Overview

An encoder is a rotary device that outputs digital pulses in response to incremental angular motion. Encoders have many uses in positioning applications. For example, a rotary encoder attached to a DC motor can be used to keep track of the number of revolutions the motor has rotated from its initial position.

One of the simplest applications of rotary encoders is the mechanical computer mouse. A mechanical mouse has 2 rotary encoders: One for X position and one for Y position. As the mouse moves, each encoder outputs square wave pulses. The number of pulses indicate how far the mouse has moved in X or Y direction.

Encoders are also used in Computer Numerical Control (CNC) systems to accurately position the X-Y table.

Theory of Operation

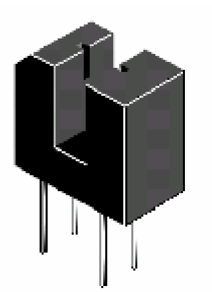
A rotary encoder typically has 2 outputs. These outputs emit signals that are 90 degrees out of phase with respect to each other. The output signals may be square wave or sine wave. Sine wave outputs are typically used in higher resolution encoder applications. For simplicity, we will talk about square wave output encoders in this application note.

Here is a typical rotary encoder:

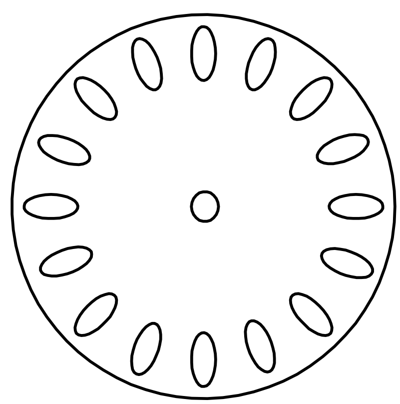
Although this looks like a potentiometer, it has infinite rotation. You can turn it in either direction without hitting an end point.

Inside, the encoder, there is typically a slotted disc and 2 optical interrupters.

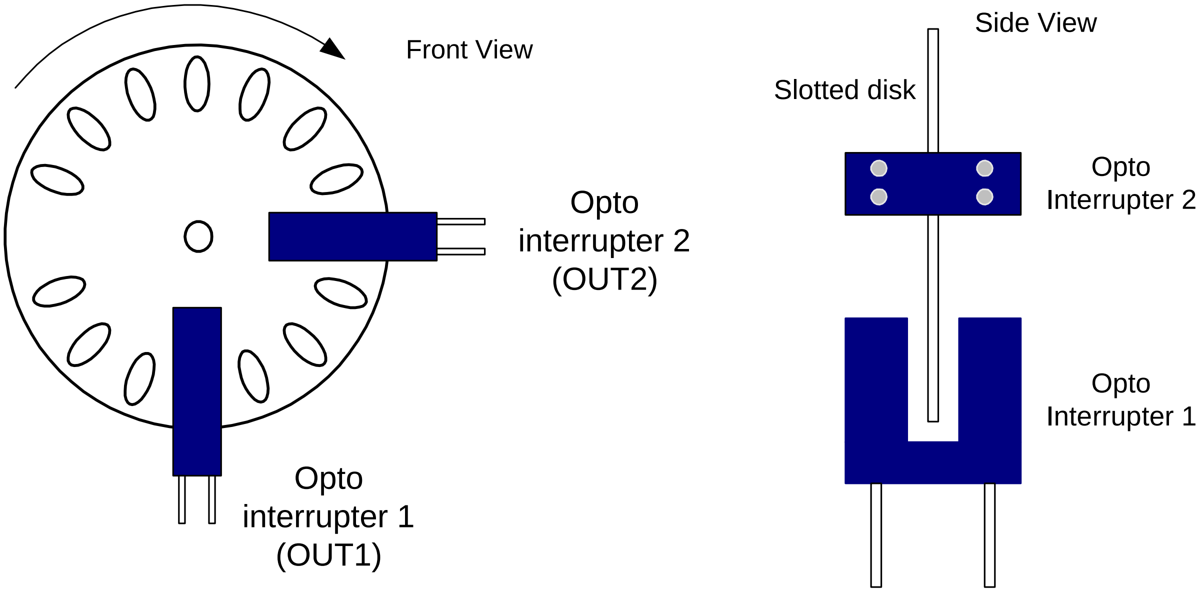
Here is a typical optical interrupter:

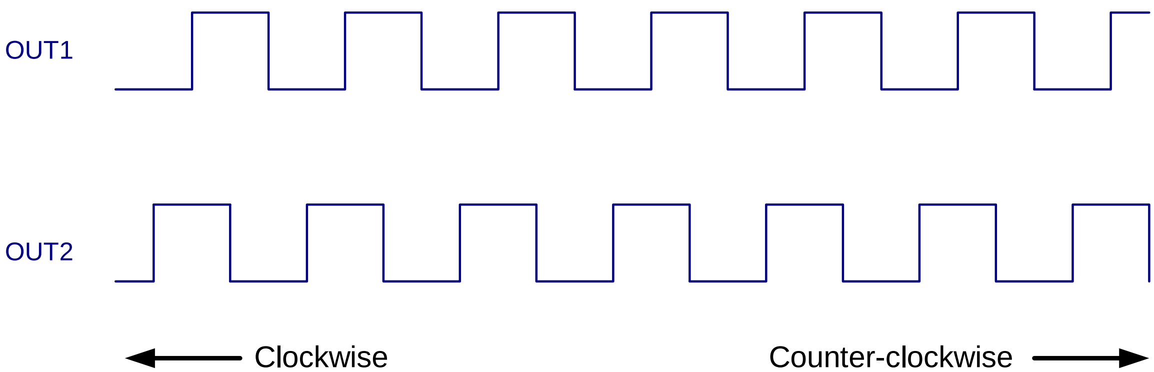


Here is a slotted disc:



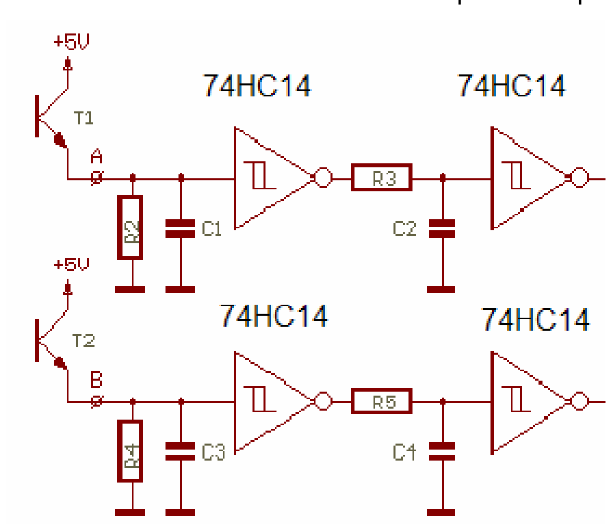
Two opto interrupters are mounted on the slotted disk. As the slotted disk turns, the light beam between the LED and the phototransistor of the opto interrupters are connected and disconnected. This results in a pulse outputs from each of the opto interrupters:





OUT1 and OUT2 are 90 degrees out of phase. Let's define OUT 1 as our direction. If OUT 1 is high when a pulse starts on OUT 2, then the rotary encoder is going clockwise. If OUT 1 is low when a pulse starts on OUT 2, then the encoder is going counter-clockwise. This way, the rotary encoder also tells us the direction of motion.

The square wave output from a rotary encoder is typically passed through a Schmitt Trigger circuit that filters out unwanted noise and chatter from the opto interrupters:



Installation

Figure 1 below shows a typical encoder with an interface board. Interface board has the 74HC14 Schmitt Trigger circuit to clean and shape the pulse output from the photo interrupters in the encoder.

