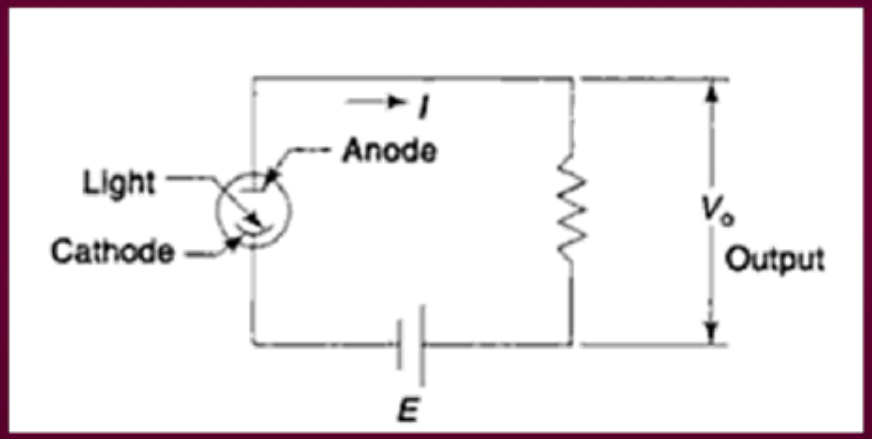
OPTO-ELECTRICAL TRANSDUCER

- Convert light beam into an electrical signal.
- By proper interruption of the light signal due to motion input, the electrical signal produced can be related to the input.
- Operate on principle that when light strikes special combination of materials then following may result.
    1. Electrons may flow
    2. A voltage may be generated
    3. A resistance change may take place
- Types – Photo-emissive
    - Photo-conductive
    - Photo-voltaic

Photo-Emissive Transducer

- Light beam strikes a photo-emissive cathode, which releases electrons.
- Electrons are attracted towards the anode producing a current I in the circuit.
- Enclosure is evacuated or filled with an inert gas.
- Cathode is made up of silver that is oxidized and converted with a layer of an alkali metal like cesium or alternatively of an alkali metal combined with antimony.



- Current I depends upon intensity of radiation and anode cathode voltage.
- Used in

1. Field of photometry & calorimetry
2. Sound reproduction from a motor picture film
3. ‘on and off’ circuits concerning the counting or sorting of objects on a conveyor belt, automatic opening of door etc.

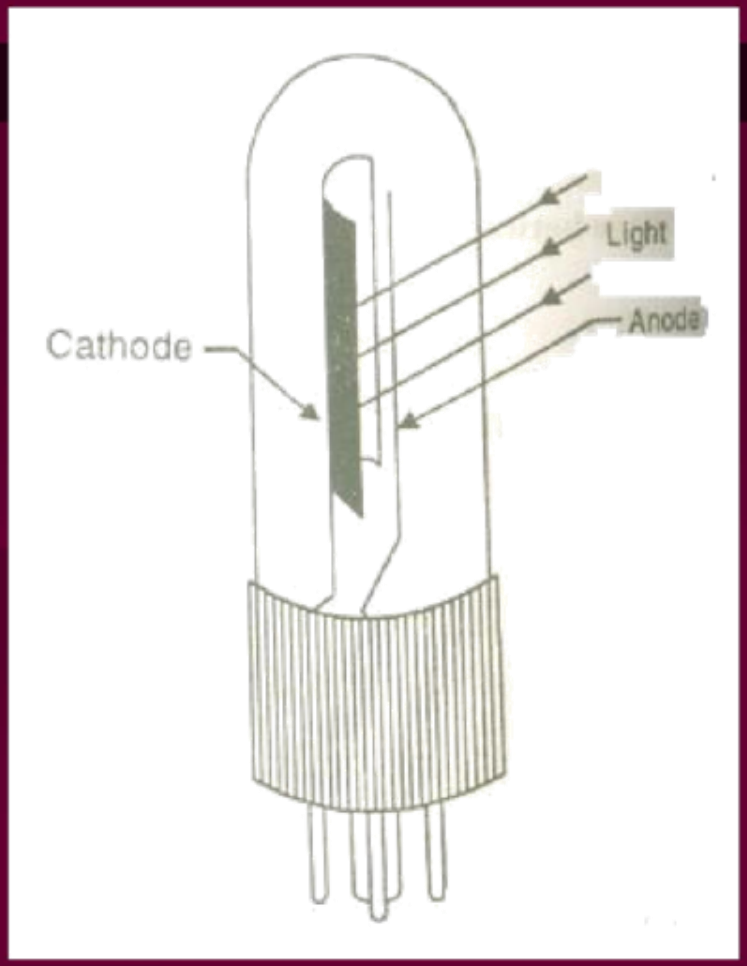


Photo-Conductive Transducer

- It uses semiconductor material whose resistance changes in accordance with the radiant energy received.
- Resistivity of selenium, cadmium sulphaide, lead sulfide and thalmium sulphide is decreased when irradiated.
- Used for detecting ships & aircrafts by the radiations given out by their exhausts and for telephony by modulated infrared lights.

