

Control system Components

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Synchros

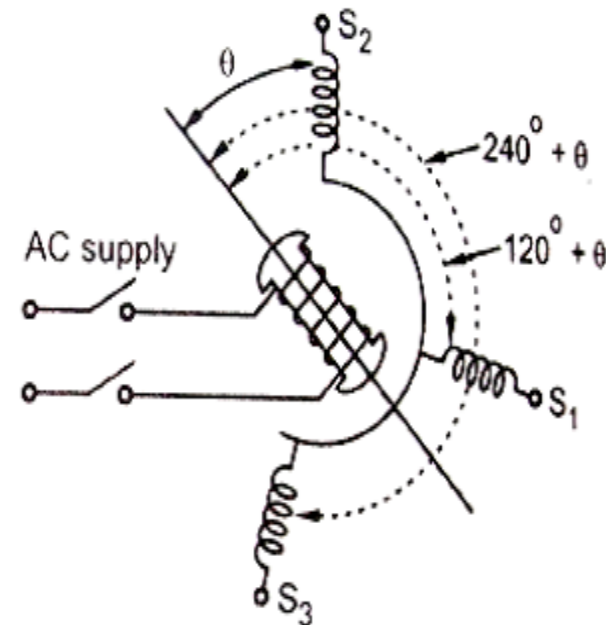
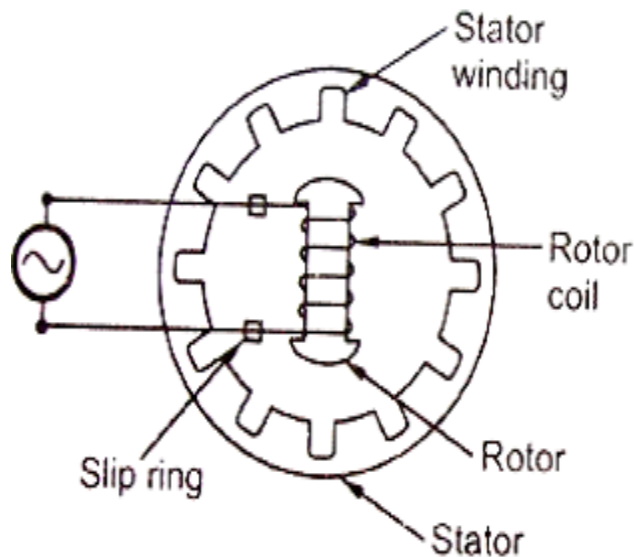
- It is basically an electromagnetic transducer which operates on the principle of transformer.
- Converts angular position of shaft into electrical signal
- It is used in measuring the angle of rotating machines .e.g: Antenna



- A synchro functions as an electromechanical transducer
 - which, as a circuit element, is essentially a variable
 - coupling transformer.
 - The magnitude of the magnetic coupling between the primary and secondary varies according to the position of the rotating element.
 - This in turn varies the magnitude of the output voltage.
- In some systems, a mechanical input, such as a shaft rotation, is converted to a unique set of output voltages. In others, a set of input voltages is used to turn a synchro rotor to a desired position.

Construction of Synchros

1. **Stator:** stationary and made up of Laminated steel with balanced (120 degree apart) 3 phase –star connected winding
2. **Rotor:** rotating part with salient pole, dumb bell shaped magnet with single winding



Working of Synchros

- The primary winding of the transformer, fixed to the rotor, is excited by an alternating current, which by electromagnetic induction, causes currents to flow in three star-connected secondary windings fixed at 120 degrees to each other on the stator.
- The relative magnitudes of secondary currents are measured and used to determine the angle of the rotor relative to the stator, or the currents can be used to directly drive a receiver synchro that will rotate in unison with the synchro transmitter

Synchros can be classified in two overlapping groups: torque synchros and control synchros.

