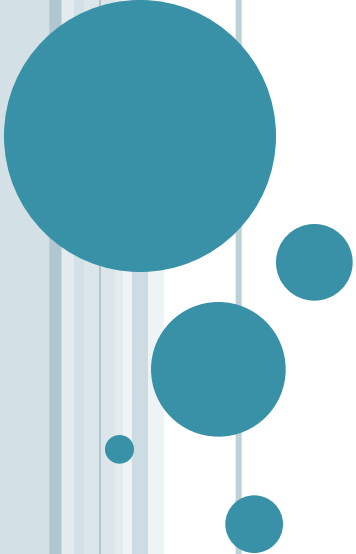


# MEASUREMENT OF ANGULAR VELOCITY



**Prof. N. D. Mehta**  
**Assistant Professor,**  
**Department of Power Electronics Engineering ,**  
**Vishwakarma Government Engineering College,**  
**Chandkheda - 382424**

# MEASUREMENT OF ANGULAR VELOCITY

- Velocity is the first derivative of displacement.
- It is mainly categorized as **linear** and **angular** velocity.
- There are various methods to measure linear velocity and they are less complicated.
- We will learn the methods of measuring angular velocity in different work environments using appropriate Tachometers.



# MEASUREMENT OF ANGULAR VELOCITY

- Necessity of Angular Velocity Transducer
- As the mechanical industry has been growing since the invention of the steam engine in 1781 by James Watt, there has been a need to measure the speed of the engine's crankshaft.
- This need was fulfilled by **Dietrich Uhlhorn** in 1817 by inventing the Tachometer. Since 1840 it is significantly used for angular velocity measurement till date.

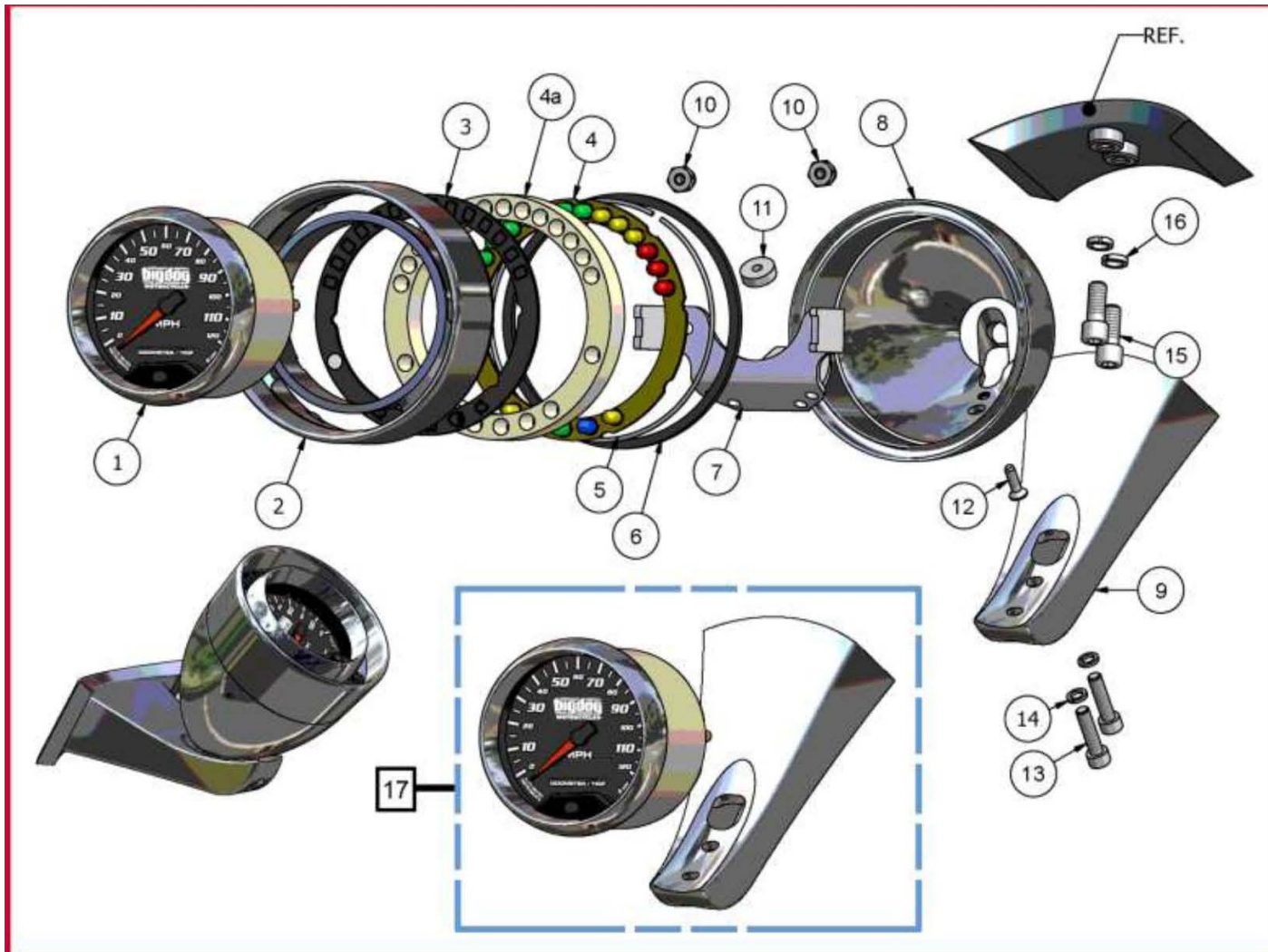


# MEASUREMENT OF ANGULAR VELOCITY

- In many cases the linear velocity is to convert into angular velocity.
- For example speedometer uses the wheel rotational speed as a measure of the linear road speed.
- The disadvantage with measurement of linear velocity arises because a fixed reference must be used and if the moving object has to travel large distance, the detection become impossible.



