Cool-Emerald

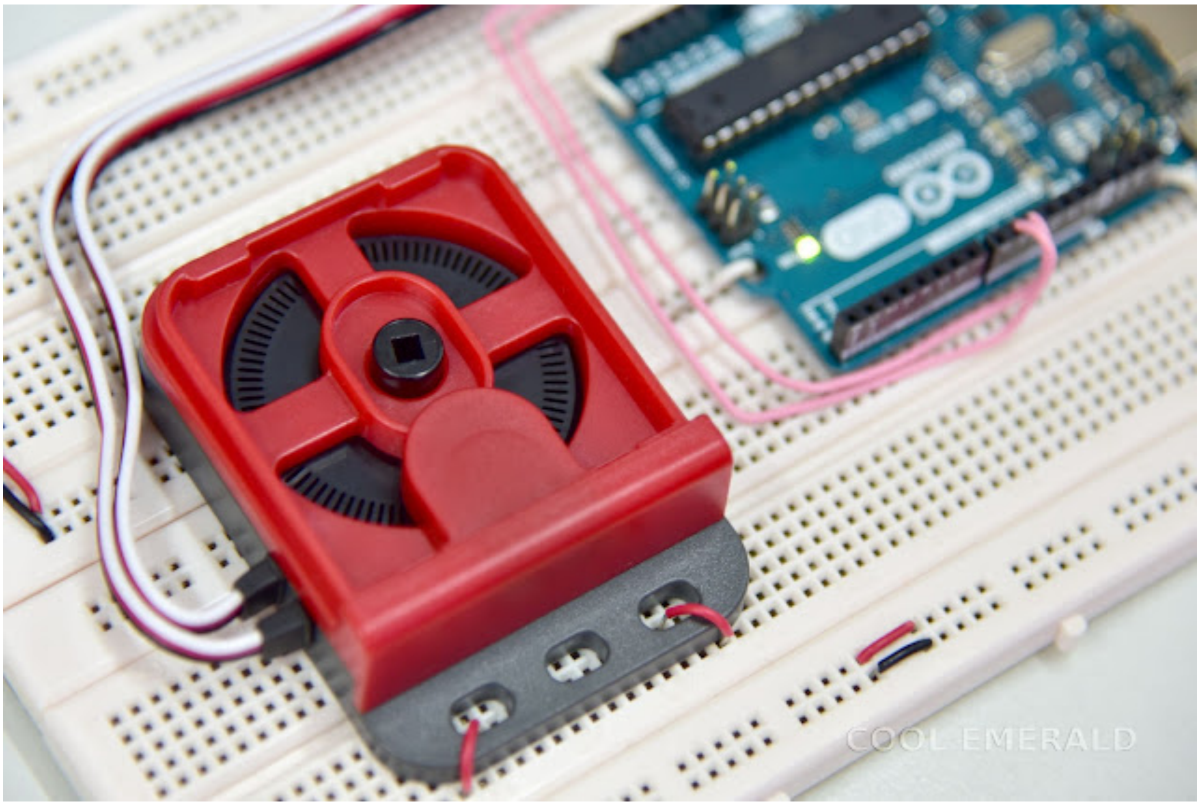
Our thoughts and memories...

Sasana Year 2566 , Myanmar Year 1384 , Tagu new moon, Friday , Sabbath.

Thursday, March 6, 2014

Reading Rotary Encoder Using Microcontroller

Rotary encoders are commonly used for measuring angular position or motion sensing. An optical encoder has a disc with a pattern of cutouts. As the disc rotated, an LED light that shines on photo detector is turned on and off accordingly to produce a digital waveform.