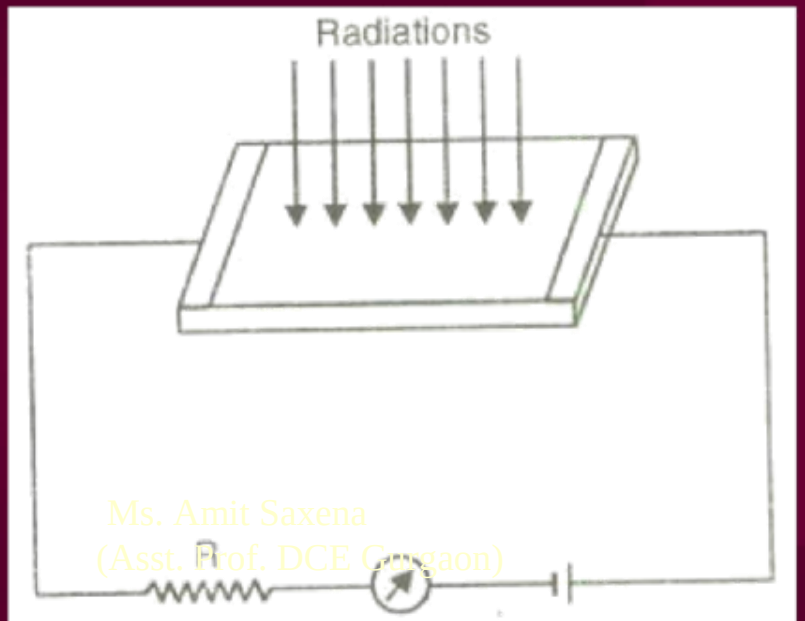
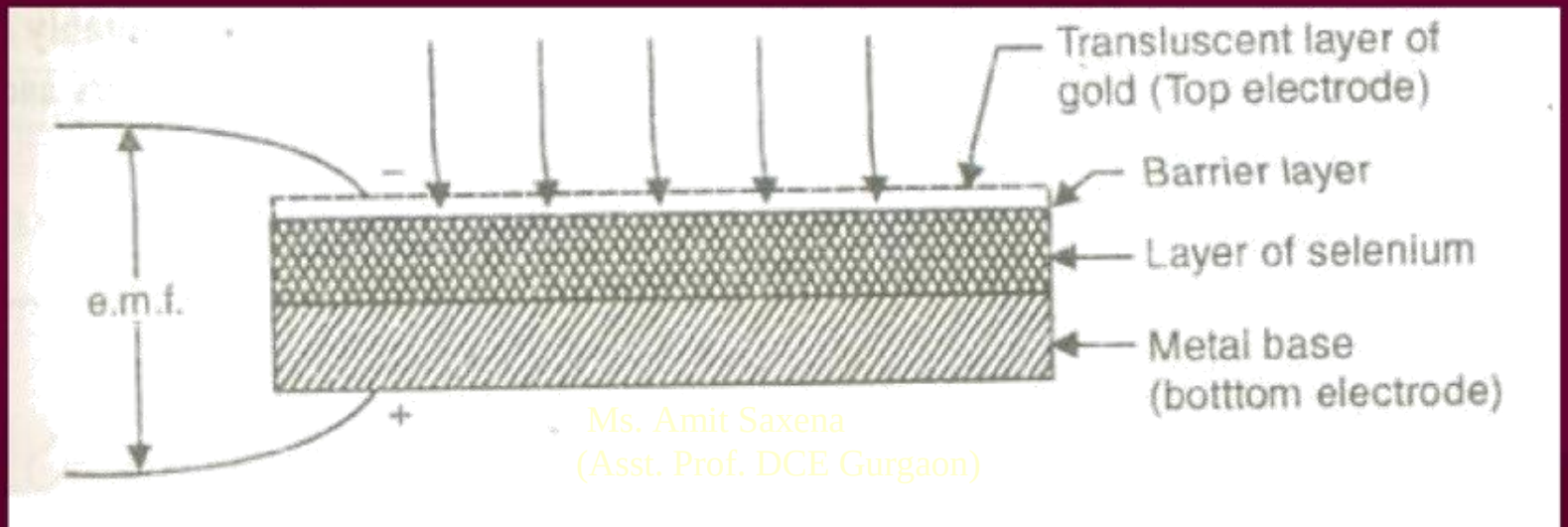


Photo-Voltaic Transducer

- A sensitive element is semiconductor (not metal) generates voltage in proportion to the light or any radiant energy incident on it.
- In ‘selenium cell’ due to light, a negative charge will build up on gold electrode and positive charge on bottom electrode.
- Used in fields

