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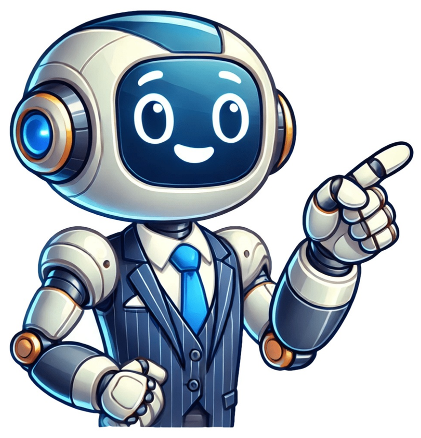

April 27, 2014. I have interfaced a 200 line count QR145 optical encoder to a DL06 PLC. The PLC's inputs are set up in high speed mode to receive the incremental quadrature pulses coming from the optical encoder. . CT174, the designated high speed up/down counter is used to interface to the incremental encoder. By default, inputs X0 and X1 are used for the A& B incremental signals, without having to code them to the counter. Input X2 is designated as the reset, and may normally be connected to the index pulse of the encoder. For an RPM application we will not be needing X2. To calculate RPM with an optical rotary encoder we use this formula: RPM = (Frequency X 60)/ Line Count Since frequency is "cycles per second" we set up our high speed timer on rung three to give us a count total every second; this is our frequency. Rung four is where all the heavy lifting happens: After the high speed timer has timed out to one second, we load the PLC'c accumulator with the value from the counter (CT174). This will be our frequency, or the number of optical encoder counts that we have accumulated in one second. We then multiply that value by 60, which uses our one second total to convert to the number of pulses occurring in a minute. And we divide that total by 200, the line count, to get the RPM of the optical encoder. We move the value to V2500, a location that we can pick up with the screen. C3 is then used to reset the timer and counter and start the process over again. . . Explore more incremental optical rotary encoders that can be used to find RPM, shop rotary encoders online, or contact Quantum Devices for help with optical encoders in your application. Image credit: Encoder Products Company The most common use for encoders is to measure angular or linear distance, but encoders can also be used to perform speed or velocity measurements. This is possible because there is a linear relationship between an encoder's pulse frequency and its rotational velocity. In other words, as the encoder rotates faster, the pulse frequency increases at the same rate. Encoder speed can be determined by either of two methods: pulse counting or pulse timing. Refresher on quadrature encoding Incremental encoders often output signals on two channels – typically termed "A" and "B" – offset by 90 degrees (in quadrature). The direction of rotation can be determined by which channel is leading. Generally, if channel A is leading, the direction is taken to be clockwise, and if channel B is leading, the direction is counterclockwise. Quadrature output also allows the encoder's resolution to be increased, by using X2 or X4 decoding techniques. With X2 decoding, both the rising and falling edges of channel A are counted, doubling the number of pulses counted for each rotation, and therefore doubling the encoder's resolution. With X4 decoding, the rising and falling edges of both channels A and B are counted, increasing the resolution by four times. X4 encoding, in which both the rising and falling edges of channels A and B are counted.Image credit: National Instruments Corporation Pulse counting Pulse counting uses a sampling period (t) and the number of pulses (n) that are counted over the sampling period to determine the average time for one pulse (t/n). Knowing the number of pulses per revolution (N) for the encoder, the speed can be calculated. ω = 2πn/Nt Where: ω = angular speed (rad/s) n = number of pulses t = sampling period (s) N = pulses per rotation At low speeds, the resolution of pulse counting is poor, so this method is best applied in high speed applications. Pulse timing With the pulse timing method, a high-frequency clock signal is counted during one encoder period (the pitch, or interval between two adjacent lines or windows). The number of cycles of the clock signal (m), divided by the clock frequency (f), gives the time for the encoder period (the time for the encoder to rotate through one pitch). If the encoder PPR is denoted by N, the angular speed of the encoder is given by: ω = 2πf/Nm Where: ω = angular speed (rad/s) f = clock frequency (Hz) m = number of clock cycles N = pulses per rotation At high speeds, there may be too little time between pulses for pulse timing (also referred to as pulse frequency) to accurately measure clock cycles, so this method is best for low speed applications. Accuracy of speed measurement The accuracy of the encoder speed measurement can be affected by a variety of factors, including instrument