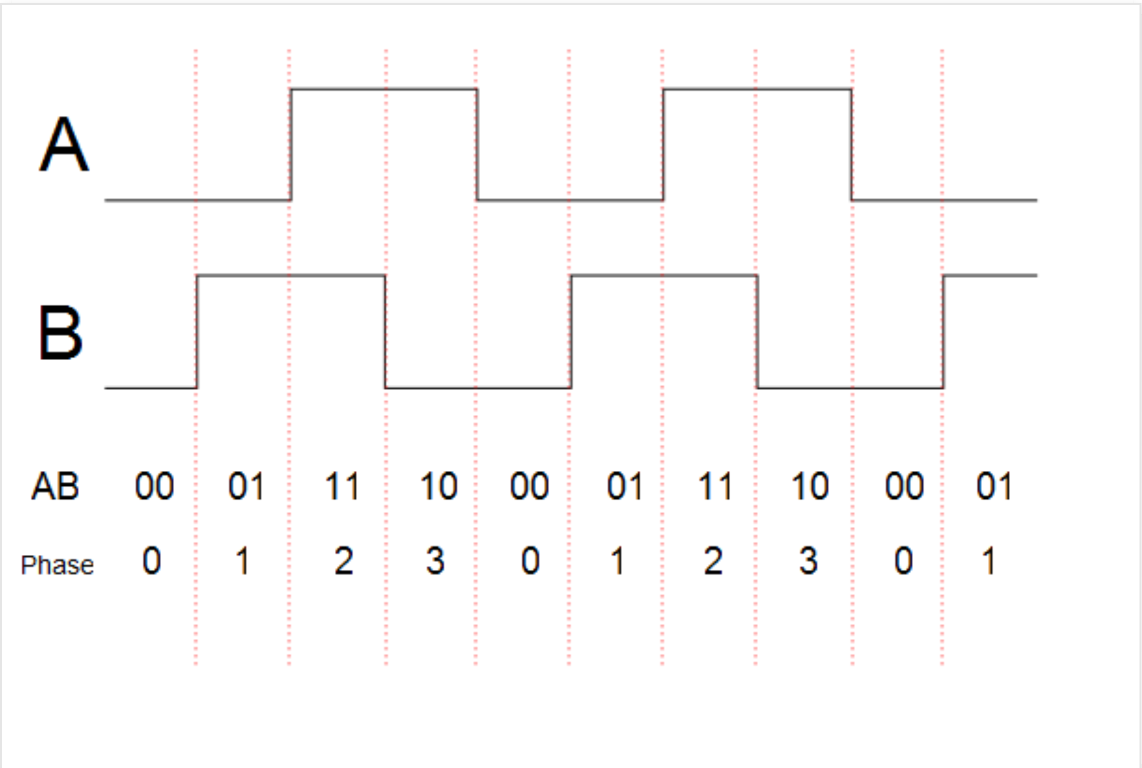
An optical encoder produced by VEX Robotics Design System

Gray code is normally used in encoders instead of ordinary binary code to prevent glitches. In Gray code, the number of changing bits between successive numbers is only 1. The following table shows 2 bit Gray code from 0 to 3.

Gray code

Number	2-bit Gray Code
0	00
1	01
2	11
3	10

Encoders typically have two outputs called A and B. When it is turned clockwise, the waveform as shown in the following figure is produced. Its phase increases from 0 to 3. When it is turned counter-clockwise, the output phases are produced in reverse order.



I have found several example programs in the Internet to read an encoder from a microcontroller. But I think, those programs are long and inefficient. The program presented here is simple, short and efficient. The resulting resolution of the program is 4 times the pulses per revolution of the encoder.

I use the state machine design. I define the output phases of the encoder 0, 1, 2 ,and 3 as states - s0, s1, s2, and s2 respectively. Then, the counting of the encoder states is shown in the following table.

Counting encoder states

Next state	Present state	Count
s0	s0	No change
s0	s1	Down
s0	s3	Up
s0	s2	Don't care
s1	s0	Up
s1	s1	No change
s1	s3	Don't care
s1	s2	Down
s3	s0	Down
s3	s1	Don't care
s3	s3	No change
s3	s2	Up
s2	s0	Don't care
s2	s1	Up
s2	s3	Down
s2	s2	No change

When the states are replaced by the corresponding binary bits, the following truth table is obtained.