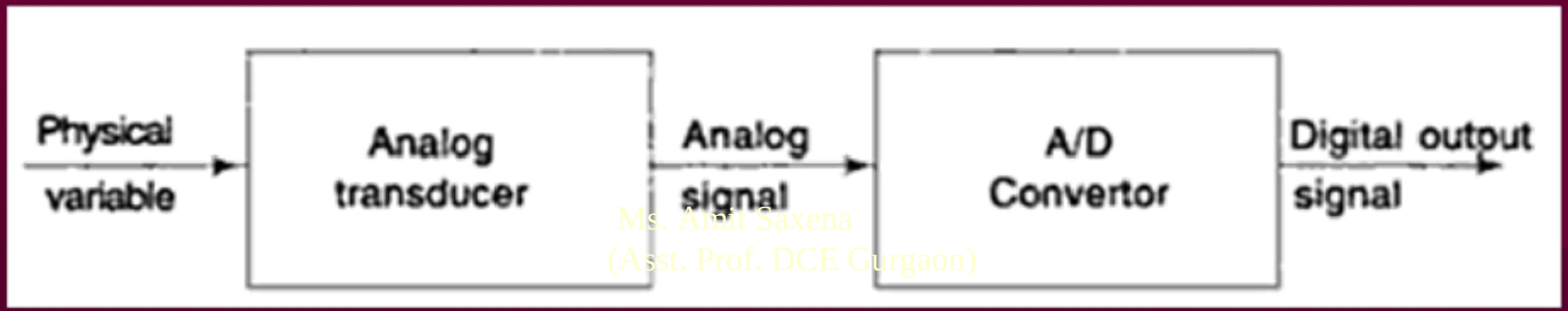
1. Automatic control system
2. Television circuits
3. Sound motion picture & reproducing equipment.



DIGITAL TRANSDUCERS

- Output is discrete and may give frequency type or digitally coded output, of binary or some other type.
- Advantages are:

1. Use of digital computer – easy for data manipulation.
2. Digital signals – don't depend on signal amplitude so easy to transmit without distortion and external noise.
3. Increased accuracy in pulse count.
4. Ergonomic advantages in presenting digital data.



Frequency Domain Transducers

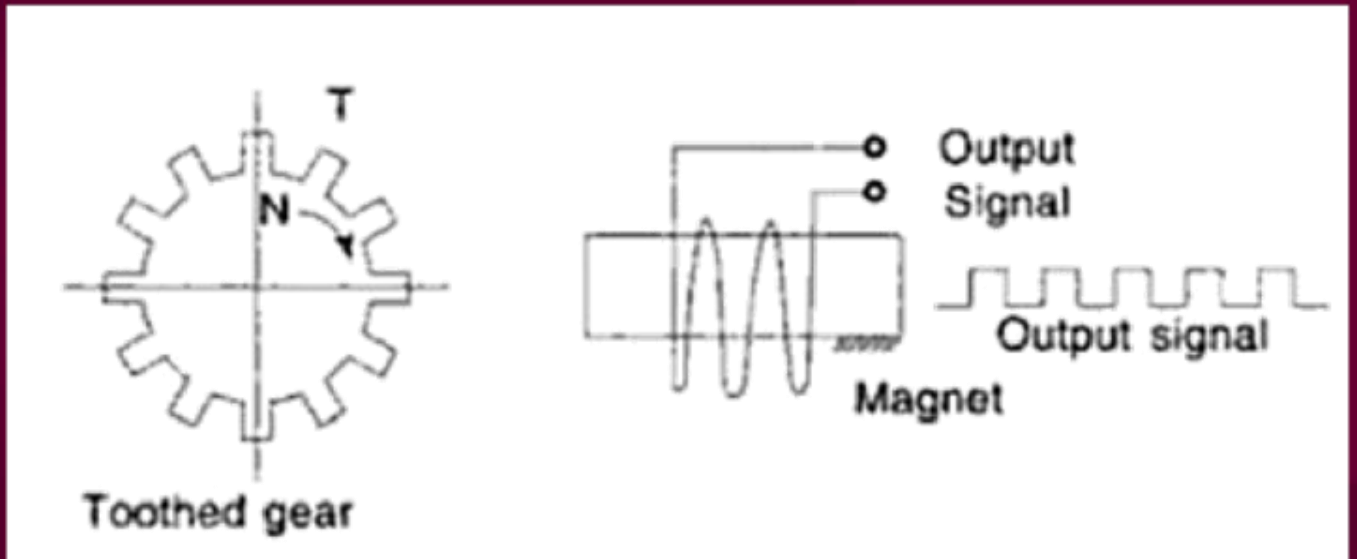
- The output is in the form of pulses or sinusoidal waveforms, the frequency of which is a measure of magnitude of physical variable.
- Frequency can be measured by a frequency or pulse counter.
- Types as: 1. Electromagnetic F.D.T.

  2 . Opto-electrical F.D.T.

