ROBOTICS II

Robotic Sensors
Incremental & Absolute Encoders

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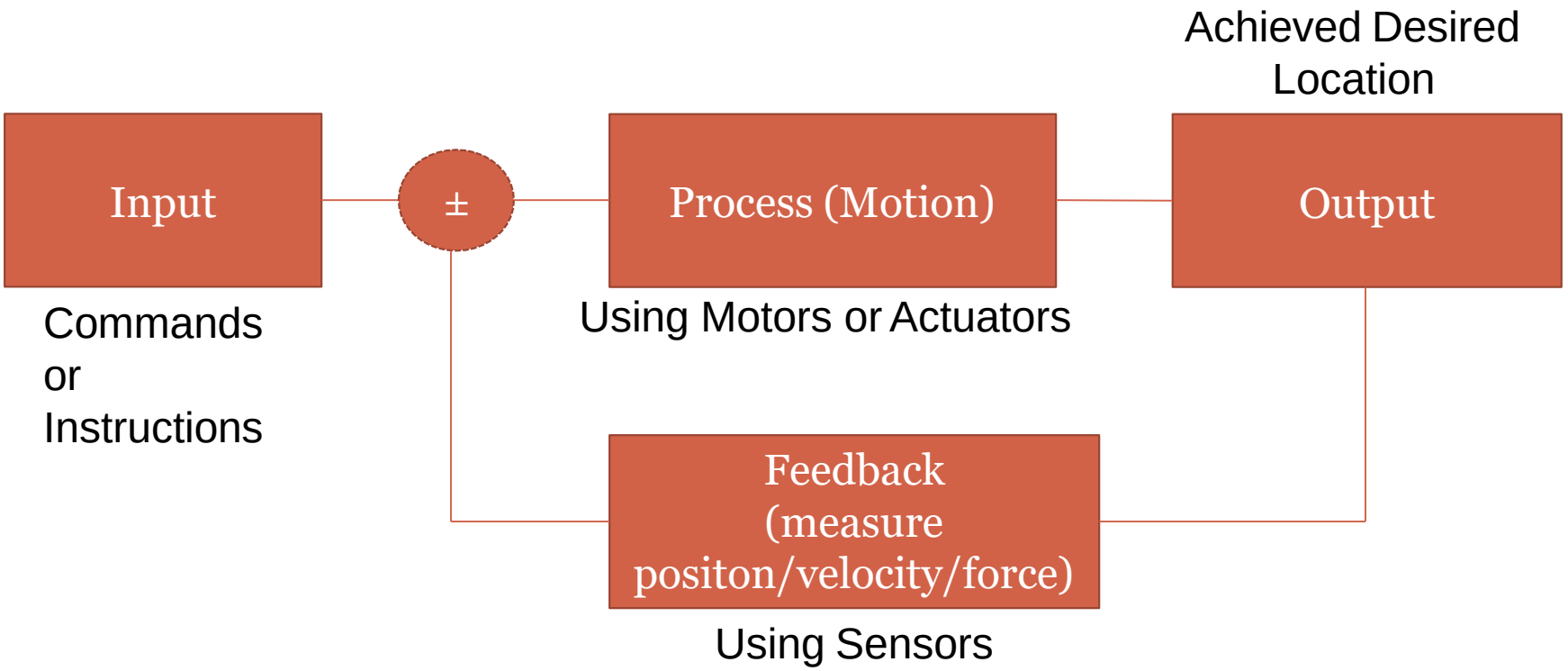
Robotic Control System



Importance of Sensors and Actuators

What is Robotic Sensor

Robotic sensors are used to detect the environment and measure the parameters for controlling the robotic manipulator such as distance, velocity, pressure, and force etc.