➤ **Torque synchros**

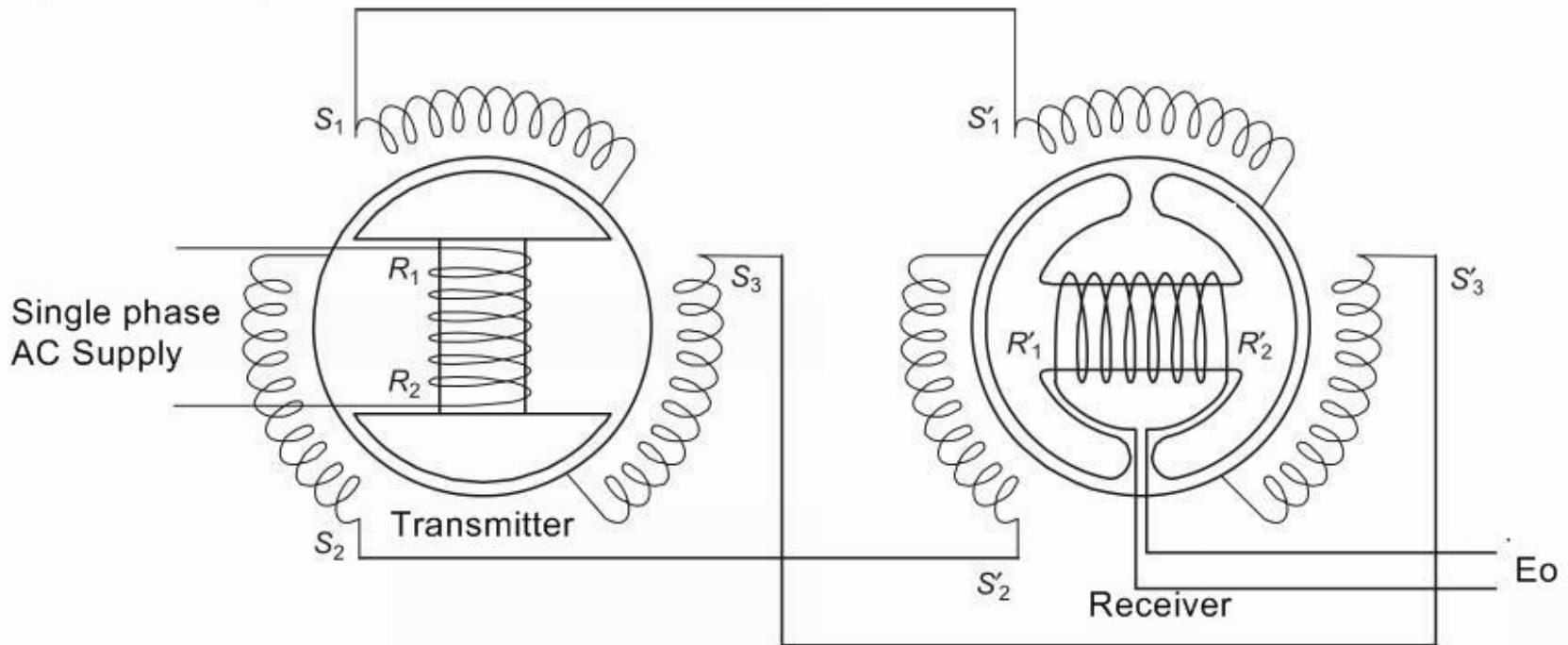
transmitters (CG), differentials(CD) and receivers (CR).

➤ **Control synchros**

transmitters (CG), differentials(CD) control transformers (CT), resolvers (CS), linear transformers (LT) and the two hybrid units: transolvers (CSD) and differential resolvers (CDS).

Synchro Pair as an error detector

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Synchro Pair as an Error Detector

Transmitter

- The synchro transmitter (CG) consists of a single-phase, salient-pole (dumbbell-shaped) rotor and three-phase, Y-connected stator.
- The primary or input winding is usually the rotor, with the stator as the secondary or output element. The rotor is excited through a pair of slip rings with an AC voltage.
- The field produced by this voltage induces a voltage into each of the stator phases.
- The magnitude of the induced voltage depends on the angle between the rotor fields and the resultant axis of the coils forming that stator phase.

• Since the axes of the three stator phases are 120° apart, the magnitudes of the stator output voltages can be written as:

$$V_{S1-3} = K V_{R2-1} \sin \theta$$

$$V_{S3-2} = K V_{R2-1} \sin (\theta + 120^\circ)$$

$$V_{S2-1} = K V_{R2-1} \sin (\theta + 240^\circ)$$

where K is the maximum coupling transformation ratio (TR), which is defined as $TR = \frac{V_{out} (max.)}{V_{in}}$

θ is the rotor position angle. V_{S1-3} is the voltage from the S1 terminal to the S3 terminal.