# MEASUREMENT OF ANGULAR VELOCITY



# MEASUREMENT OF ANGULAR VELOCITY

## ○ TACHOMETER

### ○ Tachometer is –

- An instrument used for measurement of angular velocity, as of shaft ,either by registering the total number of revolutions during the period of contact, or by indicating directly the number of revolutions per minute.
- An instrument which either continuously indicates the value of rotary speed or displays a reading of average speed over rapidly operated short intervals of time.



# MEASUREMENT OF ANGULAR VELOCITY

- Tachometers can be classified

  - On the basis of data acquisition

    - Contact
    - Non contact

  - On the basis of the measurement technique

    - Time based
    - Frequency based

  - On the basis of method of display

    - Digital
    - Analog

  - On the basis of working principle

    - Electrical
    - Mechanical
    - Non contact type



# MEASUREMENT OF ANGULAR VELOCITY

## **Mechanical Tachometers**

- ❑ Revolution counter and timer
- ❑ Tachoscope
- ❑ Hand speed indicator
- ❑ Slipping clutch tachometer
- ❑ Centrifugal force tachometer
- ❑ Vibration reed tachometer





# MEASUREMENT OF ANGULAR VELOCITY

## Electrical tachometers

- ❑ Drag cup tachometer
- ❑ Commutated capacitor tachometer
- ❑ Tachogenerators
- ❑ DC – Tachogeneraor
- ❑ AC – Tachogeneraor



# MEASUREMENT OF ANGULAR VELOCITY

## Contact Less Electrical Tachometers

- ❑ Inductive pick up tachometer
- ❑ Stroboscope tachometer
- ❑ Photoelectric tachometer
- ❑ Capacitor tachometer



# MEASUREMENT OF ANGULAR VELOCITY

□ Electrical Tachometer :

□ Electrical tachometers mainly depend upon an electrical signal generated in proportion to the rotational speed of the shaft. Depending upon the type of transducer used there is a variety of different designs.



# MEASUREMENT OF ANGULAR VELOCITY

- ❑ Electrical Tachometer :

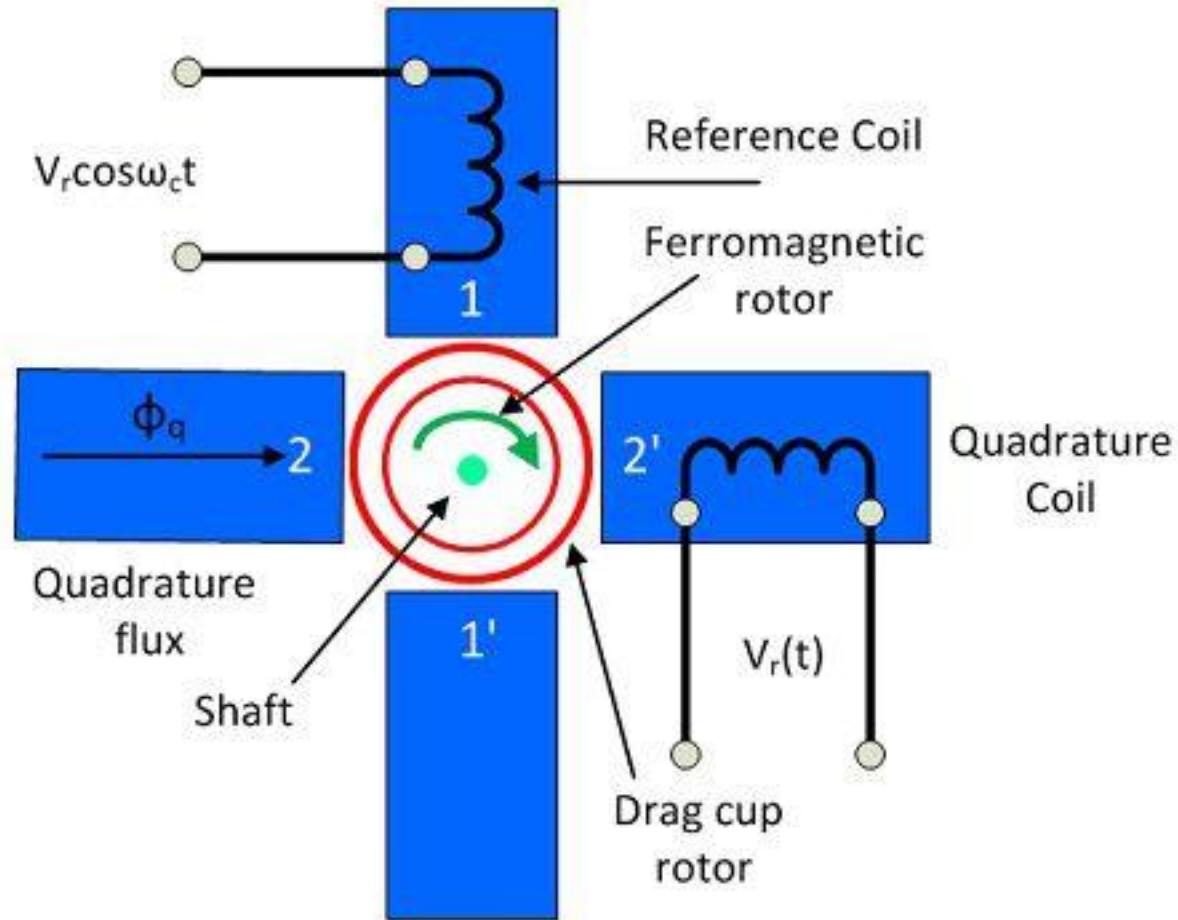
- ❑ Drag cup tachometer basically consists of stator and a rotor. The stator has two windings mounted at 90° to each other known as