  3. Vibrating string transducer

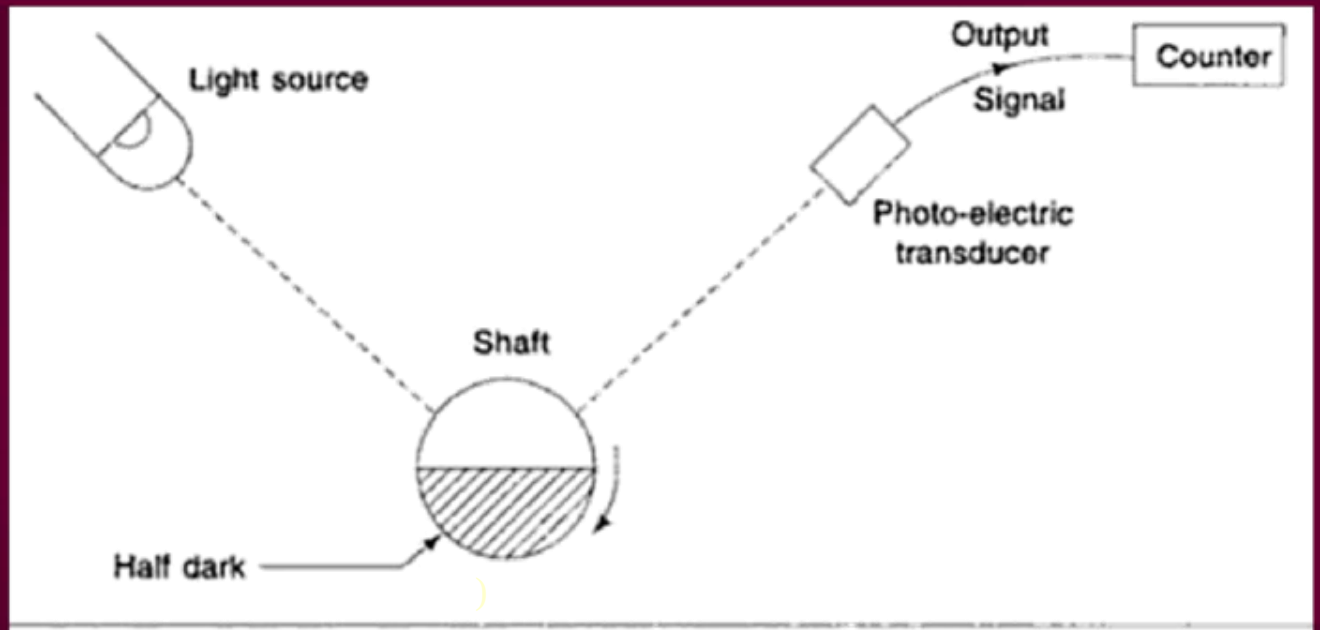
Electromagnetic Frequency Domain Transducers

- Used for speed measurement.
- It consists of permanent magnet or solenoid.
- Gear is of ferromagnetic material.
- Change in gap length changes the flux density and a voltage pulse is induced in the coil.
- Pulse frequency equals speed N times the number of teeth T.



Opto-electrical Frequency Domain Transducers

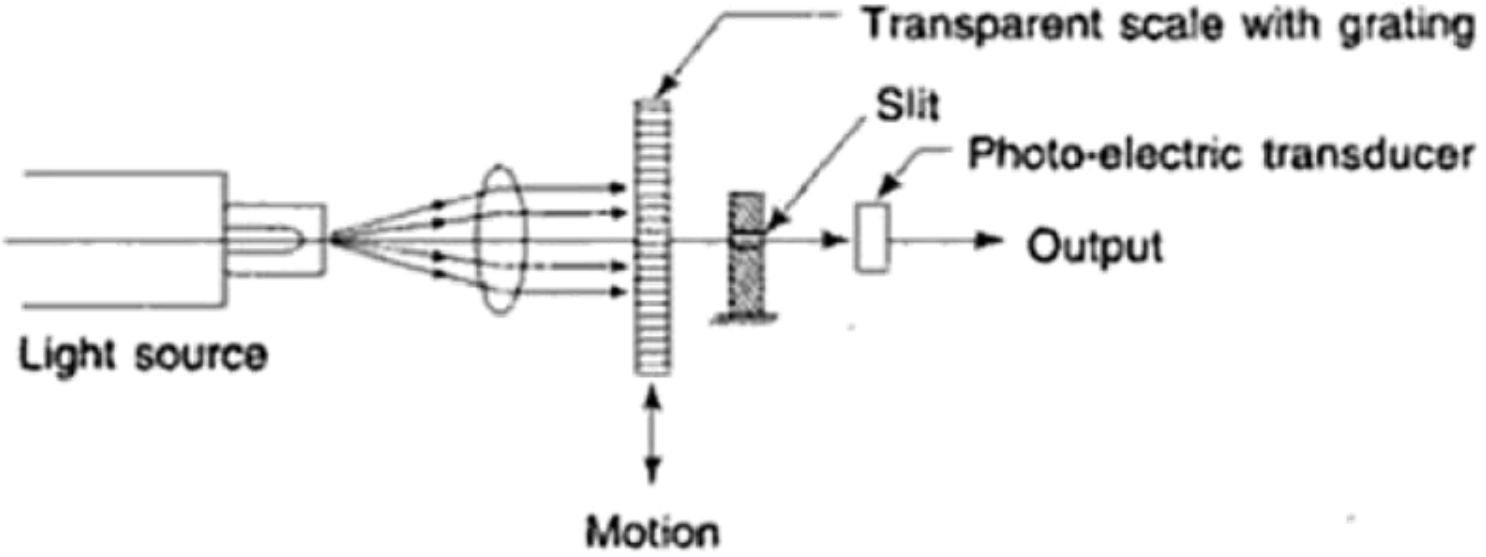
- Used for both rotary and linear motion measurement.
- Shaft has half dark and half white or shining portion.
- When white portion is in front of light source, the light is reflected which falls on photo-electric transducer. It gives an electrical pulse output.
- Frequency of pulses is thus a measure of speed of rotation.