Focusing only position and velocity sensors

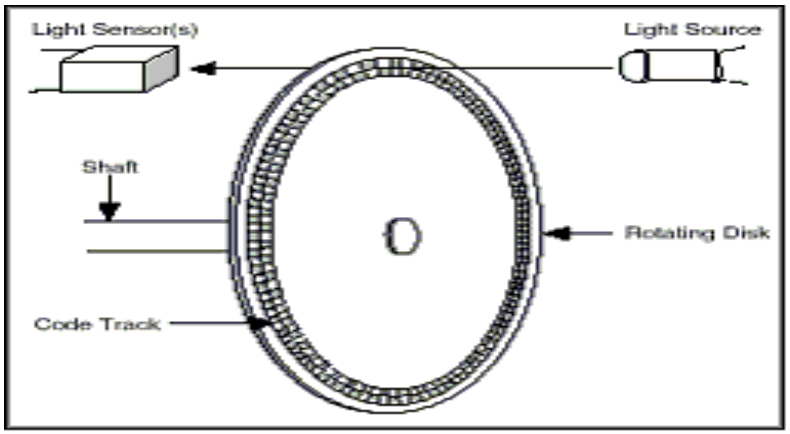
Applications of Sensors in Robotics

- To detect the object in work envelop
- Position and velocity of robotic joint and links
- Pressure and Force measurement in gripper to hold an object

Angular Position and Velocity Sensors

- Encoders
  - Incremental Encoders
  - Robotics I
  - Absolute Encoders
  - Robotics II

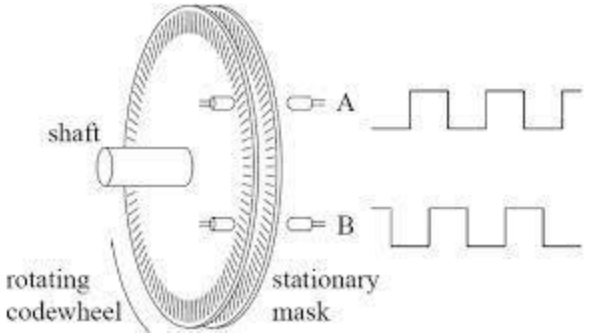
Incremental Encoders



Opaque disk with slits

$$S = \frac{Total\ no's\ \ of\ \ \ pulses\ in\ one\ \min}{number\ of\ slits}\ \ rpm$$

Resolution = 360 / number of slits



Quiz

Question 1

If an optical encoder has 12 slits and it gives 8 output pulse signals then determine the angular displacement of the joint where the encoder is attached. If you get 100 pulses in one minute then tell the speed of the joint (rpm: rev. per minute)

Number of slits = 12

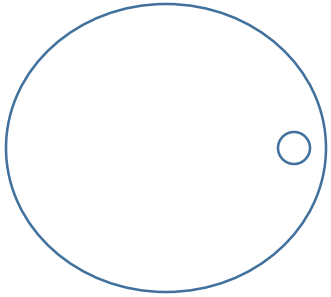
Number of output pulses = 8

Angular Displacement = ?

Resolution= minimum value of detection= 360/360 = 1 degree

One pulse = 30 deg.

8 pulses = 8x30 = 240 deg.



Speed=?

12 pulses = 1 rev

1 pulse = 1/12 rev

100 pulses = (1/12) x 100 rev/min = 100/12 = 8.33 rpm

Absolute Encoder

Consists of an optical disk (Glass disk) in which the number of tracks are produced Chemically