- ❑» Reference Winding » Quadrature winding

- ❑ A low reluctance path is provided by a ferromagnetic core.



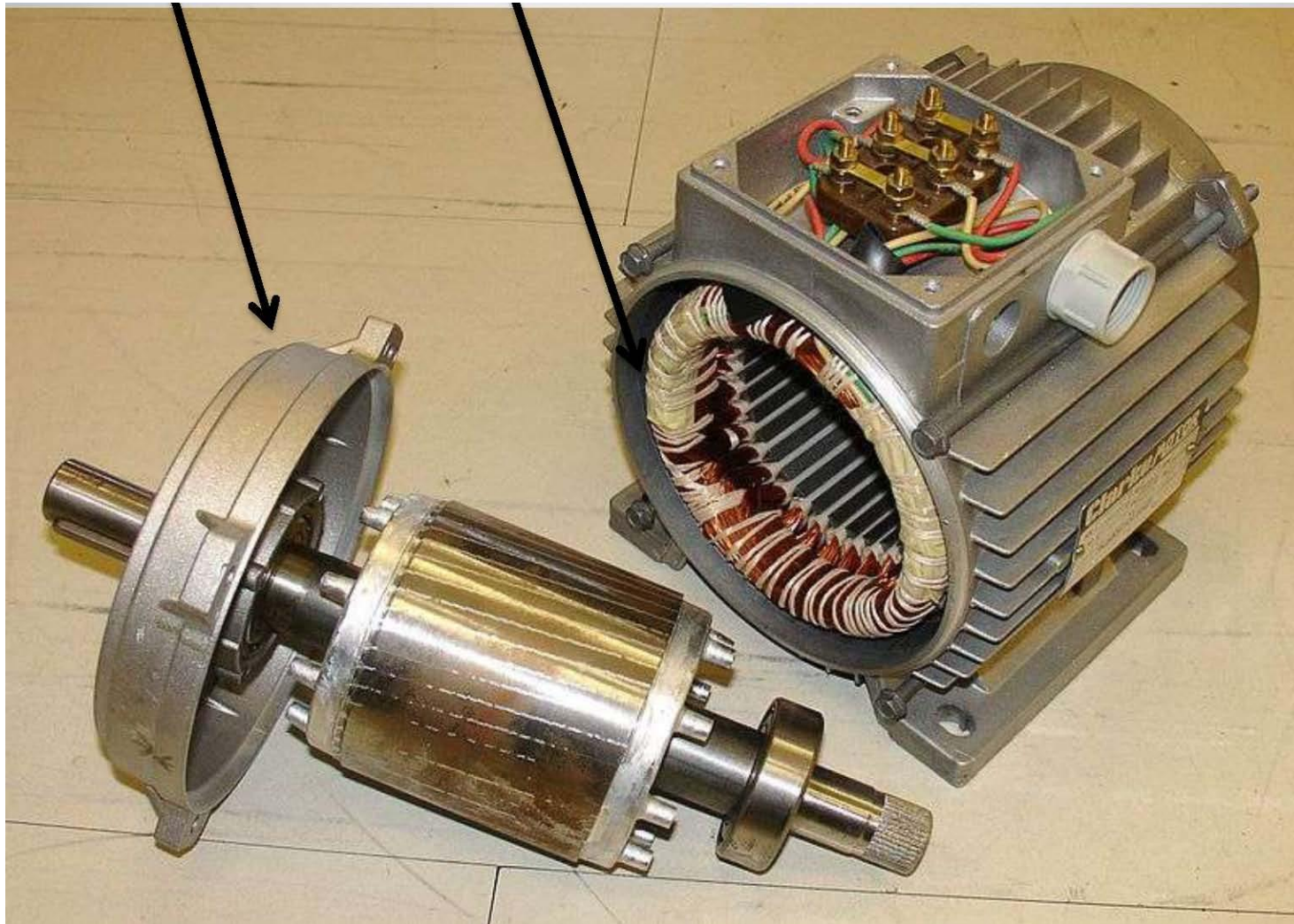
# MEASUREMENT OF ANGULAR VELOCITY



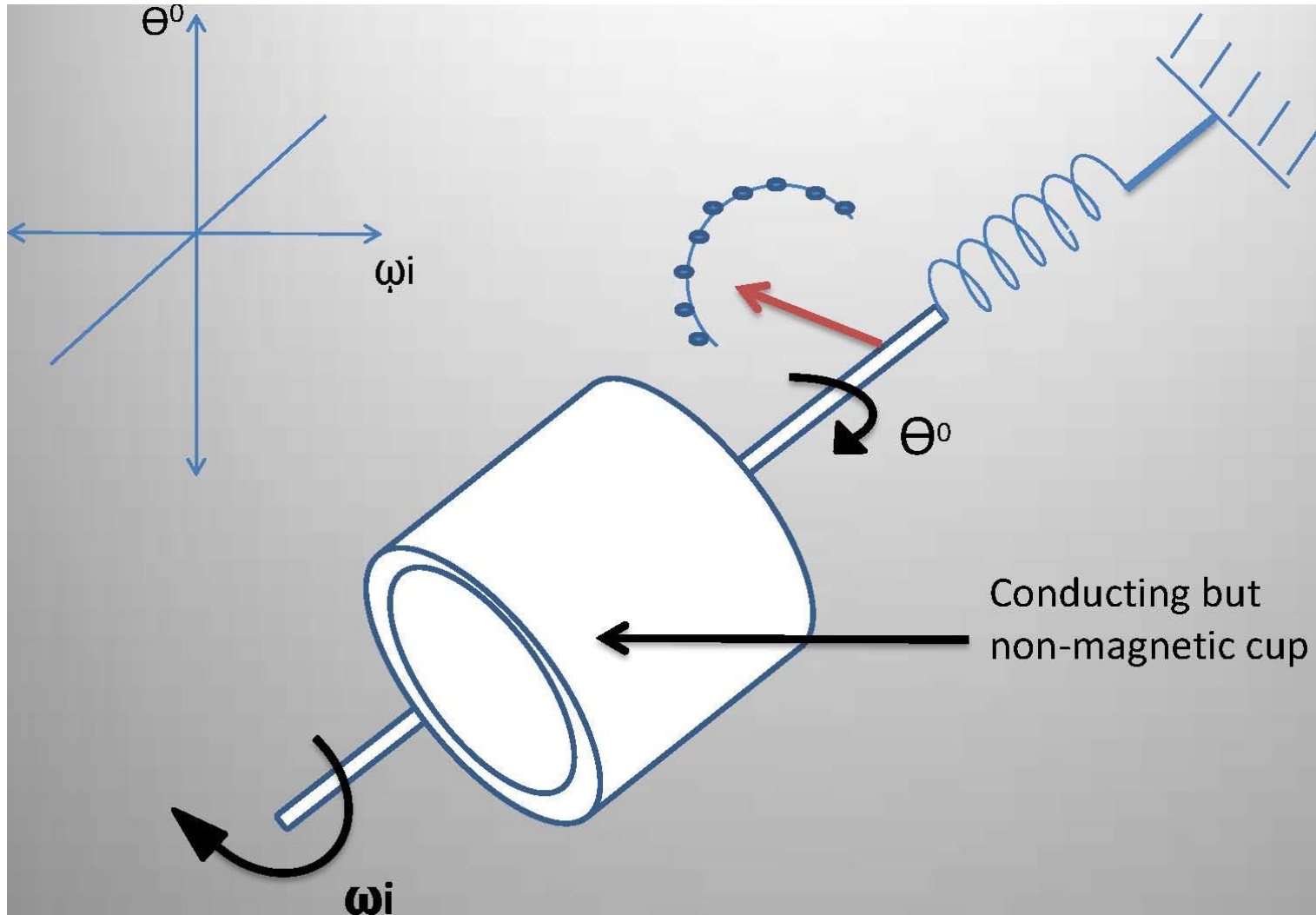
**A.C Tachometer Generator**



# MEASUREMENT OF ANGULAR VELOCITY



# MEASUREMENT OF ANGULAR VELOCITY



# MEASUREMENT OF ANGULAR VELOCITY

❑ Construction and Working :

❑ Rotor is made up of thin aluminum cylinder which is called drag cup. This rotor is highly conducting and acts as short-circuited secondary winding.

❑ An A.C voltage is applied to the AC winding, while the output is taken from the quadrature winding.

❑ The driving shaft rotates the permanent magnet and this induces eddy current in a drag cup held closed to the magnet.

❑ The eddy current produce a torque which rotates the cup against the torque of spring.





# MEASUREMENT OF ANGULAR VELOCITY

## ❑ Construction and Working:

❑ The cup turns in the direction of the rotating magnetic field until the torque developed equals that of the spring which results into turning of the pointer. The driving shaft rotates the permanent magnet and this induces eddy current in a drag cup held closed to the magnet.

❑ The eddy current produces a torque which rotates the cup against the torque of spring.

❑ The cup turns in the direction of the rotating magnetic field until the torque developed equals that of the spring which results into turning of the pointer.