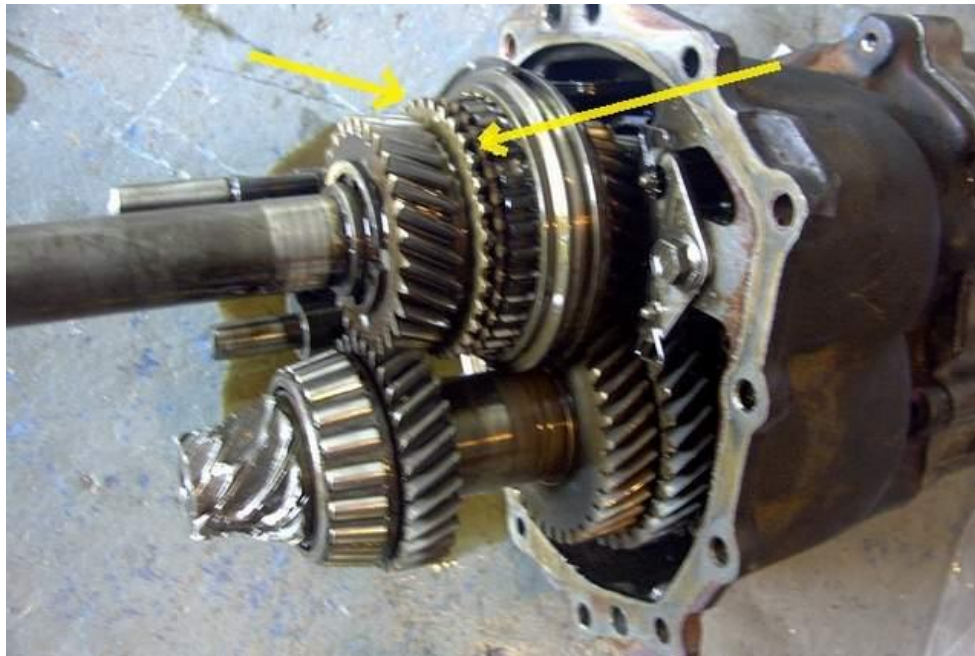
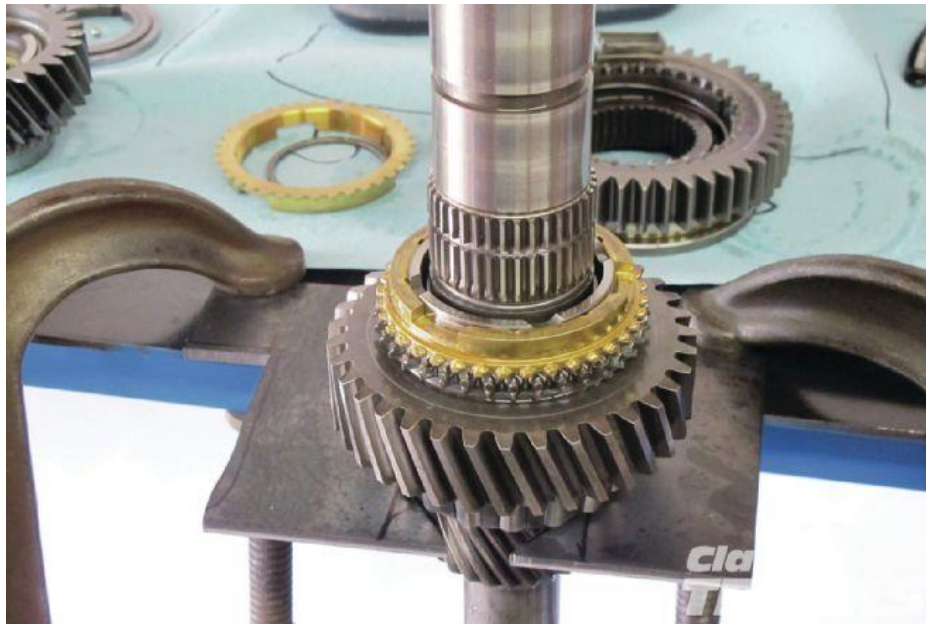
Receiver

The transmitter equations show that no where over the entire 360° rotation of the rotor will the same set of stator voltages appear.

The transmitter, therefore, supplies information about the rotor position angle as a set of three output voltages.

To convert this information, it is necessary to use an instrument which will measure the magnitude of these voltages, examine their time-phase relationships, and return them to their original form: a shaft position. Such a device is the synchro receiver (CR).

- The construction of the receiver is electrically identical to that of the transmitter.
- The output voltages vary with rotor position in the same manner as those of the transmitter.
- In use, the receiver is connected back-to-back with a transmitter. Like-numbered terminals are connected together and the rotors are excited in parallel.
- At the instant the system is energized, voltage differences exist across each pair of stator windings if the rotors of the units are not at the exact same angle relative to the stator phases. This causes current to flow in both stators, producing a torque on each rotor.
- Since the transmitter rotor is constrained, the resultant torque acts on the receiver rotor in such a direction as to align itself with the transmitter.
- When alignment occurs, the voltages at each stator terminal are equal and opposite, and no current flows.



Applications of Synchros

- Motion and position sensing applications
- On board ships—engine data, heading, roll angle, pitch angle, speed, radar, longitude and latitude
- The electromechanical aviation instruments
- Robotics

