ROTATING SPEED MEASUREMENTS WITH THE DT9836

Quadrature encoders are used in a wide range of applications relating to rotating objects. They are used for positioning purposes and also to measure the rotating speed of an object. For many applications, not only the position and the rotating speed of a device is of interest but physical and electrical data has to be acquired along with the rotating object. The Data Translation DT9836 combines the ability to synchronously and simultaneously measure position, high accuracy rotating speed, and analog/digital signals with one data acquisition device connected through USB to the controlling PC.

QUADRATURE DECODER SIGNALS

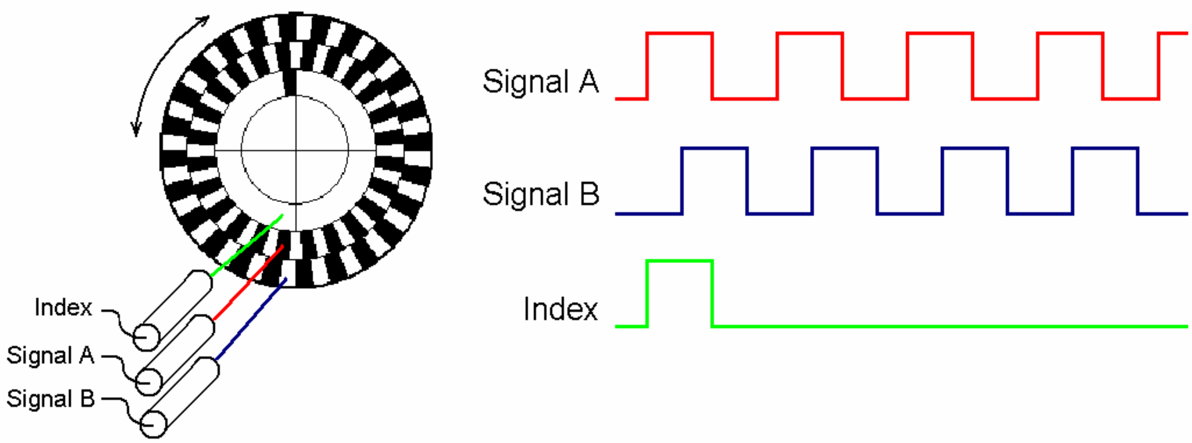


FIGURE 1. TYPICAL SIGNALS PRODUCED BY A QUADRATURE ENCODER.

Figure 1 gives an example of typical signals that are produced by a quadrature decoder. Specifically, the circular movement is detected over the rotation of a code disk. The code is detected by optical sensors which create two square waves that are 90° out of phase. Given the two signals and the two phases there are four signals from this encoder (hence the Quad designation).

The index signal is not necessarily needed for quadrature encoding. It supplies a single pulse per revolution, which is used for precise determination of a reference position and to count revolutions. This increases the overall accuracy of the encoder. This signal is usually used as a synchronization position so that the absolute position of the rotating unit is known.

POSITIONING

By counting the pulses of signal A and signal B, it is possible to get the exact position of the rotating device. The precision of this measurement depends on the resolution, meaning the number of pulses per revolution of the quadrature encoder.

From the phase relation, the direction of the movement can be detected. If signal A leads signal B, e.g. the rotation is clockwise, if signal B leads signal A, it is counter clockwise.

For positioning purposes, the DT9836 has a quadrature decoder input. You can select whether your encoder has an index output, or is using the X4 or X1 mode. The values of the quadrature decoder can be read out, either by a single value command or continuously with hardware sample clock speed.

If the index input is used and a rising edge on this input is detected, the counter values are reset to zero.

ROTATING SPEED MEASUREMENT

The pulses of a quadrature encoder also contain time information (signal frequency) and distance information (by the step width). The rotating speed can be calculated from these.

The step width which a pulse of signal A or signal B represents is dependent upon the encoder resolution. The formula to calculate this is:

$$\textit{rotation}/\textit{pulse} = \textit{step width} = \frac{360°}{\textit{resolution}}$$

where resolution is the full number of pulses generated by the encoder for one complete rotation of 360 degrees.

The time component can be measured in two different ways. The easier, but less precise method, is to perform a frequency measurement. The number of pulses are counted for a defined time period and from this the frequency is calculated. The problem is that the result is only an average value over many pulses. This method is slow and does not work if the unit under test is rotating slowly.

The more precise method is to measure the duration of every single pulse from the encoder. This can easily be done by an edge-to-edge measurement with the counter inputs of the DT9836 module.

EDGE-TO-EDGE MEASUREMENT

The figure below shows a detailed graph of the time relations between the pulse signal and the function of the edge-to-edge measurement. Since signal A and signal B have only a difference in the phase it doesn't matter which one is analyzed.

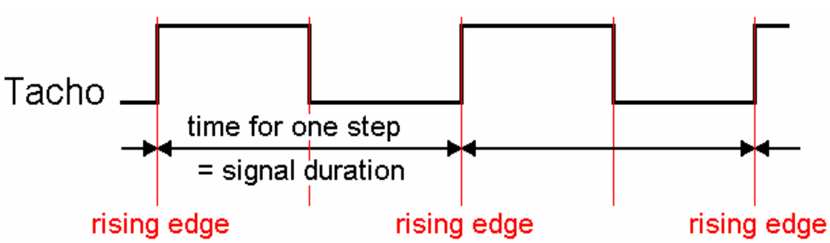


FIGURE 2. A DETAILED GRAPH OF THE TIME RELATIONS AND THE PULSE SIGNAL AND THE FUNCTION OF THE EDGE-TO-EDGE MEASUREMENT.

It is important to measure the full signal duration from rising edge to rising edge, since this gives the time value for a full step of the quadrature encoder.

