Technical Bulletin 105
Noise Suppresion Using Differential Signals

BRITISH ENCODER PRODUCTS COMPANY

An Encoder is an electro-mechanical transducer that converts mechanical rotary motion into digital signals for the control of machinery. It sends out a square wave signal as the shaft is rotated, and by the proper processing of these signals, speed, position, servo feedback, etc. can be determined.

When the electrical signals leave the Encoder they are "clean" in the sense of not having any electrical noise along with them. However, by the time these signals reach their intended counter, PLC, etc., they are degraded and may not be "clean" enough for the system to work properly. One of the causes of this signal degradation is due to the cable length. All cable has small amounts of capacitance between adjacent conductors, and this capacitance is a direct function of the cable's length. The effect of this capacitance is that it tends to round off the leading edge on the square wave signal. If this rounding is excessive, the counter may begin to miscount.

Also, the longer the cable run, the more electrically induced noise is picked up on the cable which acts like a long antenna. This noise can become excessive to the point of also causing miss-counting. Very seldom will this noise actually harm the Encoder. Electrical noise causes miss-counting because the counter can not tell if an input signal is a valid encoder signal or a noise pulse. Usually there is sufficient input signal conditioning, or filtering, to take care of this problem. However filtering at the input of the counter 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 not acceptable.

One way to help alleviate the problem of electrical noise getting into the input of the counter is by using what is called differential signals. What this means, is that each signal 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 first signal.

In most of our Encoder models, this line driver, or differential output is called out in the part number in the output type box as "HV" or "L1" It is rapidly becoming more popular all the time. In today's world, speed is what matters, and with speeds increasing all the time, this line driver output circuit option may be what you need for foolproof system operation.

As long as the two conductors are next to each other, any noise that is picked up by the cable will have equal and in-phase components on each conductor in the cable. By utilizing 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 utilize this type of noise immunity, it requires that the Encoder have what we refer to as the line driver output circuit. Just having the line driver output circuit is only half of the equation, however. The device the Encoder is feeding into also must have a differential input circuit, or what is commonly called a "line receiver" input. The signals have to be transmitted in differential form and they also must be received in differential form.

A lot of people think that by specifying the differential output on the Encoder, their noise problems will go away. However, without the proper line receiver input circuitry, it is a waste of money, and it may even be worse from a noise standpoint, because if the differential output of the Encoder is not properly terminated, quite often ringing, and other spurious oscillations will appear on the signal lines. The actual length of the cable really is not that important. As a rule of thumb, use only enough cable to reach where you are going. Use proper engineering practice when installing the cable (do not route adjacent to AC power cables, etc.)

Encoder Products offers this differential output circuitry on most of our more common models. It will operate over the voltage range of 5 to 24 volts DC supply voltage. The older standard for differential signals (also known as RS-422) called for 5 volt operation. If the voltage in the system is raised, say to 24 volts, a much better signal to noise ratio results. If you are running a five volt system, and have three volt spikes, in reality, the spikes are nearly as great as the desired signal amplitude. With this exact same setup, if the voltage is simply increased to, say 24 volts, it is easy to see that the same three volt spikes can be pretty much ignored. However, this also requires the input circuitry to be able to handle this higher voltage.