Opto-electrical frequency domain transducer for rotary motion

Opto-electrical Frequency Domain Transducers

- Linear motion measurement uses a transparent scale with a grating.
- Moving object is attached to transparent scale.
- Light from a source passes through the scale & a slit and then falles on photo-electric transducer.



Opto-electrical frequency domain transducer for linear motion

Vibrating String Transducer

- Used to measure force applied to a metal string, which is kept vibrating, the frequency of which is dependent on the force applied.
- The natural frequency ***f*** of a string is given by

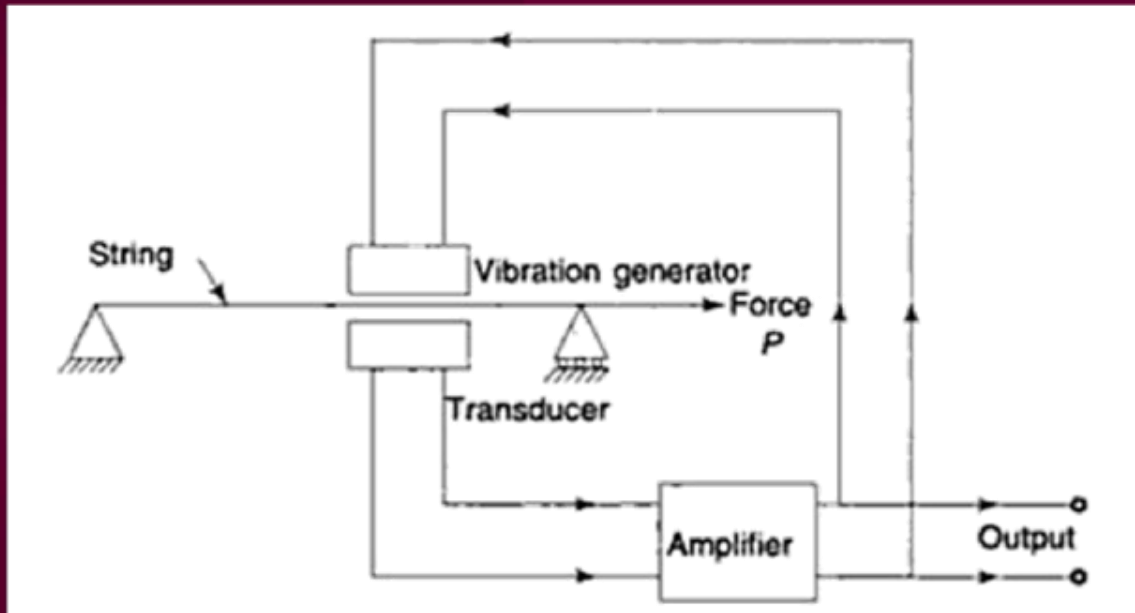
$$f = \frac{1}{2L}\sqrt{\frac{P}{a\rho}}$$

ρ = mass density of wire

material a = area of cross-section

P= applied force

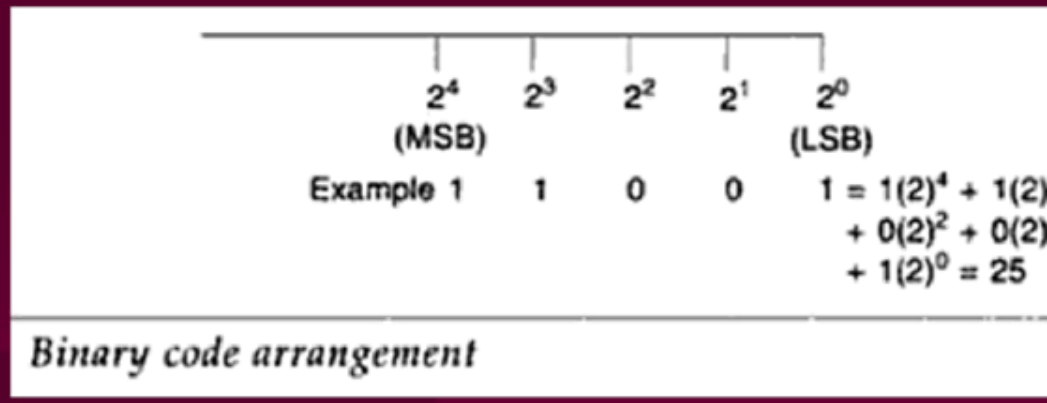
L = length of string



- One end of string is fixed and other can be moved relative to it, due to force applied.
- The frequency ***f*** gets changed due to change in magnitude of force P. the frequency is measured by a frequency counter and is a measure of force applied.
- Initial string vibrations are obtained by an electro-magnetic device.
- The transducer can be used for measurement of force, displacement and pressure as well.