errors, quantization errors, and interpolation errors. Instrument errors include both mechanical imperfections in the encoder and errors in the pattern on the code disc or reticle, such as variations in spacing between lines or windows. Also included in instrument-related errors are substrate flatness, inexact positioning of sensors, and lack of concentricity between the encoder and the shaft. Quantization error stems from the fact that there is no information between pulses or readings. In other words, quadrature encoders only read the edges of the signals on one or both channels (A and B), and relay no information between these readings. Quantization error is inherently ± ½ of the measuring step, or count. Interpolation error occurs only if the encoder resolution is increased electronically beyond the X4 decoding that is inherent to quadrature encoders. Interpolation error tends to increase with increasing encoder speed. Both interpolation and quantization errors can be reduced by using encoders with higher line counts or a greater number of windows. Step 1: Select Feedback Type (Learn How to Choose) READ NEXT In the previous post, 365EVN show you the basic steps to select an encoder. Today, we will show you about: Calculate Encoder Resolution and Encoder Connect To PLC. You can refer to the previous post before reading this post: select an encoder. Before calculating encoder resolution, we need some parameters: The maximum speed of the system using encoder, unit: RPM (Revolutions Per Minute). We called this parameter is "A". For example, we use an encoder to calculate motor speed (the motor speed control by an inverter) and we direct connect it with the motor (4P, 380VAC, 50Hz). In this case, the maximum speed using to calculate the resolution of the encoder is 1500rpm (equal to maximum motor speed). The maximum input frequency of Hight Speed Counter equipment (PLC, PIC…), unit: kHz. We can find it in the catalogue or user manual of Hight Speed Counter (HSC) equipment. And we called this parameter is "B". For example, with Siemens S7-200 PLC the maximum input frequency of HSC is 30 kHz (200 kHz with CPU 224 XP) In normal, we will see the power supply, output phases on the encoder. You can refer to the encoder catalogue to read more information. Power supply: (5VDC, 24VDC…) For example Encoder Omron (on photo): Brown-wire connects to DC+ (24VDC, 12VDC…). Blue-wire connects to DC- (0 V). And ground the shield wire to the frame ground (F.G) terminal. Output phases (A, B, Z) In normal we will use phase A, phase B connect to the input of PLC (or Another Hight Speed Counter equipment). We need to read the catalogue to make an encoder connect to PLC. For example, we use an Omron encoder (on photo) and Siemens S7-200 PLC. We use HSC2 Mode 9 for HSC function, and then we will connect Black-wire and White-wire to PLC inputs (I1.2 and I1.3) With the PLC you can change the counter direction by changing the PLC inputs for phase A and phase B. In future, we will guide you to connect an encoder with some PLCs as Siemens PLC S7-1200, S7-200 SMART, Delta PLC… -365evn- If you find this content valuable, please rate it (click the button above), share it with your friends or invite me for a coffee by clicking the button below. Incremental encoders determine rotary position by generating a specific number of pulses per revolution (PPR) and counting those pulses as the encoder spins. The PPR rating indicates resolution, and is typically the most important factor when selecting an incremental encoder. But how do you determine what PPR is needed for a specific application? Fortunately, establishing the required PPR is not difficult—just follow a few guidelines. Feature image credit: Danaher Distance When linear motion is being measured, the required pulses per revolution is calculated by dividing the lead of the screw by the linear resolution needed for the application. Conversely, for an encoder with a given PPR, the resulting linear resolution is calculated by dividing the screw lead by the PPR. Keep in mind that if X2 or X4 encoding is being used, this should be factored into the PPR number. For example, if the desired linear resolution requires a PPR of 5000, and X4 encoding is being used, the encoder chosen should have a PPR of 1250 (5000/4). If the travel is being measured by use of a wheel or roller, a calibration constant might be necessary, depending on the required display resolution. The calibration constant is calculated by dividing the wheel or roller circumference by the PPR of the encoder, multiplied by the gear ratio being used (if any). This is then multiplied by any conversion required to translate from the wheel/roller circumference units to the desired units for the display. (For example, multiply by 1000 to convert from circumference in meters to display units in millimeters.) K = calibration constant C = wheel or roller circumference (typically inches or meters) G = gear ratio N = encoder PPR Using a calibration constant or scaling factor has the drawback of introducing a rounding error that will accumulate over many cycles of the encoder. To avoid this, choose an encoder whose PPR is an even multiple of the value that is being measured. For example, if one revolution of the encoder equals 12 inches, choose a 1200 PPR encoder. Speed Another important factor in determining the required pulses per revolution is the encoder's maximum speed—both mechanical and electrical. The mechanical speed limit is based on the maximum speed that can be obtained without causing potential damage to the encoder. The electrical speed limit is determined by the maximum frequency response of the encoder's electronics—that is, how fast the electronics can switch between "On" and "Off." The lower of the two values—mechanical speed or electrical speed—indicates the maximum speed the encoder can turn. To convert electrical speed to rpm, the frequency response is divided by the PPR and multiplied by 60 (seconds per minute). Again, if X2 or X4 encoding is being used, the PPR must be multiplied by 2 or 4, respectively. For example, consider an encoder that is rated at 100 PPR with a maximum mechanical speed of 3000 rpm and a maximum frequency response of 100 kHz. The electrical speed is 60,000 rpm, so the mechanical speed, at 3000 rpm, is the limiting factor. An encoder is just one part of a complete electromechanical system, so it's important to also ensure that the maximum encoder speed doesn't exceed the maximum input frequency of the device the encoder is driving. Image credit: Encoder Products Company Resolution is one of the most important indicators of an encoder's performance. For incremental encoders, resolution is typically specified in pulses per revolution (PPR), or, in the case of linear encoders, pulses per inch (PPI) or pulses per millimeter (PPM). These square-wave pulses are very precisely spaced, and the encoder determines its position by counting the number of pulses generated during a movement. The resolution of a linear encoder can also be specified in terms of microns, which refers to the distance between pulses. When an incremental encoder outputs just one set of pulses, only position can be determined – not direction. This is why most incremental encoders use quadrature encoding, which produces two sets, or channels, of pulses – A and B – that are out of phase from each other by 90 degrees (hence the term "quadrature"). With two sets of pulses, the encoder can determine both position and direction, based on which channel is leading and which is trailing. And, with quadrature output, any one of three types of encoding can be employed: X1, X2, or X4. X1 encoding counts either the rising or falling edge of channel A. X2 encoding counts both the rising and falling edges of channel A are counted. And with twice the edges counted, the encoder's resolution is doubled. So a 1000 PPR encoder that uses X2 encoding has a resolution of 2000 PPR. X4 encoding counts both the rising and falling edges of both channels A and B. This provides a four-fold increase in resolution, since now, four edges are counted. With X4 encoding, both the rising and falling edges of channels A and B are counted.Image credit: National Instruments Corporation When a rotary encoder is used to measure linear distance, the required encoder resolution (PPR) can be found by dividing the lead of the screw or pulley (distance traveled per revolution) by the linear resolution required by the application. For example, if the required linear resolution is 10 microns (0.01 mm), and a screw with a 25 mm lead is used, the encoder resolution should be 2500 PPR (or higher). If the encoder uses X2 or X4 encoding, the encoder's required PPR should be divided by a factor of 2 or 4, respectively. For example, if the application calls for an encoder that has a resolution of 2500 PPR, but X4 encoding is being used, then the encoder's actual resolution only needs to be 625 PPR (2500 ÷ 4). Once the encoder's resolution has been determined, its maximum speed – both mechanical and electrical – needs to be considered. The mechanical speed is limited by the potential for physical damage to the encoder, whereas