Truth table

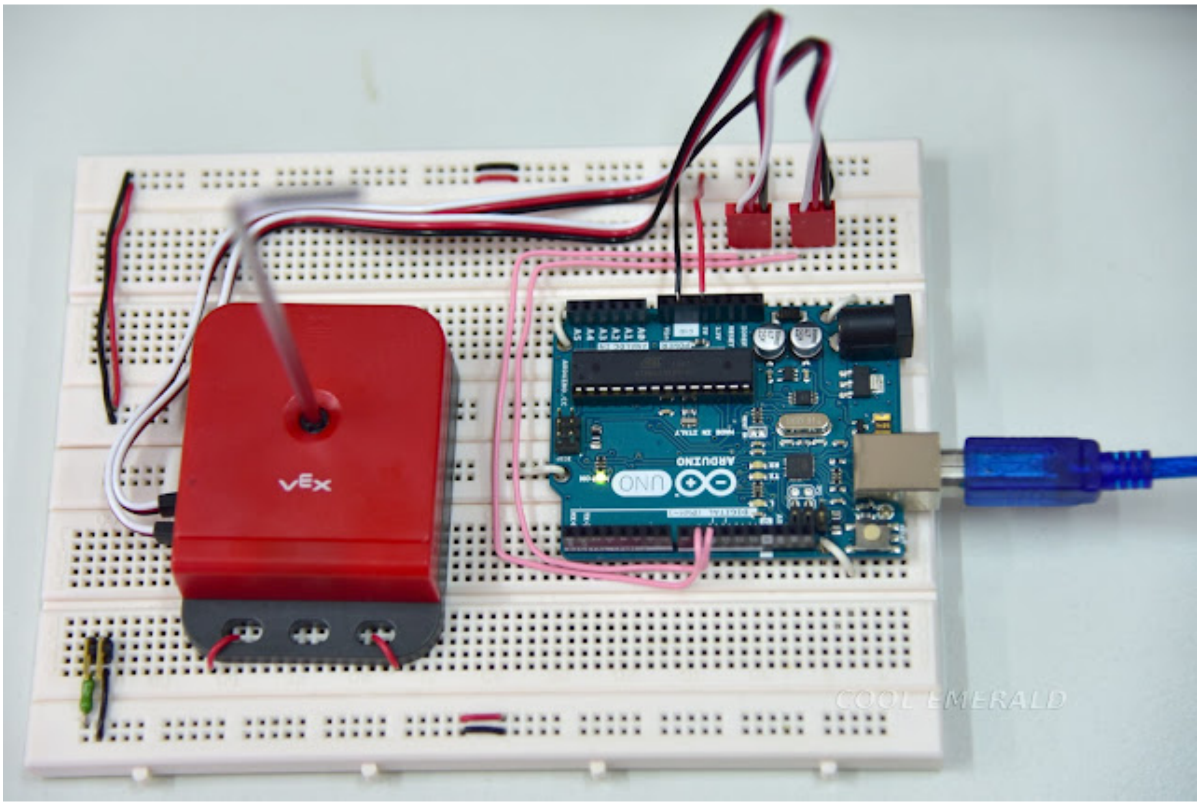
Decimal number	Next state - Present state	Up	Down
0	00 00	0	0
1	00 01	0	1
2	00 10	1	0
3	00 11	0	0
4	01 00	1	0
5	01 01	0	0
6	01 10	0	0
7	01 11	0	1
8	10 00	0	1
9	10 01	0	0
10	10 10	0	0
11	10 11	1	0

12	11 00	0	0
13	11 01	1	0
14	11 10	0	1
15	11 11	0	0

By considering next state and present state in the truth table as binary code, it is counting up at 2, 4, 11, and 13. Similarly, it is counting down at 1, 7,8, and 14. An array can be declared to represent the truth table as follows.

```
int En_TruthTable[] = {0,-1,1,0,1,0,0,-1,-1,0,0,1,0,1,-1,0};
```

Arduino UNO single board microcontroller and an optical shaft encoder from VEX Robotics Design System are used in this example.