# MEASUREMENT OF ANGULAR VELOCITY

## ❑ Advantage

❑ With the help of phase sensitive demodulator, the tachometer can show the difference in the direction of applied speed.

❑ A linear relationship can be derived between output voltage and speed by carrier frequency excitation.

❑ They are rugged and inexpensive.

❑ Need less maintenance.

❑ Ripple free output.

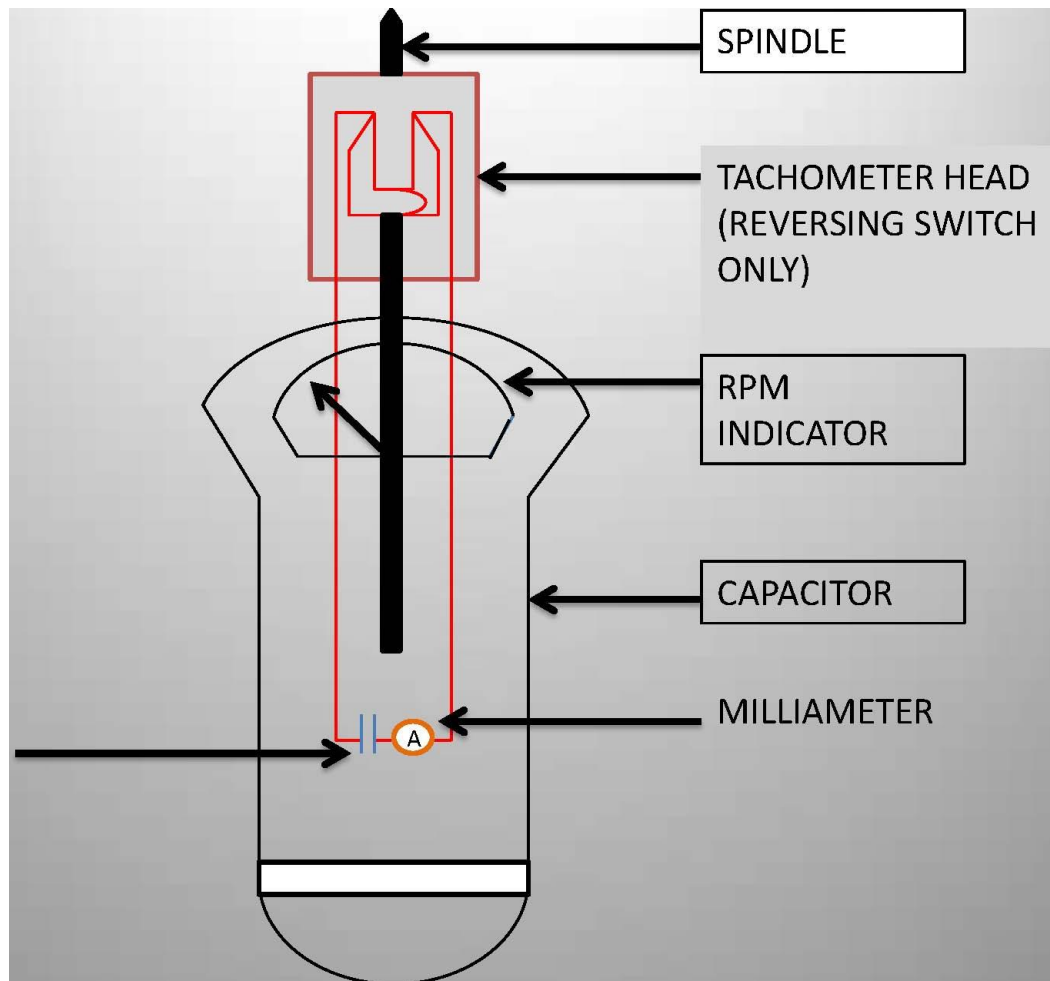


# MEASUREMENT OF ANGULAR VELOCITY

- ❑ Disadvantage
- ❑ Calibration is difficult as the input voltage should be maintained absolutely constant.
- ❑ At high speed there is a non linear relationship between output voltage and input speed. Hence we need to excite the reference winding with higher frequency



# MEASUREMENT OF ANGULAR VELOCITY



# MEASUREMENT OF ANGULAR VELOCITY

## Commutated Type Tachometer

❑ Construction and Working :

❑ Tachometer head containing a reversible switch, operated by a spindle which reverses two times with one revolution.

❑ Indicating unit, voltage source, capacitor, a millimeter and a calibrated circuit

❑ Tachometer head containing a reversible switch, operated by a spindle which reverses two times with one revolution.

❑ Indicating unit, voltage source, capacitor, a millimeter and a calibrated circuit



# MEASUREMENT OF ANGULAR VELOCITY

## Commutated Type Tachometer

- ❑ It's operation is based on alternatively charging and discharging capacitance.
- ❑ When the switch is closed in one direction, the capacitor gets charged from D.C supply and the current starts flowing through the ammeter.
- ❑ When the spindle operates the reversing switch to close it in opposite direction, capacitor discharges through the ammeter with the current flow direction remaining the same.
- ❑ The indications proportional to the rate of reversal of contacts which in turn are proportional to the speed of the shaft and reflected on the scale accordingly.