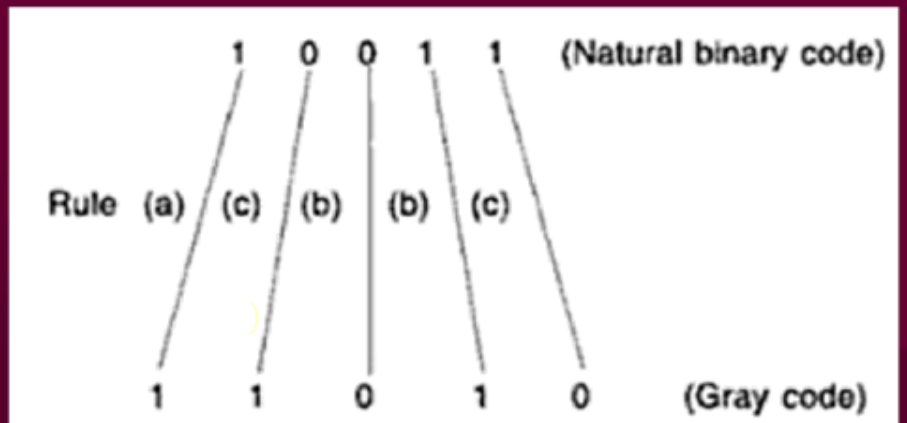
Binary Codes

- Digital output is usually required to be in binary form.
- Natural Binary Code system.
- Binary coded decimal (BCD) code.
- Gray code.



Binary code arrangement

$$387 = \underbrace{0011}_{3}\ \underbrace{1000}_{8}\ \underbrace{0111}_{7}$$

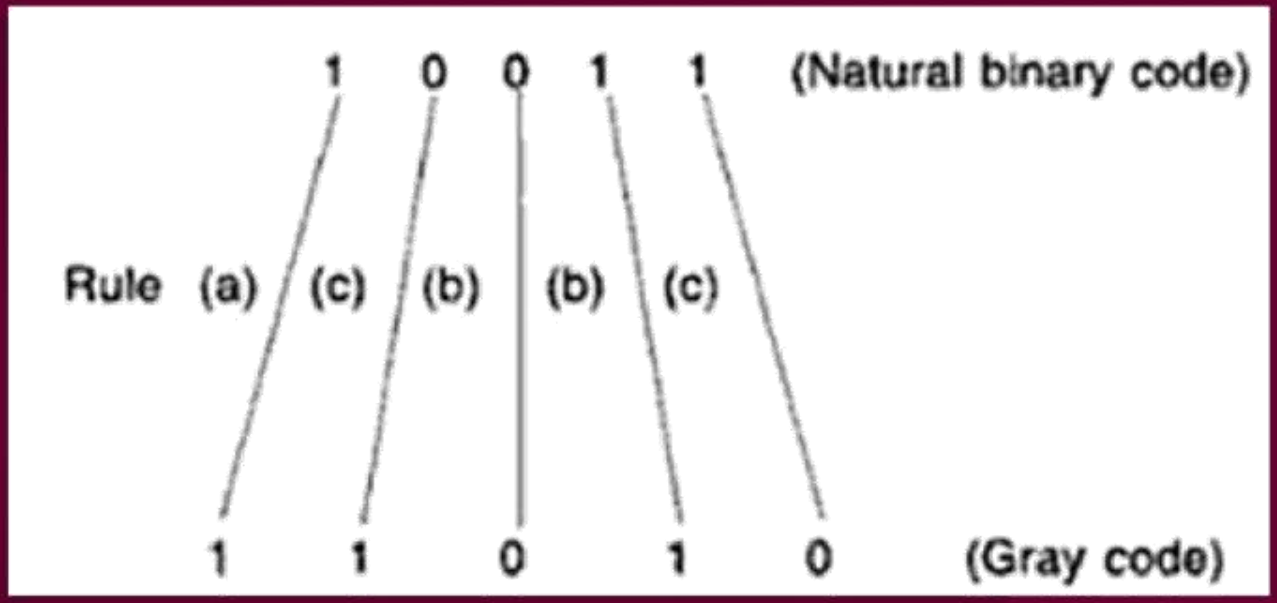


Conversion from natural binary to gray code:

a) MSB is unchanged during conversion.

b) Gray code bit for other bits in natural binary is same if digit to the left in natural binary is 0.

c) The bit is changed if the bit to the left is 1.