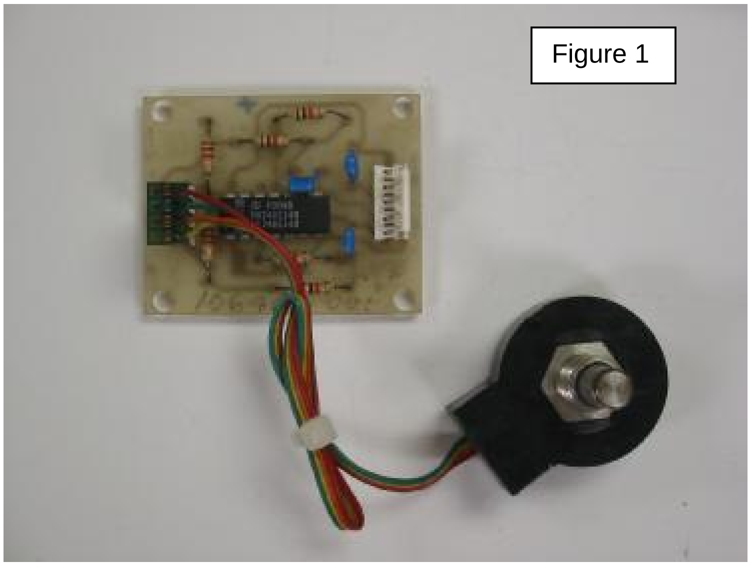


Figure 1

Figure 2 shows the pinout of the Encoder Interface board:

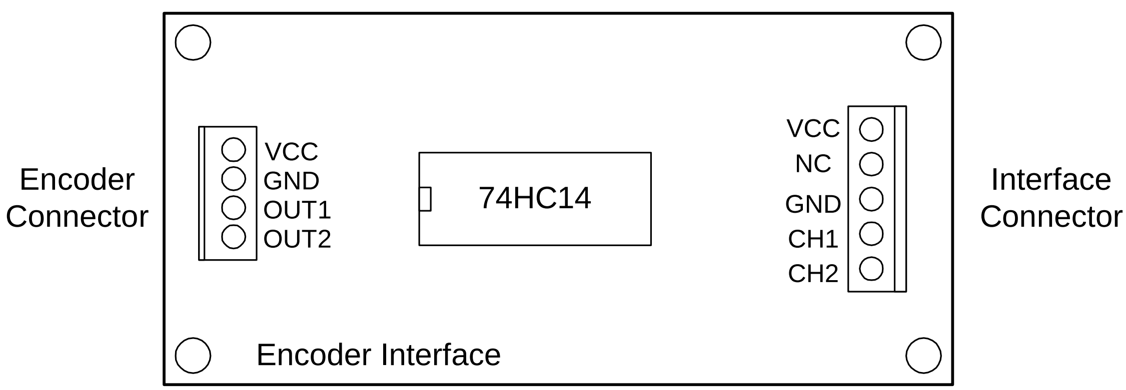


Figure 2

Figure 3 shows how everything is connected together. In this application, we use a Vacuum Fluroscent Display (VFD) with a green filter. TB-1 Training board is plugged on top of the MINI-MAX/51-C2 microcontroller board. TB-1 has terminal blocks which allow easier access to microcontroller interrupt inputs. Alternatively, connections from the encoder interface board can be made directly to the MINI-MAX/51-C2, eliminating the need for TB-1.

As the encoder is rotated, the display shows the displacement. In this example, we assume that each pulse from the encoder corresponds to 0.05 mm of linear motion. This can be modified as needed to suit any machine or application.