Resolution of encoder

$$Res = \frac{360^{\circ}}{2^{n}}$$

Res = 360 /2^8
Res = 360/256 = 1.4 deg.
=

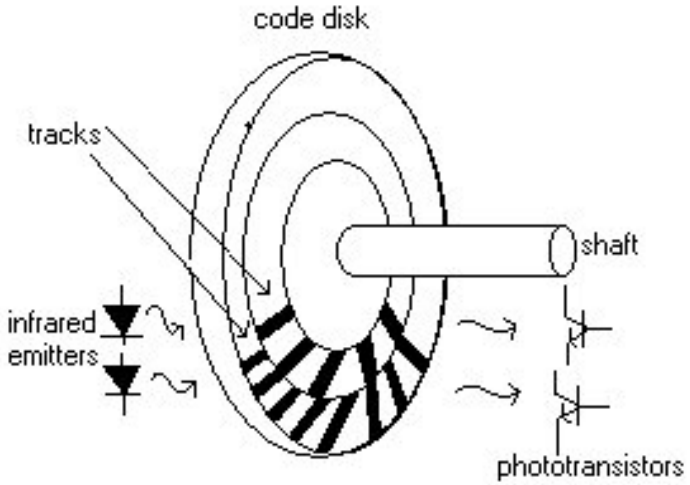


Fig 1. A rotary optical encoder

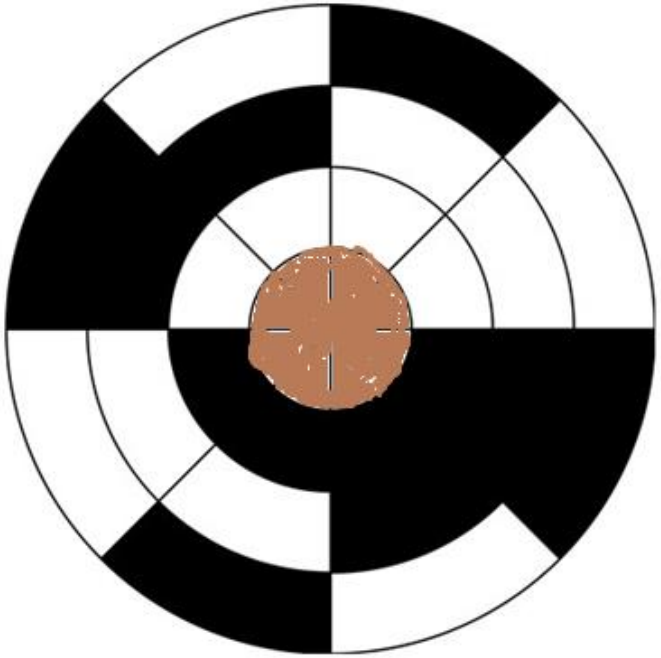
Where n is number of tracks in the optical disk

2^{n} *the unique position on you disk*

Absolute Encoder

- The optical disk of the absolute encoder is designed to produce N distinct positions of the shaft.
- If there are 8 tracks, the encoder is capable of producing 256 distinct positions or an angular resolution of 1.406 (360/256) degrees.
- The most common types of numerical encoding used in the absolute encoder are gray and binary codes

3-bit binary Code



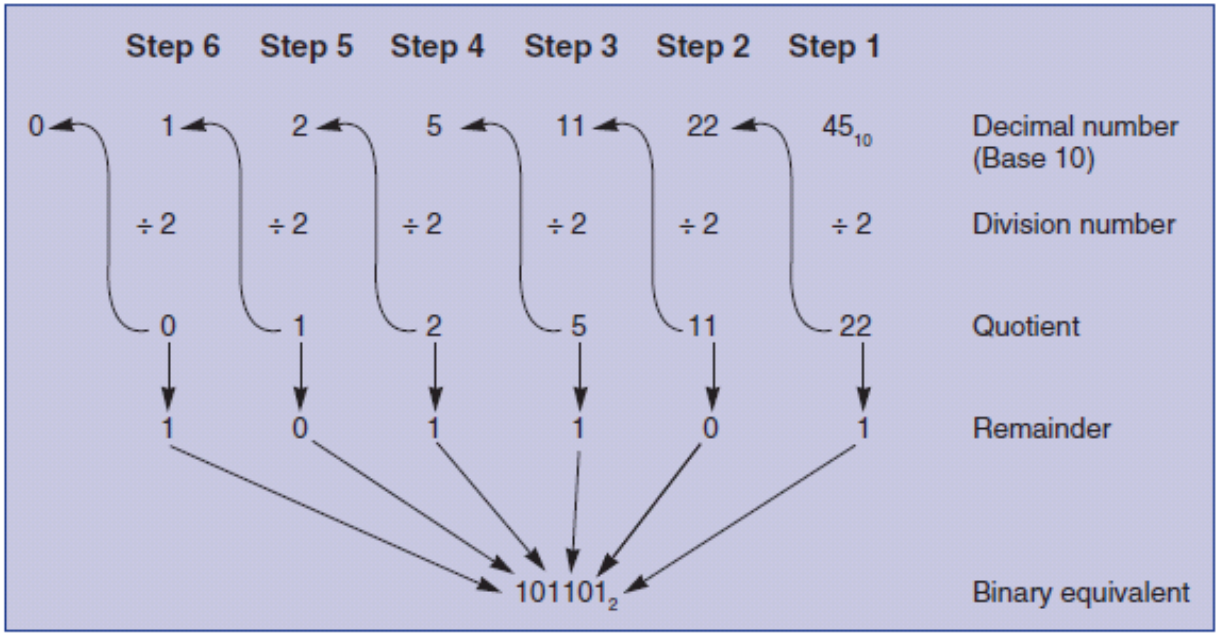
Dec	Binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Binary numbers 0, 1