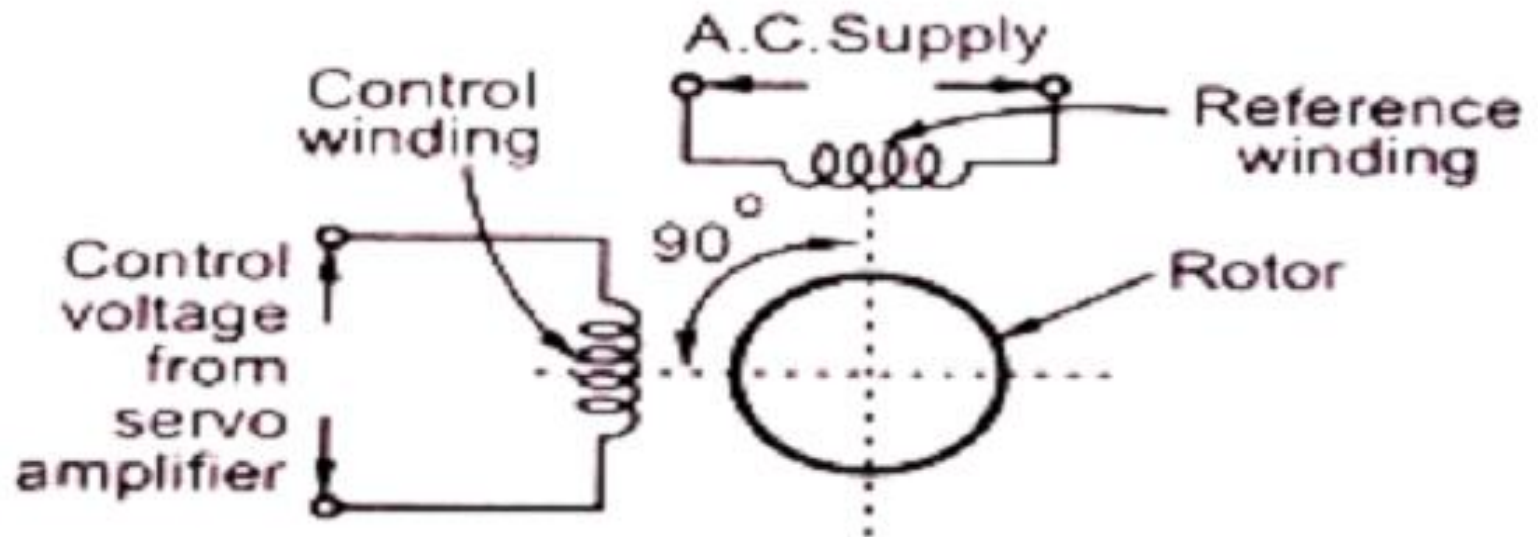
Tacho-generator

- Tachometer is an electromechanical unit which generates an electrical output proportional to the speed of the shaft
- In automatic control system tachometer performs two main functions:
 - 1.Stabilization of system
 - 2.Computation of closed loops in a control system

AC Tacho-generator

- The AC tachometer is a device, which is similar to a two phase induction motor, in which two stator windings are placed in quadrature with each other and rotor is short circuited.
- In AC Tachometer, a sinusoidal voltage of rated value is applied to the primary
- winding, which is known as reference winding, the secondary winding is placed 90 degrees apart from primary winding.
- The magnitude of sinusoidal output voltage is directly proportional to the
- speed of rotor.

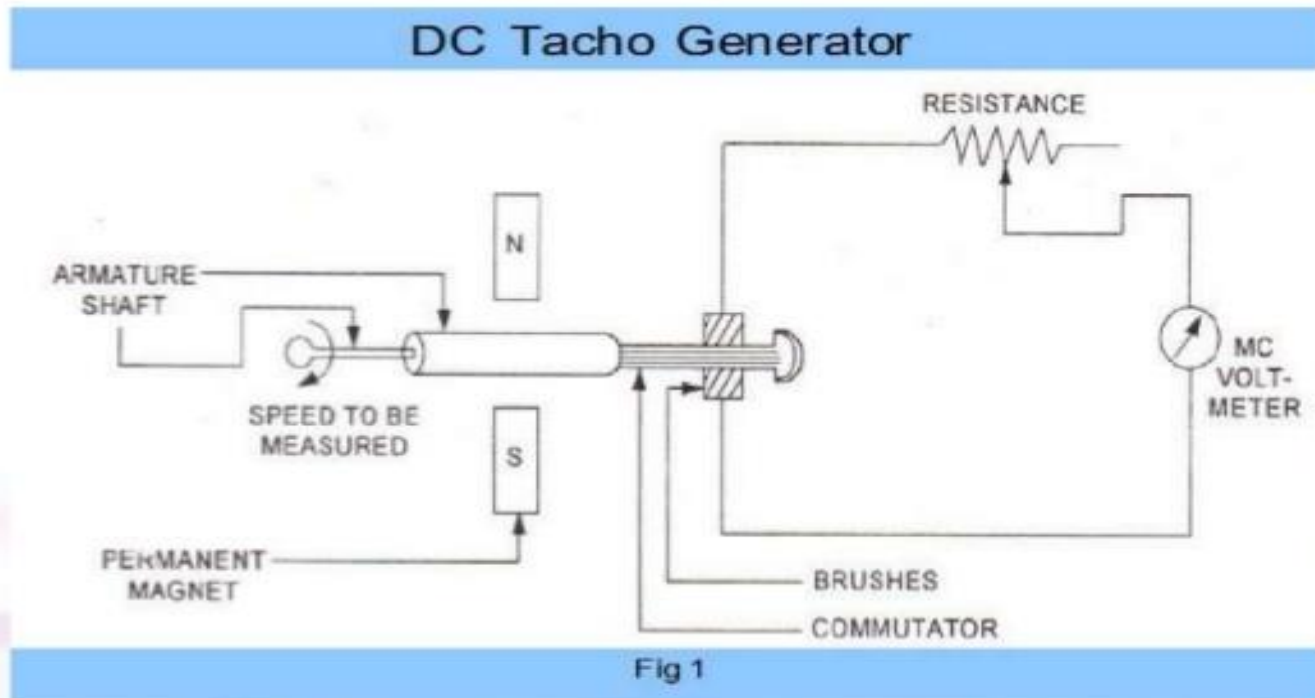
AC Tacho-generator



DC Tacho-generator

- In control systems most common type of tachometers are d.c. tachometers
- D.C. Tachometer contains an iron core rotor a
- permanent magnet
- The magnetic field is provided by the permanent
- magnet and no external supply voltage is necessary
- The input to the tachometer is the speed of the shaft and the output is voltage which is proportional to the angular speed of the shaft.