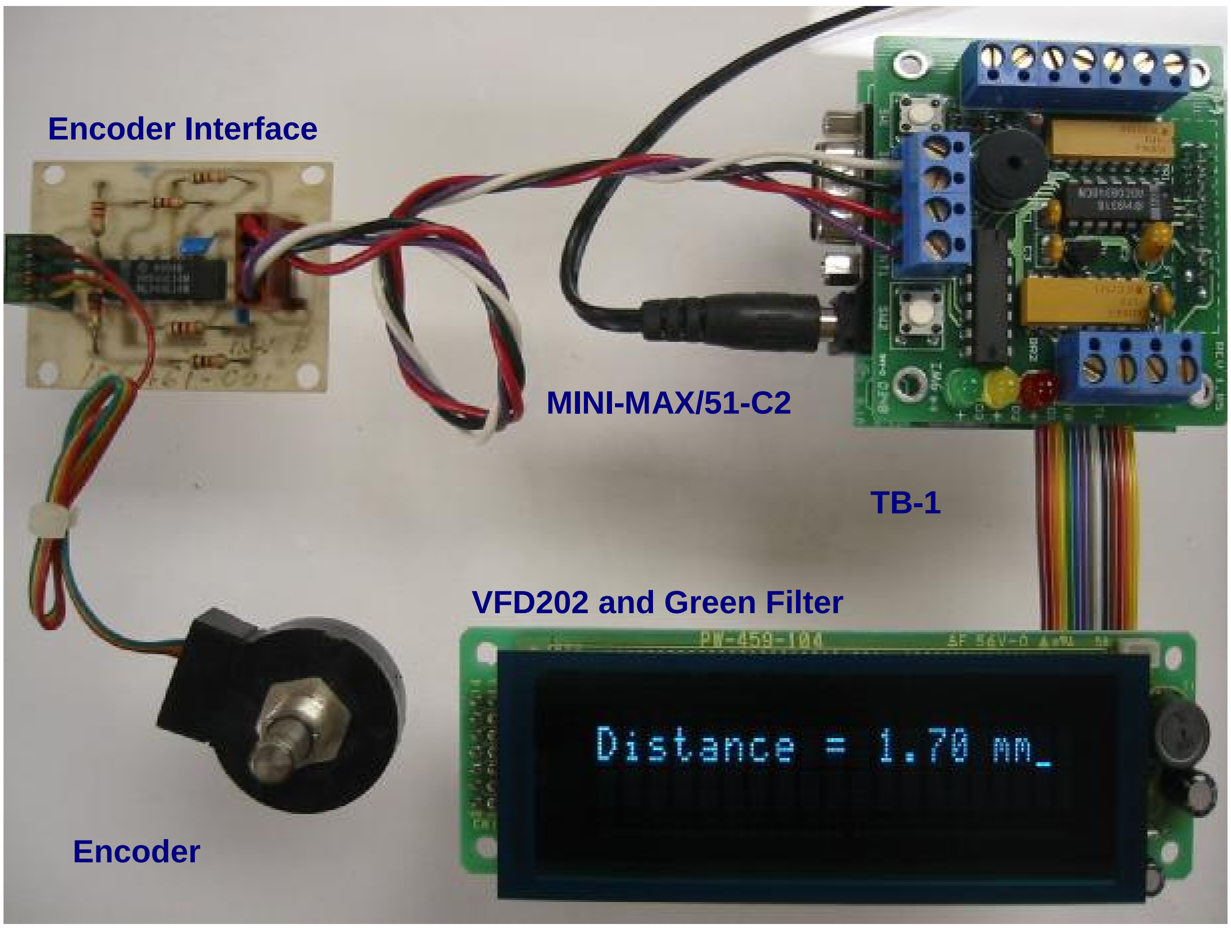


Figure 3

Parts List

MINI-MAX/51-C2 – 8051-based Microcontroller Board
TB-1 - Training Board (Optional, you can use TERMINAL-1 or direct connection to MINI-MAX/51-C2)
VFD202 – Vacuum Fluorescent Display, 20 X 2
GRN202 – Green Filter for the VFD
Encoder – Rotary Encoder
Encoder Interface Board – 74HC14 based rotary encoder interface board

Software

The complete rotary encoder example is part of our BASCOM51 programming package (available in version 2.16h and higher). It is under bascom51\examples\encoder folder. Or you can download directly here: http://www.bipom.com/applications/encoder/encoder.zip

Please download the latest BASCOM51 package from http://www.bipom.com/bascom51.shtm

The encoder example program counts the pulses from a rotary encoder on ports P3.2 and P3.3. Each pulse on P3.2 causes a hardware interrupt INT0. Depending on the level of the signal (high or low) on port P3.3 (Phase_B), the counter (count) is incremented or decremented. Resulting value of the current count is converted to a position value (mm_whole and mm_frac) and displayed on an LCD or VFD display that is connected to the MINI-MAX/51-C2 board.