# MEASUREMENT OF ANGULAR VELOCITY

## Tachogenerators:

❑ An Electromechanical generator is a device capable of producing electrical power from mechanical energy, usually of a shaft. When not connected to a load resistance, generators will generate voltage roughly proportional to speed of shaft. They employ small magnet type DC or AC generator which convert rotational speed into DC or AC voltage signals.

❑ Magnitude of the voltage generated by relative perpendicular motion between the magnetic field and a conductor is a direct function of the strength of the magnetic field and the speed of the conductor.

❑ Speed is measured with a moving coil voltmeter.

# MEASUREMENT OF ANGULAR VELOCITY

Tachogenerator:

## **DC TACHOGENERATORS**

❑ The construction consists of a horse shoe type permanent magnet.

## **AC TACHOGENERATORS**

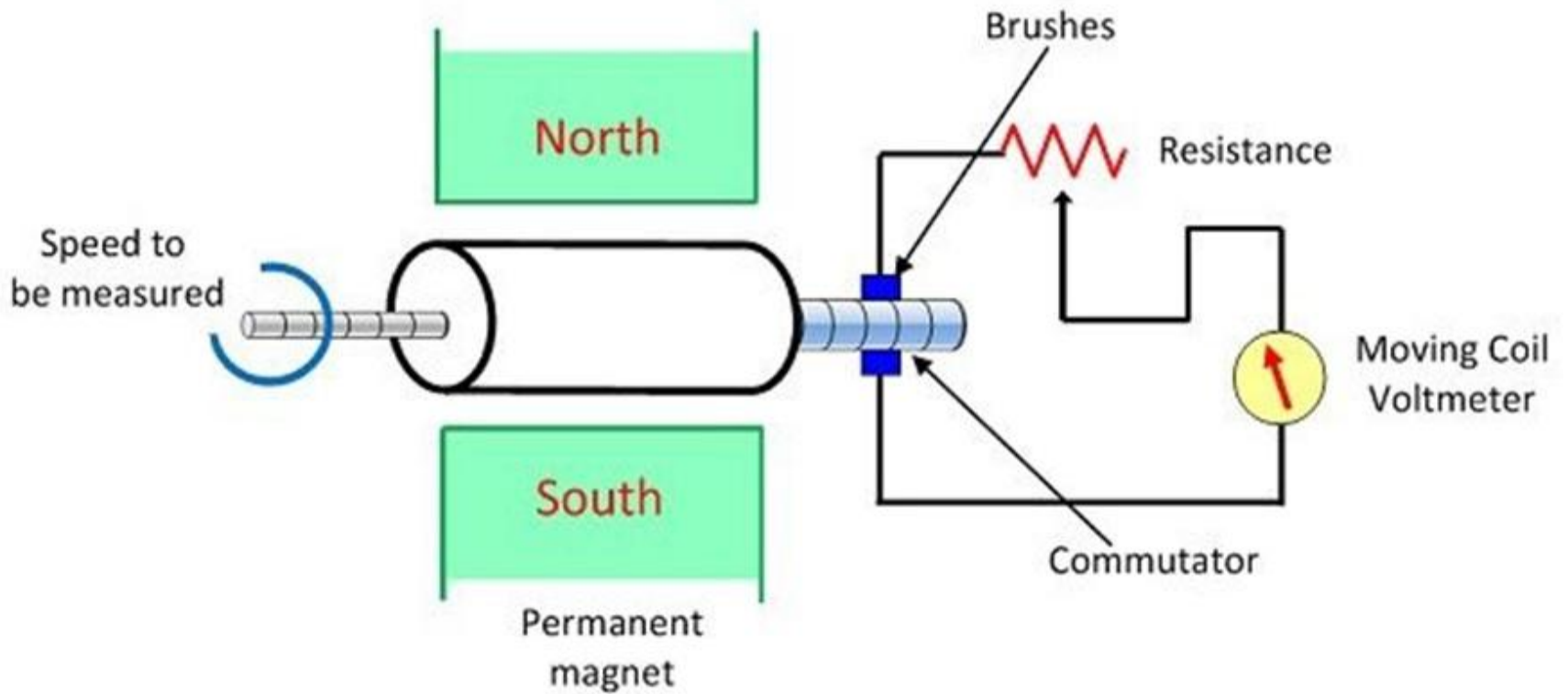
❑ It consists of a stator and a rotor arrangement or a squirrel cage setup.

❑ Speed is measured with a moving coil instrument either a permanent magnet or an electromagnet.



