiving device cannot tell if an input signal is a valid encoder signal or a noise pulse. Normally there is sufficient input signal conditioning, or filtering, to take care of this problem. However, filtering at the input of the receiving device will reduce the speed at which the system can operate. Years ago, most counters had high frequency limitations of between 5 and 20 kHz. Speed is now the name of the game, and these frequency limitations are simply not acceptable in today's production environments.

One method to alleviate the problem of electrical noise is using what is called differential signals. With differential signals, the output from the encoder is "split" into two signals that are exactly 180 degrees out of phase with each other. This is also called complementary signals, because one signal is the complement, or mirror image, of the other. As long as the two signal conductors are next to each other, any noise picked up by the cable will have equal and in-phase components on each conductor in the cable. Using differential input circuitry, the input will recognize only the DIFFERENCE between the signals. As one signal line is in a high, or logic 1 state, the complement is at a low, or logic 0 state. The differential input circuitry will accept this as a legitimate signal, and the in-phase noise products are simply ignored. To use this type of noise immunity, the encoder must have what we refer to as a line driver output circuit. However, having the line driver output circuit is only half of the equation. Transmitting the signal in differential form is not enough; it must also be received in differential form. To accomplish this, the receiving device must also have a differential input circuit, or what is commonly called a "line receiver" input. Many people believe that by specifying the differential output on the encoder, their noise problems will simply go away. However, without the proper line receiver input circuitry, it is a waste of money, and may even be worse from a noise standpoint. If the differential output of the encoder is not properly terminated, ringing and other spurious oscillations will appear on the signal lines.

Encoder Products offers differential output circuitry on most models. It operates over the voltage range of 5 to 28 volts DC supply voltage. The older standard for differential signals (also known as RS-422) called for 5-volt operation. By raising the voltage in the system, a much better signal to noise ratio results. In a 5-volt system with 3-volt spikes, the spikes are nearly as great as the desired signal amplitude. In the same setup with the voltage increased to 24-volts, for example, it is easy to see that the same 3-volt spikes can be easily ignored. However, it is important to remember the input circuitry must also be able to handle this higher voltage.

In today's world, speed rules supreme. With speeds increasing all the time, this line driver output circuit option may be just what you need for foolproof system operation.

White Paper 2005