Number of tracks = 03

Distinct position = 2^3 = 8 000,01,10,11

Decimal to Binary



Decimal-to-Binary Conversion

3-bit binary Code

4/2= 20=100

Convert from Decimal to Binary

Divide the number with 2

Example 1: Decimal number =2

$2/2 = Quotient = 1 ; Remainder = 0$

Combined them $= 10$

In 03 bits $= 010$

Example 2: Decimal number 3

$3/2 = Quotient = 1 ; Remainder = 1$

Combined them $= 11$

In 03 bits $= 011$

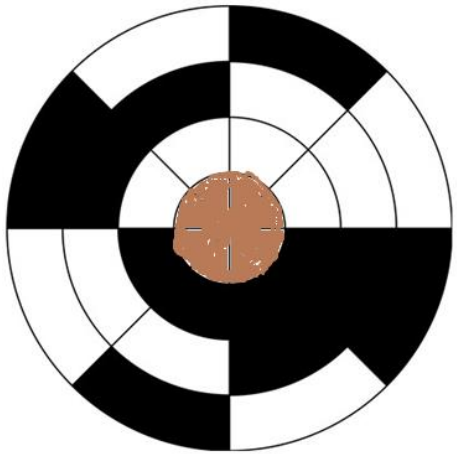
Example 3: Decimal number 4

$4/2 = Quotient = 2 ; Remainder = 0$

Quotient (2) /2 = $Quotient = 1 ; Remainder = 0$

Combined all them $= 100$

Dec	Binary
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111



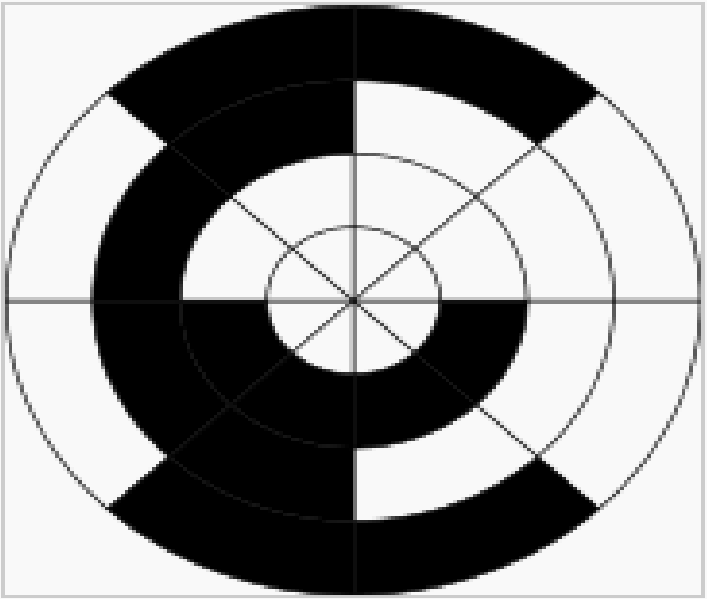
Binary to Gray Code

- Start with a word that contains all zeros.
- Go to the least significant bit and toggle it (i.e., change it from 0 to 1 or from 1 to 0).
- If the resulting code has not been used before (i.e., is unique), then keep the resulting code and proceed to the next.
- Otherwise, if the code is not unique, then undo the change and move to the next significant bit and toggle it.
- Repeat the steps above until all codes have been generated.