the electrical speed is limited by its frequency response, which is the maximum speed at which the encoder's electronics can switch between "on" and "off." Mechanical speed is specified in rotations per minute (rpm), but the electrical speed is determined by dividing the frequency response, which is specified in Hz or kHz, by the encoder's resolution. For example, if a 2500 PPR encoder has a maximum mechanical speed of 3000 rpm, a frequency response of 100 kHz, and is used with X1 encoding, its maximum electrical speed will be 2400 rpm. In this case, the maximum electrical speed (2400 rpm) is less than the maximum mechanical speed (3000 rpm), so electrical speed is the limiting factor. Again, if X2 or X4 encoding is used, it must be factored into the maximum electrical speed, by multiplying the encoder's stated PPR by 2 or 4, respectively. In the example above, if X2 encoding is used, then the PPR will be 5000, and the maximum electrical speed will drop to 1200 rpm. This is an important step when determining maximum electrical speed, because the encoder electronics must be able to switch fast enough to keep up with the encoder's output. When choosing an encoder for motion applications, a few specifications immediately come to mind. What sensing technology should you use? What accuracy and resolution do you need? Does the application require incremental or absolute position feedback? But one specification that is sometimes overlooked during sizing and selection is the maximum encoder speed. Like any electrical component, delays in switching and processing time limit the speed at which an encoder can operate. This limitation in speed due to internal electronics is referred to as the encoder's maximum electrical speed, and applies to both linear and rotary encoders with either magnetic or optical sensing technologies. As an encoder moves — rotationally or linearly — internal electronics switch on-and-off in response to changes in light (for optical types) or magnetism (for magnetic types). This electronic switching produces a digital signal (or a binary word, for absolute encoders) indicating the encoder's position. The maximum speed at which its electronics can change state (from "on" to "off" or vice-versa) is known as the encoder's frequency response. The maximum electrical speed is directly proportional to the encoder's frequency response and inversely proportional to the encoder's pulses per revolution (PPR) for rotary encoders, or pulses per distance (typically pulses per millimeter, PPM) for linear designs. In addition to the maximum electrical speed, rotary encoders are also limited by a maximum mechanical speed. The maximum mechanical speed primarily depends on the speed capability and lifetime of the bearings that support the encoder as it rotates. Exceeding the encoder's maximum mechanical speed (specified by the manufacturer) can result in physical damage to the encoder or a shortened service life. How to calculate maximum encoder speed For rotary encoders, the maximum rotational speed is determined by dividing the encoder's maximum frequency response by its pulses per revolution (PPR). For linear encoders, the maximum linear speed is determined by dividing the frequency response by the number of pulses per distance (typically PPM). How quadrature encoding affects encoder speed To improve resolution, incremental encoders often produce two signals in quadrature and count both the rising and falling edges of one signal — known as X2 encoding — or the rising and falling edges of both signals — known as X4 encoding. It's important to remember that when X2 or X4 encoding is used, the encoder's pulses per revolution (or per distance) must be multiplied by either "2" or "4" accordingly, since the electronics will have to switch two or four times as quickly. You can see from the equations above that although increasing the pulses per revolution (or per millimeter) improves resolution, it reduces the encoder's maximum speed. X2 and X4 encoding can increase encoder resolution by a factor of 2 or 4, respectively. But increasing resolution decreases the maximum encoder speed.Image credit: Danaher Regardless of the resolution, sensing technology, output type, or encoder design, if the encoder's maximum electrical speed is lower than the speed required by the application, an encoder with a higher frequency response will need to be selected. Feature image credit: Renishaw plc April 27, 2014. I have interfaced a 200 line count QR145 optical encoder to a DL06 PLC. 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