
Closed Loop Techniques Using a Quadrature Shaft Encoder

Submitted by:

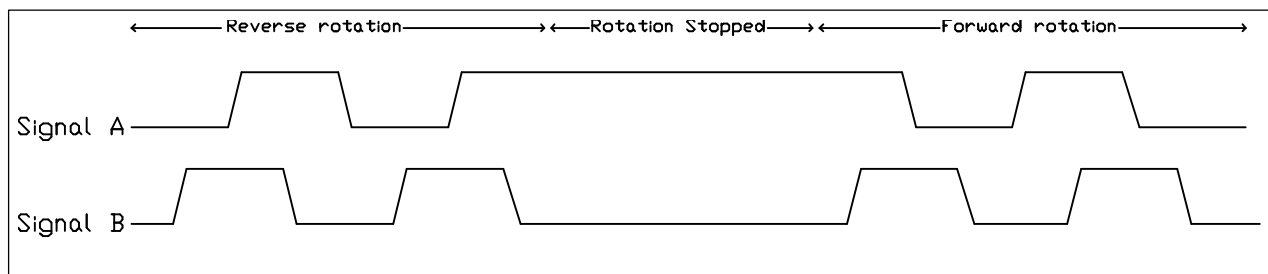
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This example is taken from the "examples" chapter of the Development Kit Manual.

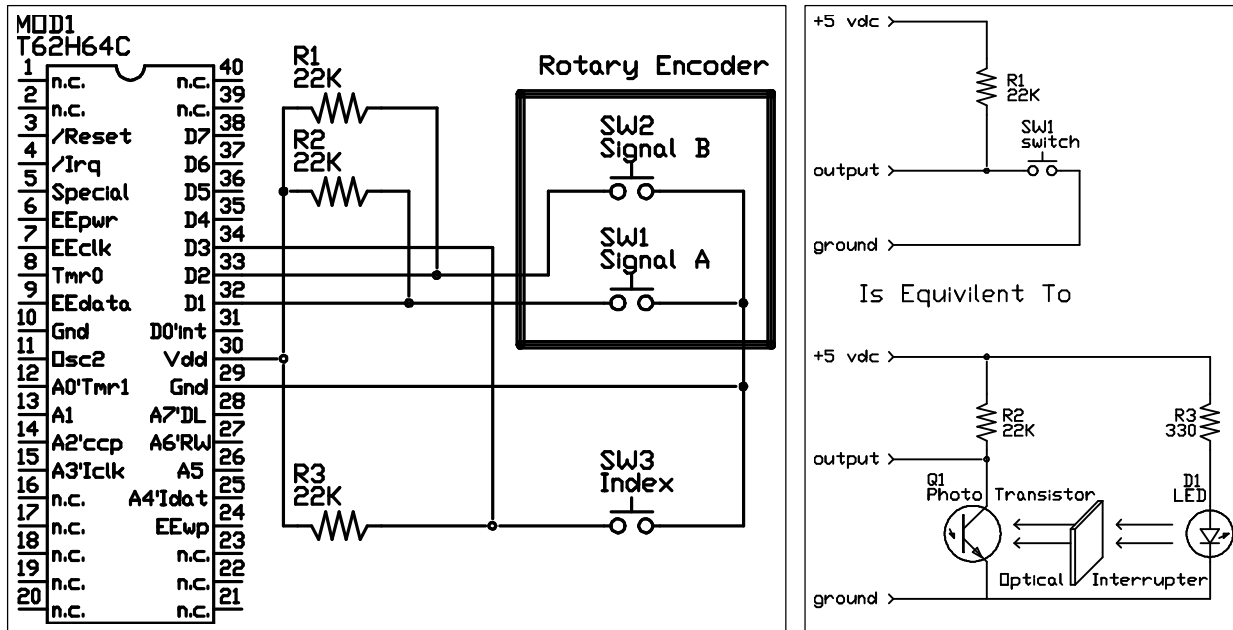
Most control systems, especially those dealing with mechanical control, use a feedback system to see if the desired positioning has indeed taken place. When an action is double checked by a sensor and corrective action is taken the control mechanism is called "closed loop". This is similar to sending a registered letter through the mail with a return receipt requested. You can be sure your letter was indeed delivered. Ordinary mail is "open loop" and you rely on the integrity of the postal system to get your mail delivered, and you tolerate some lost mail.

In the next example a quadrature encoding sensor is used with an index sensor to locate the absolute position of a rotating shaft. Although we won't put all the electronics for driving the motor in the schematic, these additional components could easily be incorporated with a motor driving circuit like those talked about earlier.

First, what is a quadrature encoding sensor. An encoding sensor is a collection of switches, either mechanical, optical, or magnetic that indicate the angular position of a shaft. These types of encoders usually have between 16 and 512 positions per revolution. Some encoders produce an absolute binary or Gray's coded position output. The one used in this example is a relative position sensor that produces a quadrature output. The output waveforms look as shown below. When the sensor rotates in one way, signal A's phase leads signal B's, when the sensor rotates the other way, signal B's phase leads signal A's. The sensor electronics need to watch these two signals to increment or decrement a counter. We assume the motor and mechanical inertia of the system prevent the signals from changing too fast. This is a reasonable assumption when the motor's output shaft is geared down. If there are more than 20 phases per second per signal, dedicated electronics are needed to count the position.



Earlier we said the quadrature encoder gives relative position. By this we mean an additional signal, called an "index", is required in the system to reset the position count in the controller. When power is first applied to the system, the controller must turn the motor on in the direction toward the index mark. When the index signal switches, the controller must reset the counter. After this step, the controller has the absolute position of the system mechanics.



The diagrams show an encoder circuit and how an optical index is created. The LED is continuously lit and an optical interrupting fixture is connected to the rotating shaft so that only one position interrupts the beam. When the interrupting is not in place, the light turns on the photo transistor. Because the resistance of the transistor when turned on is so much lower than the 22K pull-up resistor, the output is very nearly at ground level. When the optical interruption blocks the light from the LED, the transistor turns off and has a high resistance relative to the 22K resistor. The output then is very nearly +5 vdc.

The following program fragment for the circuit follows. Notice that this is not a complete program and needs to be integrated into a positioning program, like the ones previously shown, to be a complete servo system.

```

GLOBAL word shaft_pos    ; absolute shaft position
GLOBAL byte prev_sigb   ; previous signal B

FUNC none position_count LOCAL byte cur_sigs
BEGIN
  =( cur_sigs, dport_get() ) ; read all 8 pins of D port
  IF ==( prev_sigb, b_and( cur_sigs, 0y00000100b ) )
    ; no change to count
  ELSE
    IF prev_sigb
      IF b_and( cur_sigs, 0y00000010b )
        --( shaft_pos )
      ELSE
        ++( shaft_pos )
      ENDIF
    ELSE
      IF b_and( cur_sigs, 0y00000010b )
        ++( shaft_pos )
      ELSE
        --( shaft_pos )
      ENDIF
    ENDIF
  ENDIF
ENDIF

```

```
=( prev_sigb, b_and( cur_sigs, 0y00000100b ) )  
ENDFUN
```

This concludes our discussion on electro-mechanical control. Many other options exist in this arena from driving solenoids, to driving stepper motors, to using self contained servo mechanisms like RC servos. Check the release disk and the Protean Logic Inc. web site for sample programs and applications notes. If you are interested in building some of the circuits talked about in this section, Digi-key Corporation and Jameco Electronics are sources for all parts mentioned in these circuits. You can find their contact information at the Protean Logic Inc. web site.

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