Mechatronics I Laboratory
Encoder Design

The purpose of this laboratory exercise is to build and test an encoder for angular position measurement.

Reference

Control Sensors and Actuators, Clarence W. deSilva, Prentice Hall, Inc.

Table 1: Gray code truth table

Sector Number	Gray code msb			lsb
0	0	0	0	0
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	1	0
5	0	1	1	1
6	0	1	0	1
7	0	1	0	0
8	1	1	0	0
9	1	1	0	1
10	1	1	1	1
11	1	1	1	0
12	1	0	1	0
13	1	0	1	1
14	1	0	0	1
15	1	0	0	0

Pre-Lab Report

1. Using your handout develop a disc for the gray-code for a 4-bit encoder (i.e. with four light detectors). You should take a piece of paper, draw and cut the encoder disc (about 6-inch diameter) and draw the segments. Shade appropriate segments in the gray scale (Table 2). For example, Figure1 below illustrates the disc needed for the binary scale (Table 1). Have the paper-disc ready for lab -- you will use it to construct your encoders.
2. What is the resolution of your encoder?
3. How would the disc for an incremental encoder differ?

* Figure 1 and Tables 1 & 2 are taken from Control Sensors and Actuators, Clarence W. deSilva.

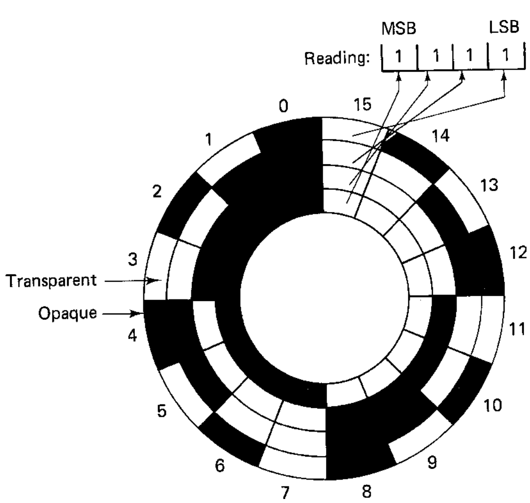
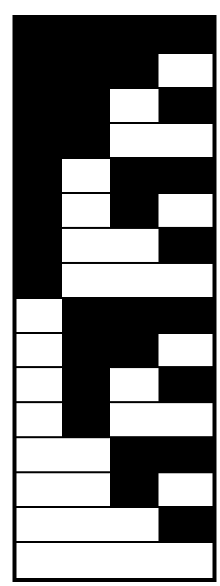


Figure 1: Binary code disc

Table 2: Binary truth table

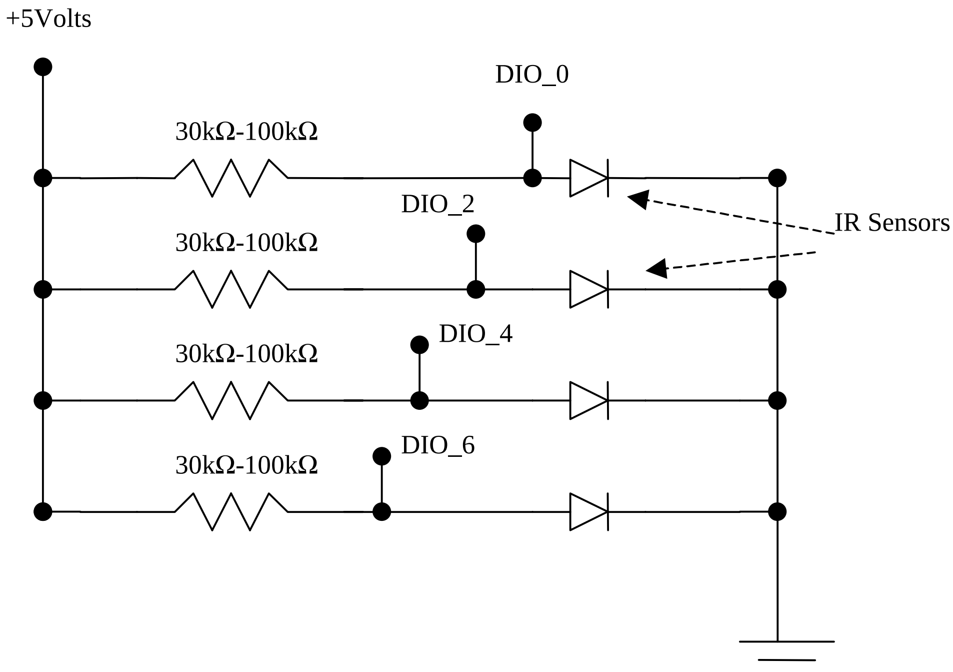
Sector Number	Binary code msb			lsb
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1



Laboratory Exercise

Equipment Needed: Foam cardboard, glue, sharp knife, IR light sensors, and IR light source

1. Construct your encoder using foam cardboard and IR light sensors. Use your pre-lab encoder design. Make sure the appropriate sections of the encoder are cut out. Interface the IR light sensors to the A/D board as shown in Figure 1 below.
2. Start CVI LabWindows and open the project "encoder.prj" from the "C:\CVI\PROGRAMS\LABS\ENCODER" directory. Connect the least significant IR sensor (Bit 0) of your encoder to **DIO_0** on the A/D board (see Figure 1). Connect the next significant sensor (Bit 1) to **DIO_2** of the A/D board and repeat until all four IR sensors of your encoder are connected to the A/D board. Expose your optical encoder to an IR light source and press the "READ" button on the user interface panel. Take note of the output from the CVI user interface. Rotate your encoder and take



another reading. What's happening? Is the output consistent with your encoder design? What is the resolution of your optical encoder? Make a truth table of the four-bit output versus binary number for your encoder. Is it consistent? Figure 1. Optical Encoder Circuit Diagram.

Gray Code to Binary Code Conversion

Given Gray Code: $g_3g_2g_1g_0$
Use the following formula to convert to binary: $b_3b_2b_1b_0$.

$b_3 = g_3$
$b_2 = b_3 \text{ XOR } g_2$
$b_1 = b_2 \text{ XOR } g_1$
$b_0 = b_1 \text{ XOR } g_0$

A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

Post-Lab Report

1. If you had an incremental encoder, how would you measure absolute position?
2. How would you measure velocity using an encoder?
3. Describe the formula for using the gray-code to measure angular position.
4. What is the advantage of using the gray-code rather than using the binary-code?