DC Tacho-generator

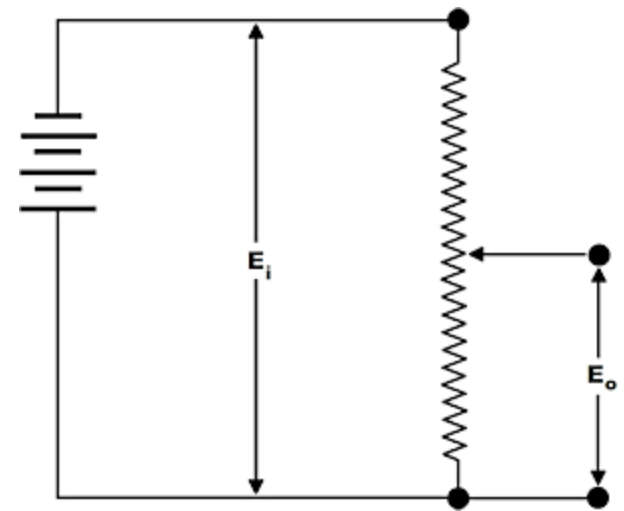
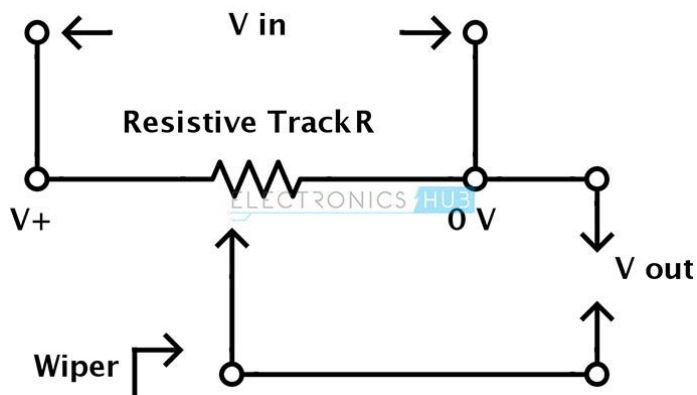


Applications of tachometer

- Automobiles, airplanes, trucks, tractors, trains and light rail vehicles
- Laser instruments
- Medical applications
- Analog audio recording, a tachometer is a device that measures the speed of audiotape as it passes across the head
- Numerous types of machinery and prime movers
- To estimate traffic speed and volume.

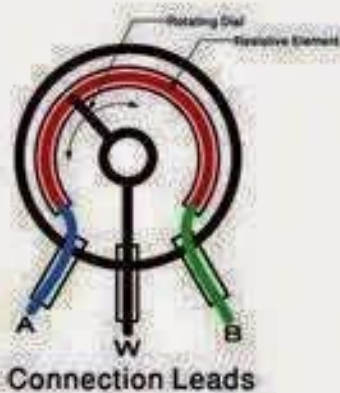
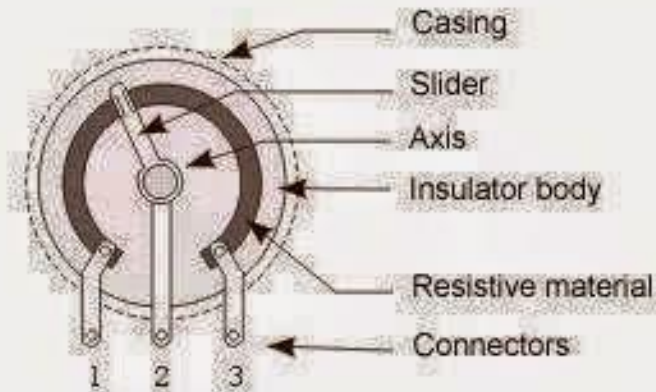
Potentiometer

- It may refer to an instrument that measures an unknown emf or voltage by comparing it to a standard emf.
- Alternatively, "potentiometer" may refer to an electronic component that is used to vary resistance in a circuit. In this article, we discuss the construction and working principle of the resistive component.
- A potentiometer is also referred to as a variable resistor or pot. They have three terminals, where the one in the middle is known as the wiper, and the other two are known as ends. The wiper is a movable contact where resistance is measured with respect to it and either one of the end terminals.
- They are useful for circuits where the resistance needs to be dynamically changed to control the current. They are also popular as voltage dividers.