In our circuit, pin 9 of the microcontroller is connected to channel A of the encoder and pin 10 is connected to channel B. The code to get the next state (NS) from the bitwise reading of channel A and channel B is shown below.

```
NS = (digitalRead(pinA)<<1) | digitalRead(pinB);
```

As we turn the shaft, the encoder produces a series of digital pulses and the microcontroller has to constantly check and update the position everytime the next state (NS) is different from the present state (PS). If c is a variable to keep track of the encoder position, its values should reach back to zero when the encoder has been turned a complete revolution. The number of state changes for one revolution (SPR) is four times the pulses per revolution (PPR) of the encoder (SPR = 4 . PPR) .

```
c=(c+En_TruthTable[(NS<<2)|PS]+SPR)%SPR;
```

The angle (a) that corresponds to c in degree ($0 \le a < 360$) is calculated as follows.

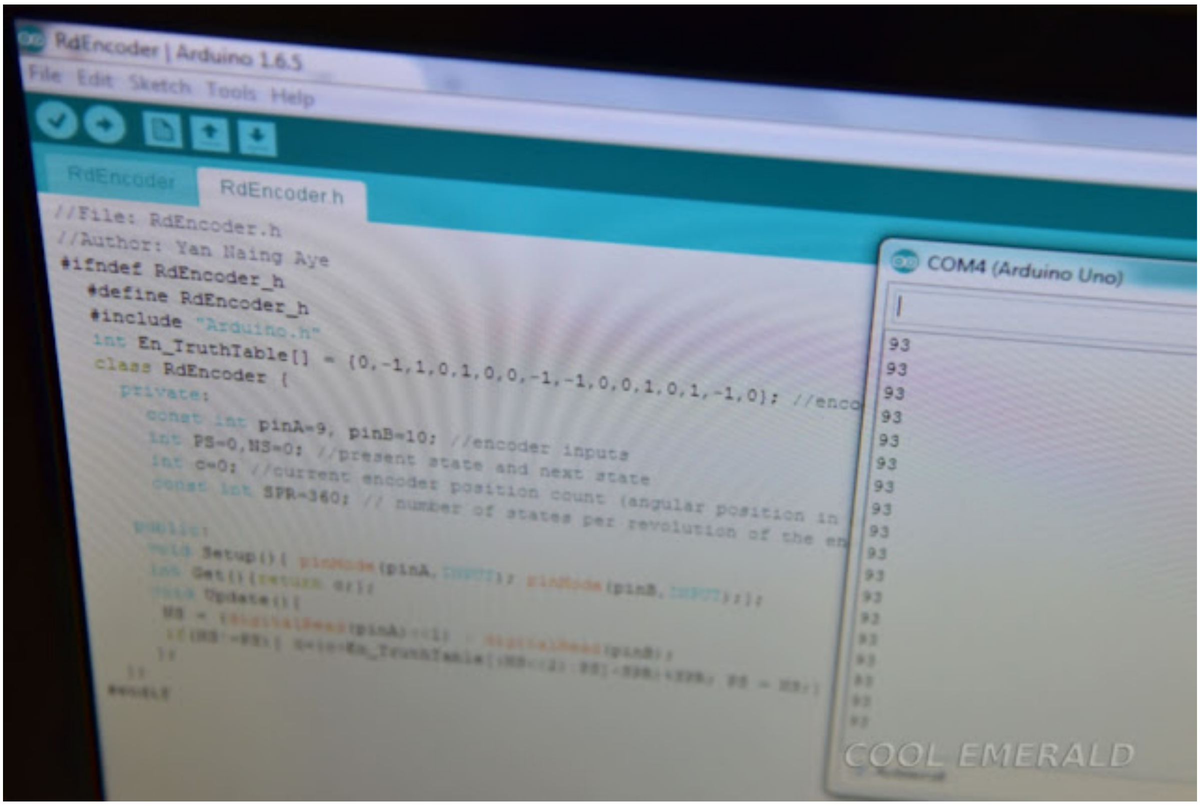
```
a =  c * 360.0  / SPR
```

Similarly, the angle (b) n degree ($-180 \le a < 180$) can be calculated from the angle (a).

```
b =  a - floor(a/180)*360.
```

An example program is available at Rotary Encoder using Arduino to get absolute value (on GitHub).

Arduino software (IDE) is available for free and I found it very easy to use. In my case, after I have chosen the correct board and correct COM port in the "Tools" menu, it worked without any problem.



Posted by Yan Naing Aye at Thursday, March 06, 2014

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