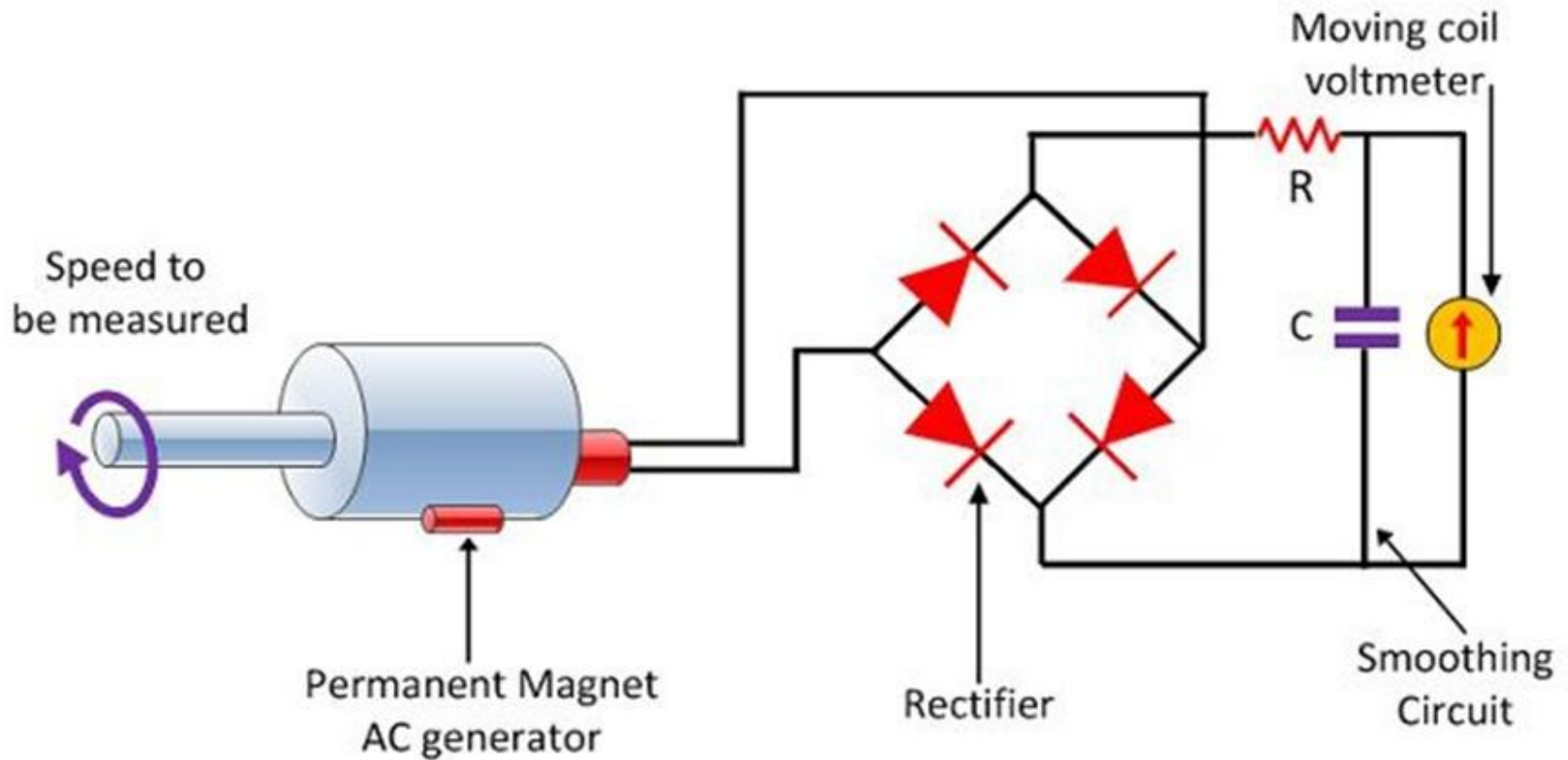


# MEASUREMENT OF ANGULAR VELOCITY



DC Tachometer Generator

# MEASUREMENT OF ANGULAR VELOCITY



**A.C Tachometer Generator**

# MEASUREMENT OF ANGULAR VELOCITY

## ADVANTAGE OF TACHOGENERATORS

### DC type

- A conventional setup reduces the installation cost
- The direction of voltage is directly indicated by the polarity of the output voltage

### AC type

- Increased output at same speed as compared to DC tachogenerators.
- Accurate to  $\pm 1\%$
- Installable in inaccessible region.



# MEASUREMENT OF ANGULAR VELOCITY

## DISADVANTAGE OF TACHOGENERATORS

### DC type

- Brushes produce maintenance cost and labor.
- The assembly requires maintenance
- If the field of the permanent magnet is distorted it gives rise to non linearity.

### AC type

- Frequency of output voltage is low at low speed.
- At high frequencies the impedance of the coils increases.



# MEASUREMENT OF ANGULAR VELOCITY

AC TACHOGENERATOR	DC TACHOGENERATOR
The AC Tachogenerator is used to measure speed only in one direction .	The DC Tachogenerator is used to measure speed in both direction
It consists of a stator and rotor arrangement or a squirrel cage setup .	It consists of horse shoe type permanent magnet
It needs rectifier to convert AC output into DC.	Output is in DC from therefore no need of rectifier.
No problem of brush friction and brush bounce.	It suffer from wear and tear brushes at high speed.
Ripple are reduced.	Small ripple are appearing at output .
Maintenance is difficult.	Easy to maintain.

# MEASUREMENT OF ANGULAR VELOCITY

AC TACHOGENERATOR	DC TACHOGENERATOR
Reversal of rotation causes the same action except there is a 180 degree phase shift.	Reversal of rotation causes the voltmeter to show a negative reading , hence keeping the pointer on the mid scale speeds in both the directions can be displayed.
Change in the direction of the rotation causes phase shift.	Direction of rotation is directly indicated by polarity of the output voltage.
Conventional voltmeters can be used as indicators.	Output voltage is rectified with a permanent magnet moving coil instrument.