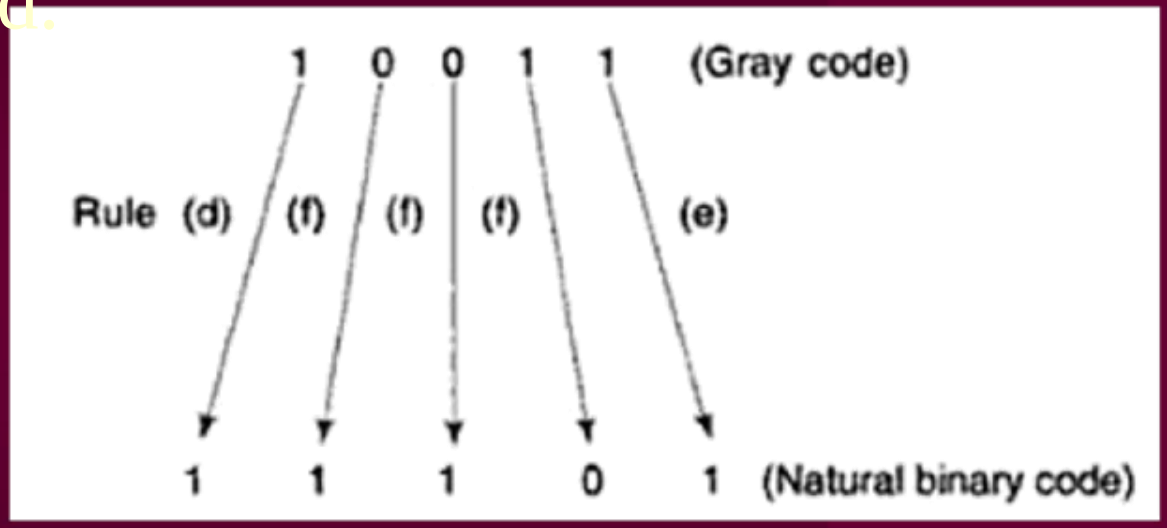


Conversion from gray code to natural binary code:

a) MSB is unchanged during conversion.

b) For every other bit in Gray code, natural binary is same if the number of 1s to the left is even.

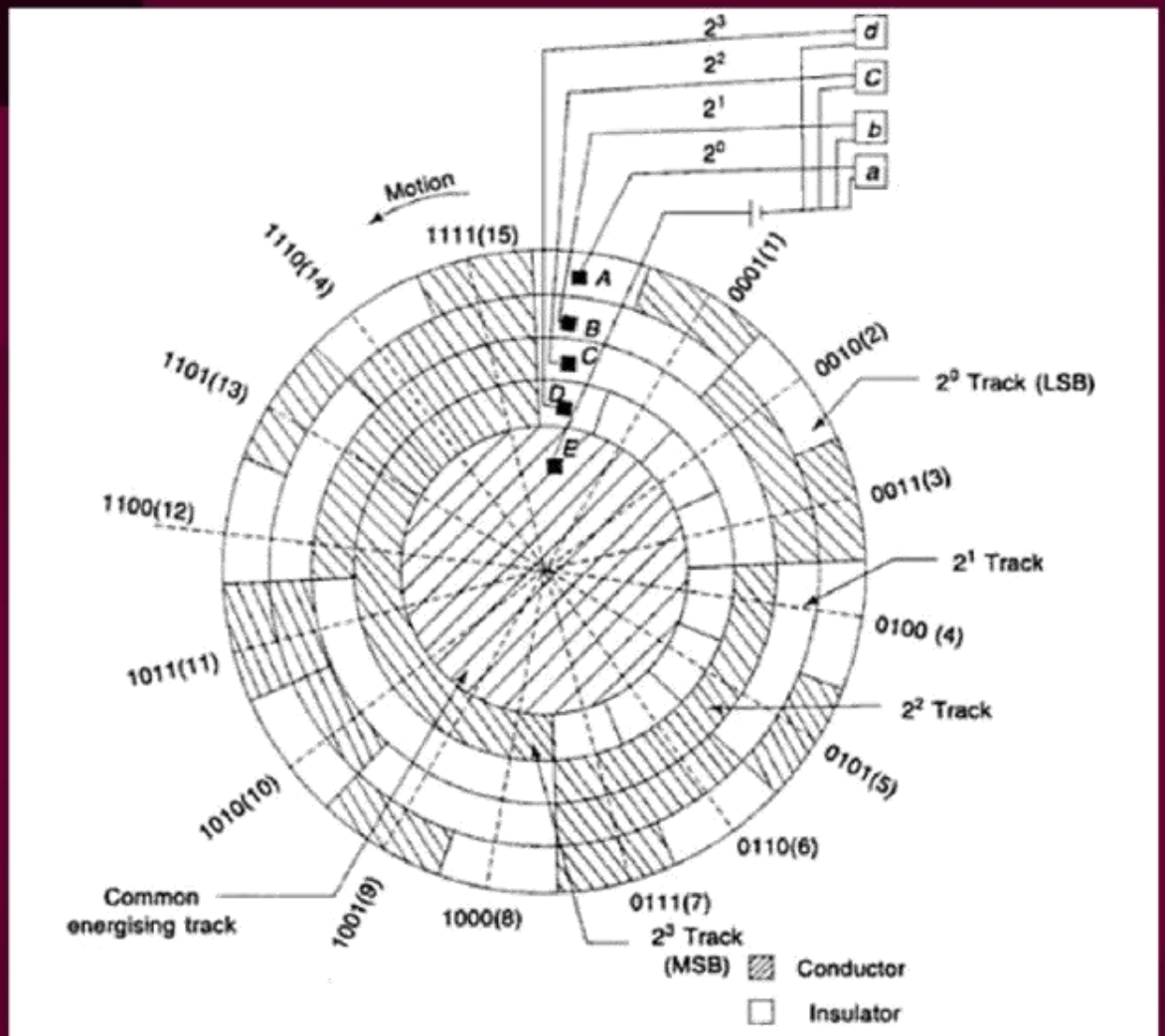
c) The bit is changed if the number of 1s to the left is odd.