Potentiometer construction

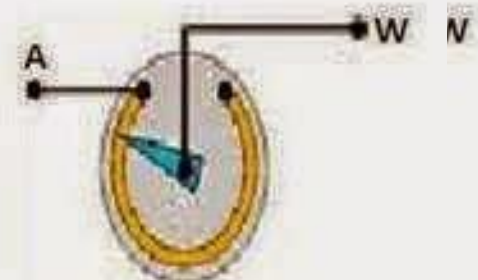
Potentiometer



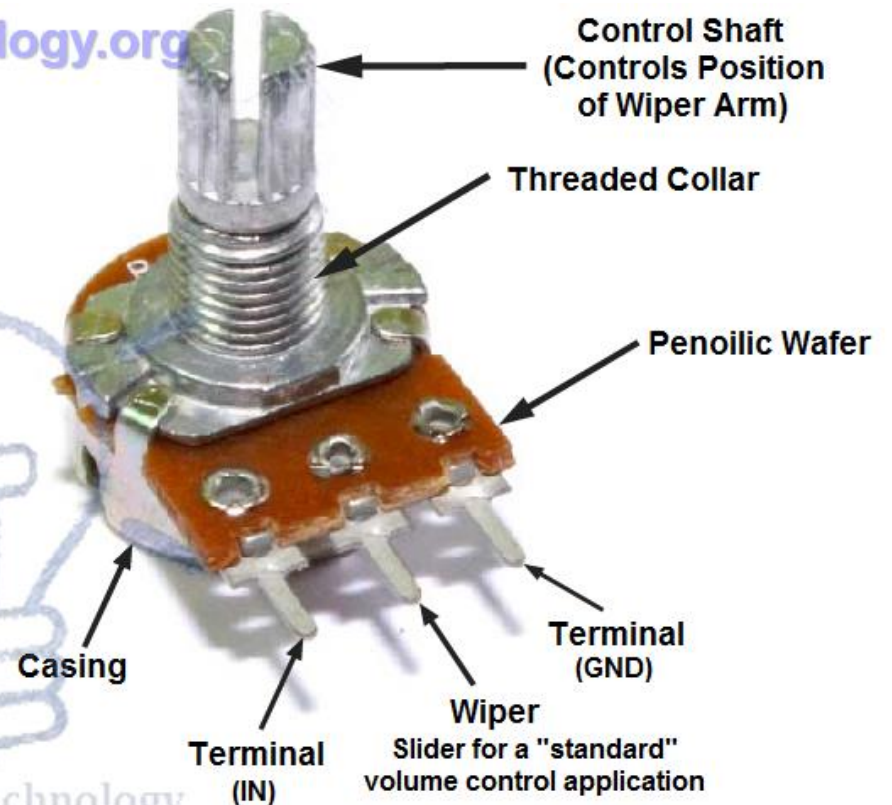
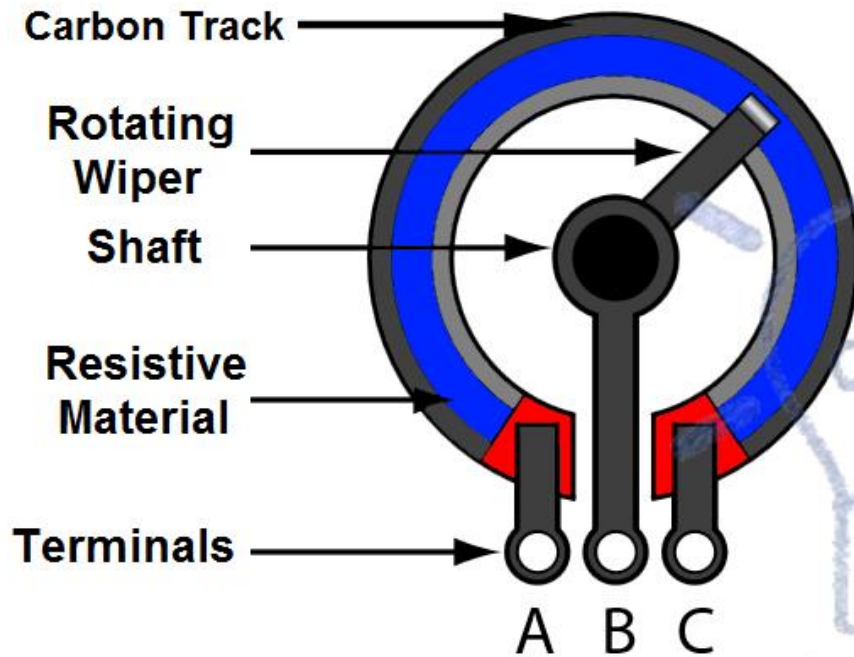
Connections For
voltage division



Connections For
Fixed resistance



Connections For
Variable resistance



Potentiometer Construction

How does a potentiometer work?

- Potentiometers work by having a resistive element inside. Both end terminals are attached to it, and do not move.
- The wiper travels along the strip when the knob is turned. The closer the wiper is to the end terminal it is wired in conjunction with, the less the resistance, because the path of the current will be shorter. The further away it moves from the terminal, the greater the resistance will be.
- The symbol for a potentiometer is the same one as a resistor, save for an arrow in the middle. In a circuit where they are used strictly as variable resistors or rheostats, only two terminals are wired to the other components.
- All three terminals are wired separately when they function as voltage dividers.