# MEASUREMENT OF ANGULAR VELOCITY

## Photoelectric Tachometer

□ The tachometer which uses the light for measuring the speed of rotation of shaft or disc of machines is known as the photoelectric tachometer. The opaque disc with holes on its periphery, light source and laser are the essential parts of the photoelectric tachometer.

□ The tachometer consists the opaque disc which is mounted on the shaft whose speed needs to be measured. The disc consists the equivalent holes around the periphery. The light source is placed on one side of the disc and the light sensor on the other side. They are in line with the each other.



# MEASUREMENT OF ANGULAR VELOCITY

## Photoelectric Tachometer

□ When the disc rotates their holes, and the opaque portion comes alternatively between the light source and light sensor. When the holes come in the line of the light source and the light sensor, then the light passes through the holes and collapse to the sensor. Hence the pulse is generated. These pulses are measured through the electric counter.





# MEASUREMENT OF ANGULAR VELOCITY

## Photoelectric Tachometer

❑ When the opaque portion comes in the line of light source and sensor, then the disc blocked the light source, and the output becomes zero. The production of pulses depends on the following factor.

❑ The number of holes on the disc.

❑ The speed of rotation of the disc.

❑ The holes are fixed, and hence the pulse generation depends on the speed of the rotation of the disc. The electronic counter is used for measuring the pulse rate.



# MEASUREMENT OF ANGULAR VELOCITY

## Photoelectric Tachometer

### Advantages of Photoelectric Tachometer

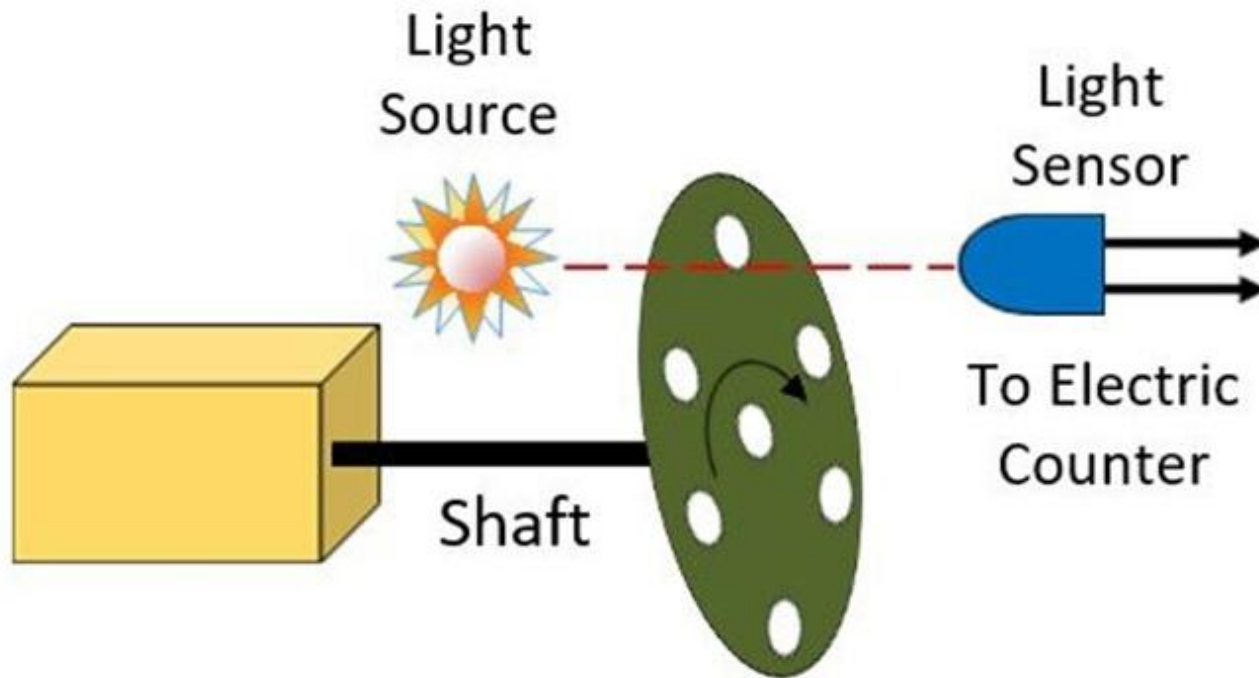
- ❑ The digital output voltage is obtained, and hence there is no need of analogue to digital conversion.
- ❑ The pulses of constant amplitude are obtained which simplify the electronic circuitry.

### Disadvantages of Photoelectric Tachometer

- ❑ The life of the light source is approximately 50,000 hours. Hence the light source needs to be replaced timely.
- ❑ The accuracy of this method depends on the error which is represented by the unit pulse. These errors can be minimized by using the gating period. The gating period means the meter measures the frequency by counting the input pulses.

# MEASUREMENT OF ANGULAR VELOCITY

The total number of pulses generated at one revolution is also used for minimizing the error.



Photoelectric Tachometer



# QUERIES ?