Decimal Number	*Natural Binary Equivalent*	*Gray code equivalent*
15	1111	1000
14	1110	1001
13	1101	1011
12	1100	1010
11	1011	1110
10	1010	1111
9	1001	1101
8	1000	1100
7	0111	0100
6	0110	0101
5	0101	0111
4	0100	0110
3	0011	0010
2	0010	0011
1	0001	0001
0	0000	0000

Digital Encoders.

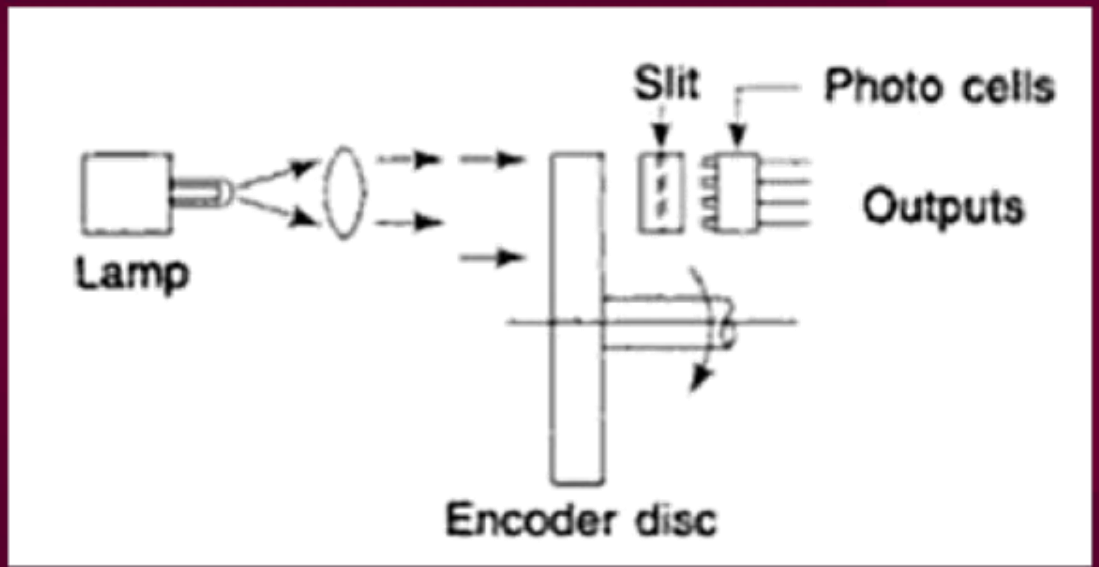
- Convert analog motion (rotary/linear) directly to digital output form.



- Encoder disc has four bits or tracks.
- Brushes A,B,C and D are stationary
- Brush E is on common energising track which is conductor.
- When brushes A,B,C or D is on conducting portion, the circuit is made & corresponding indicator is ON(state 1) or OFF (state 0).
- The disk has a resolution of 1/15.
- Resolution can be reduced by increasing number of tracks & brushes.
- Information can be supplied directly to the computer input switches, in binary digital form.
- Encoder can also be used for linear motion input.
- Direct contact type arrangement.
- So there is wear of brushes & disc and friction between brush & disc

Optical Encoder

- The disc has transparent & opaque areas.
- The photo cell, corresponding to a particular track, would produce an electrical output if the transparent portion is in front of slit and light source, giving state ON (1) while no electrical output from a cell would correspond to OFF (0) state



Magnetic Type Encoder

- Non-contact type
- Uses a number of small toroidal magnets with coils around them.
- Conducting & non-conducting areas in contact type encoder disc form non-magnetic & magnetic areas.
- The presence or absence of such areas is detected by coils which are in close proximity to each track on the disc.
- One of the coils in each toroidal magnet is energised with high frequency ac carrier signal.
- If toroid is over a non-magnetic area, a voltage due to transformer action is induced in output coil (1) while magnetic area would saturate magnetic circuit & output is very small (0)