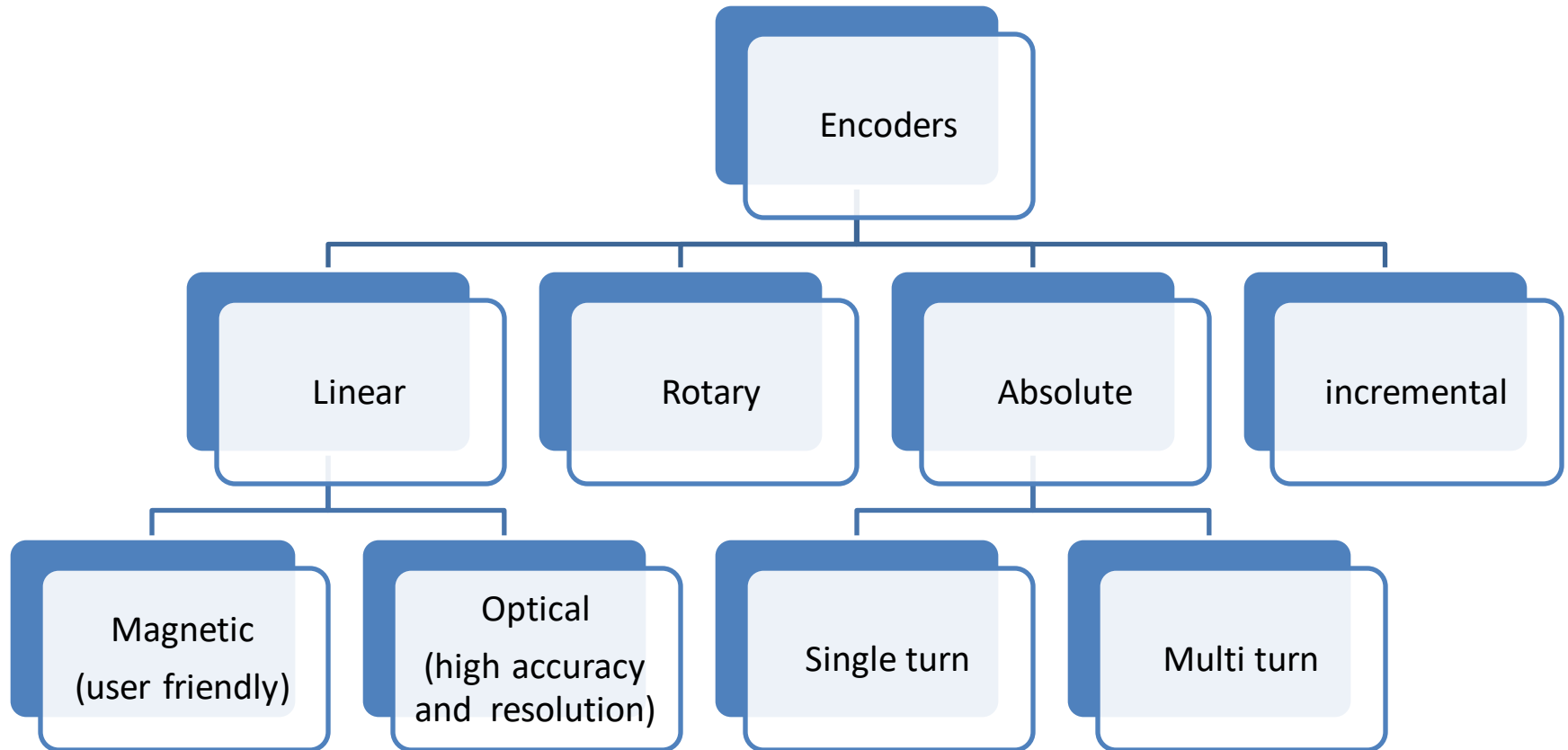
Applications:

Light dimmers in houses and volume controls on electronics are two common applications.

Encoders

- An encoder is a sensor which converts rotary motion or position to a series of electronic pulses.
- It is an electro-mechanical device, an encoder is able to provide motion control system users with information concerning position, velocity and direction.
- There are two different types of encoders: linear and rotary.
- A linear encoder responds to motion along a path, while a rotary encoder responds to rotational motion.
- An encoder is generally categorized by the means of its output.
- An **INCREMENTAL ENCODER** generates a train of pulses which can be used to determine position and speed.
- An **ABSOLUTE ENCODER** generates unique bit configurations to track positions directly.