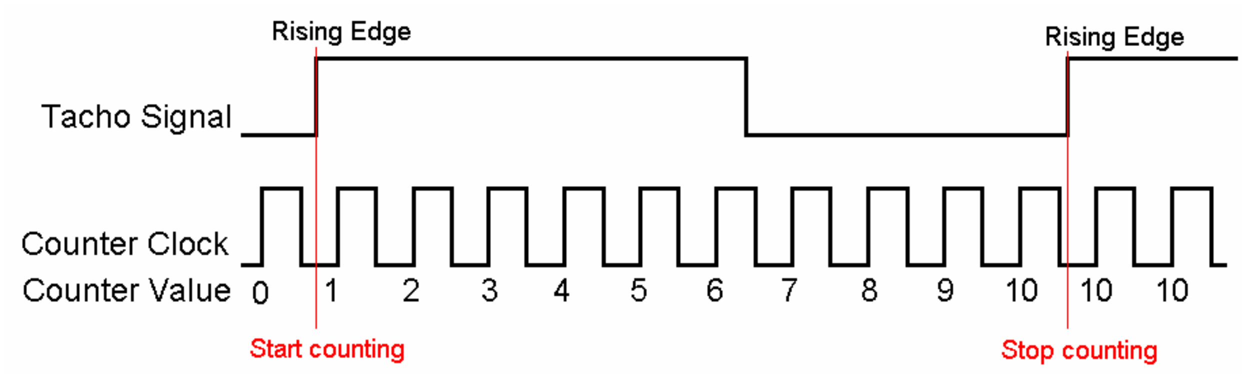


FIGURE 3. THE PRINCIPLE OF OPERATION OF THE EDGE TO EDGE MEASUREMENT.

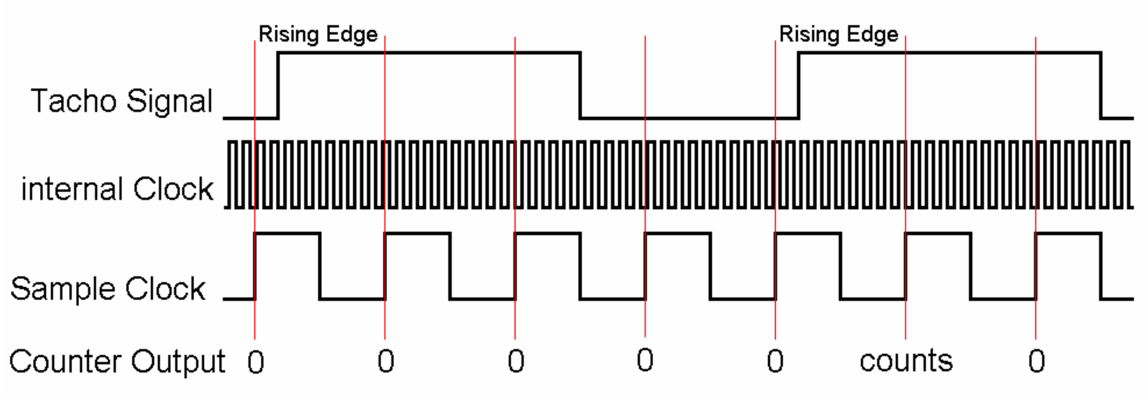
The clock source for the counter/timer unit is set to the internal clock. Depending on whether the signal to be measured is connected to the gate or the clock input, the start and stop edge have to be defined. It is also possible to measure from rising edge to falling edge.

The measurement starts when the start edge is detected. The counter is now counting the ticks from the internal clock source. For the DT9836, this is an oscillator with 36MHz which makes it possible to measure high speed signals very accurately. When the stop edge is detected, the counter stops counting.

There are two ways to read out the values: single value and continuous. For a single value edge to edge measurement, the counter is started and read out by software commands. Even after readout, the counter keeps the value until a new measurement is initiated. This method is shown in Figure 3. Only one pulse is measured with this method.

If the edge-to-edge measurement if performed continuously, the counter value is given out with the next continuous read command. Internally, the counter is reset and starts counting immediately again after one edge-to-edge measure mode was completed. With this method every period is measured. The reading of the Counter/Timer unit can be done with the sample clock speed of the data acquisition system.

This behavior is displayed below:



It is important to know that the counter value is just given once on the output for further processing.

Since the internal frequency of the Counter/Timer unit is known, the duration of the pulse can be calculated with the number of counts the following way:

$$duration = \frac{number\ of\ counts}{counter\ frequency} = \frac{number\ of\ counts}{36MHz}$$

With this time factor it is no problem anymore to obtain the rotating speed.

$$\varpi = \frac{step\ width}{duration} = \frac{360° \cdot 36MHz}{resolution \cdot counts} \left[s^{-1} \right]$$

SYNCHRONOUS AND SIMULTANEOUS SUBSYSTEM OPERATION

With the DT9836 it is possible to read out the Counter/Timer units, the quadrature decoders, the analog input and the digital input channels simultaneously and continuously in high speed mode. This leads to a direct time correlation between analog signals, digital data and counter/timer values. For every position, an exact rotating speed value can be acquired together with analog signals and digital states. The DT9836 has 3 quadrature decoders and two counter/timer units. Therefore, it is possible to get rotating speed measurements and positioning on two devices and acquire analog data over 12 channels with 16-bit resolution. All of this is synchronized and simultaneous with a maximum speed of the 225kHz sample clock.

THE DT9836 SERIES OFFERS UP TO 12 SIMULTANEOUS ANALOG INPUTS, 2 ANALOG OUTPUTS, 32 DIGITAL I/O LINES, 2 COUNTER/TIMERS, AND 3 QUADRATURE DECODERS. ALL DATA CAN BE STREAMED SYNCHRONOUSLY TO HOST MEMORY.