Dec	Binary	Gray
0	000	000
1	001	001
2	010	011
3	011	010
4	100	110
5	101	111
6	110	101
7	111	100

100

3 bit Gray Code



Rotary encoder for angle-measuring devices marked in 3-bit binary-reflected Gray code (BRGC)

Dec	Binary	Gray
0	000	000
1	001	001
2	010	011
3	011	010
4	100	110
5	101	111
6	110	101
7	111	100

4-Bit Binary and Gray Codes

Decimal code	Rotation range (deg.)	Binary code	Gray code
0	0-22.5	0000	0000
1	22.5-45	0001	0001
2	45-67.5	0010	0011
3	67.5-90	0011	0010
4	90-112.5	0100	0110
5	112.5-135	0101	0111
6	135-157.5	0110	0101
7	15.75-180	0111	0100
8	180-202.5	1000	1100
9	202.5-225	1001	1101
10	225-247.5	1010	1111
11	247.5-270	1011	1110
12	270-292.5	1100	1010
13	292.5-315	1101	1011
14	315-337.5	1110	1001
15	337.5-360	1111	1000

4-Bit Binary Code Absolute Encoder disk track pattern

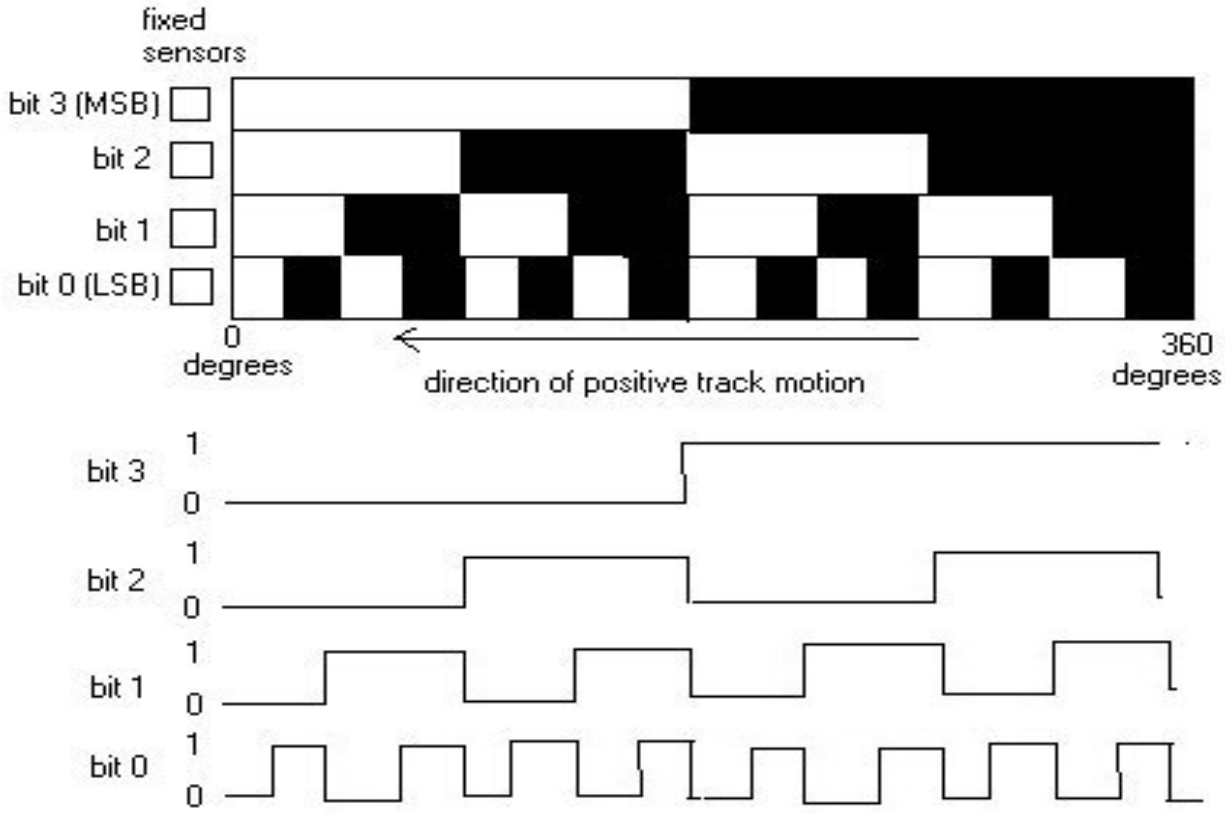


Fig 3 4-Bit binary code absolute encoder disk track patterns

4-Bit Grey Code Absolute Encoder disk track pattern

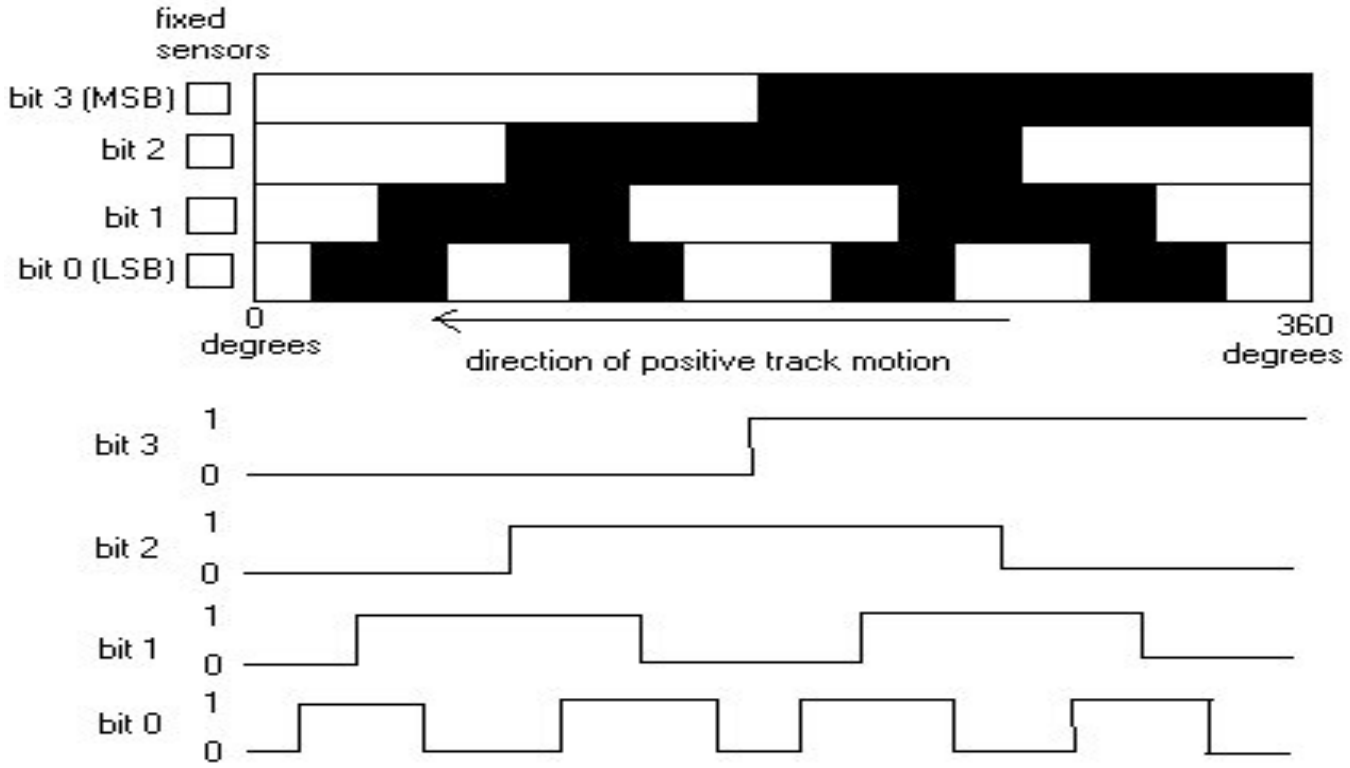


Fig 2. 4-Bit gray code absolute encoder disk track patterns

Quiz

- For an absolute encoder write down the gray code for the disk of three tracks. Calculate the resolution of the encoder and also draw the gray region on disk. Binary code for three bits data are given below.

Binary
000
001
010
011
100
101
110
111