Classification of encoders

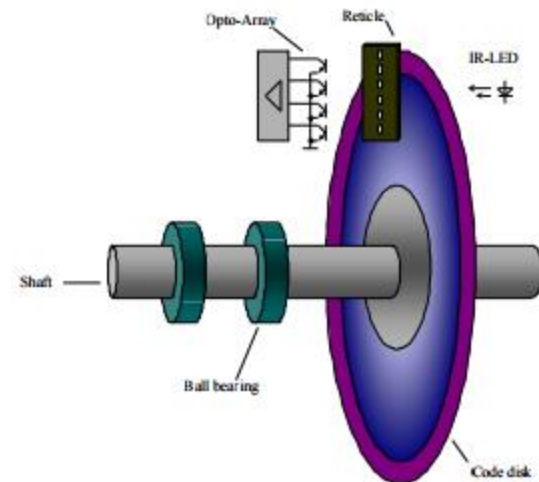


Encoders

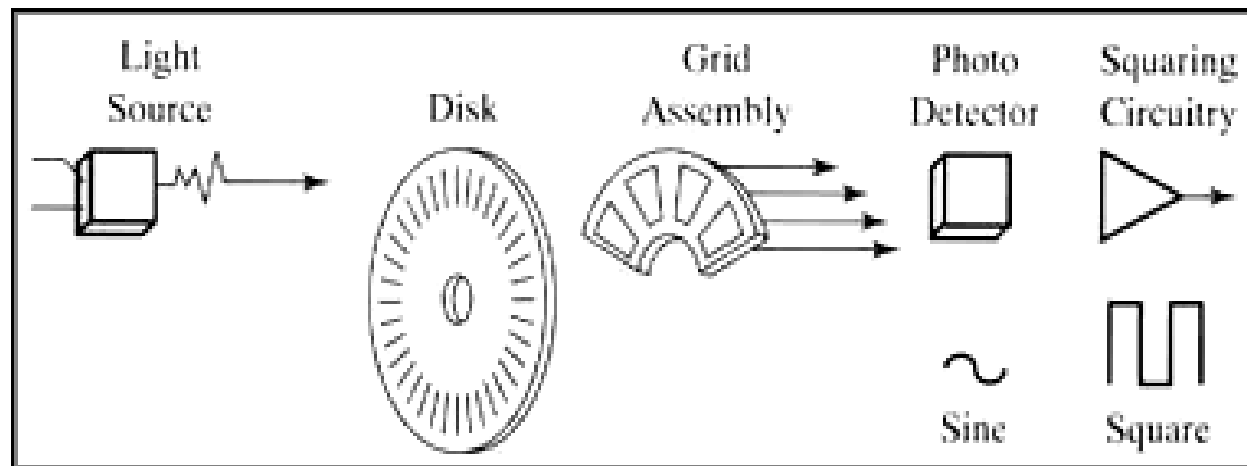
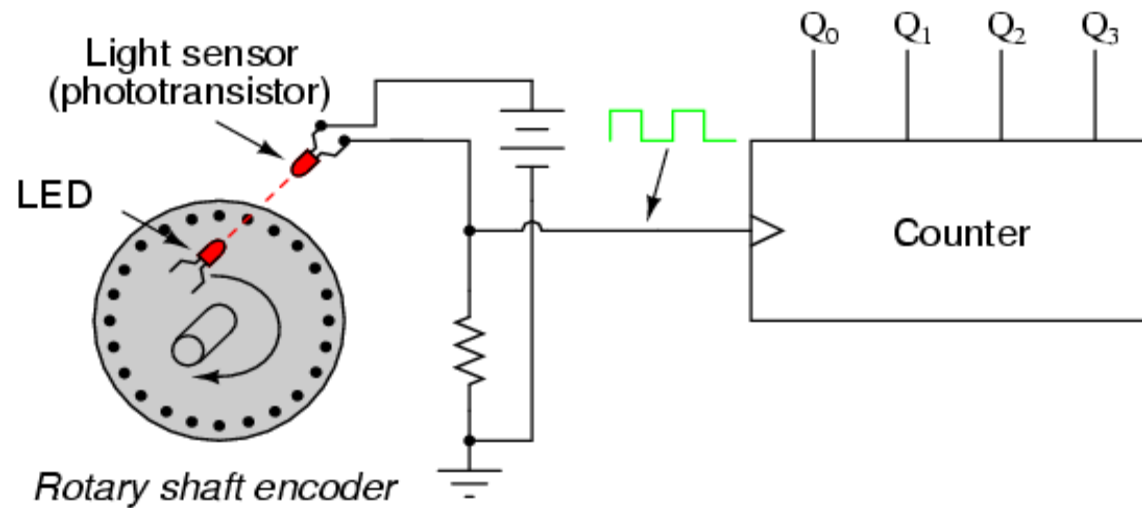


Optical Encoders

- The Optical Encoders typically consist of a rotating and a stationary member.
- The rotor is usually a metal, glass, or a plastic disc mounted on the encoder shaft. The disc has some kind of optical pattern, which is electronically decoded to generate position information. The rotor disc in absolute optical encoder uses opaque and transparent segments arranged in a gray-code pattern.
- The stator has corresponding pairs of LEDs and phototransistors arranged so that the LED light shines through the transparent sections of the rotor disc and received by phototransistors on the other side.
- After the electronic signals are amplified and converted, they are then available for the evaluation of the position.



Optical Encoder construction



Applications

- Assembly Machines
- Packaging
- X and Y Indication Systems
- Printers
- Testing Machines
- CNC
Robotics
- Labeling Machines
- Medical Equipment
- Textiles
- Drilling Machines
- Motor Feedback