# Basic Electrical Engineering (TEE 101)

## Lecture 50: Classification of DC Machines and EMF Equation

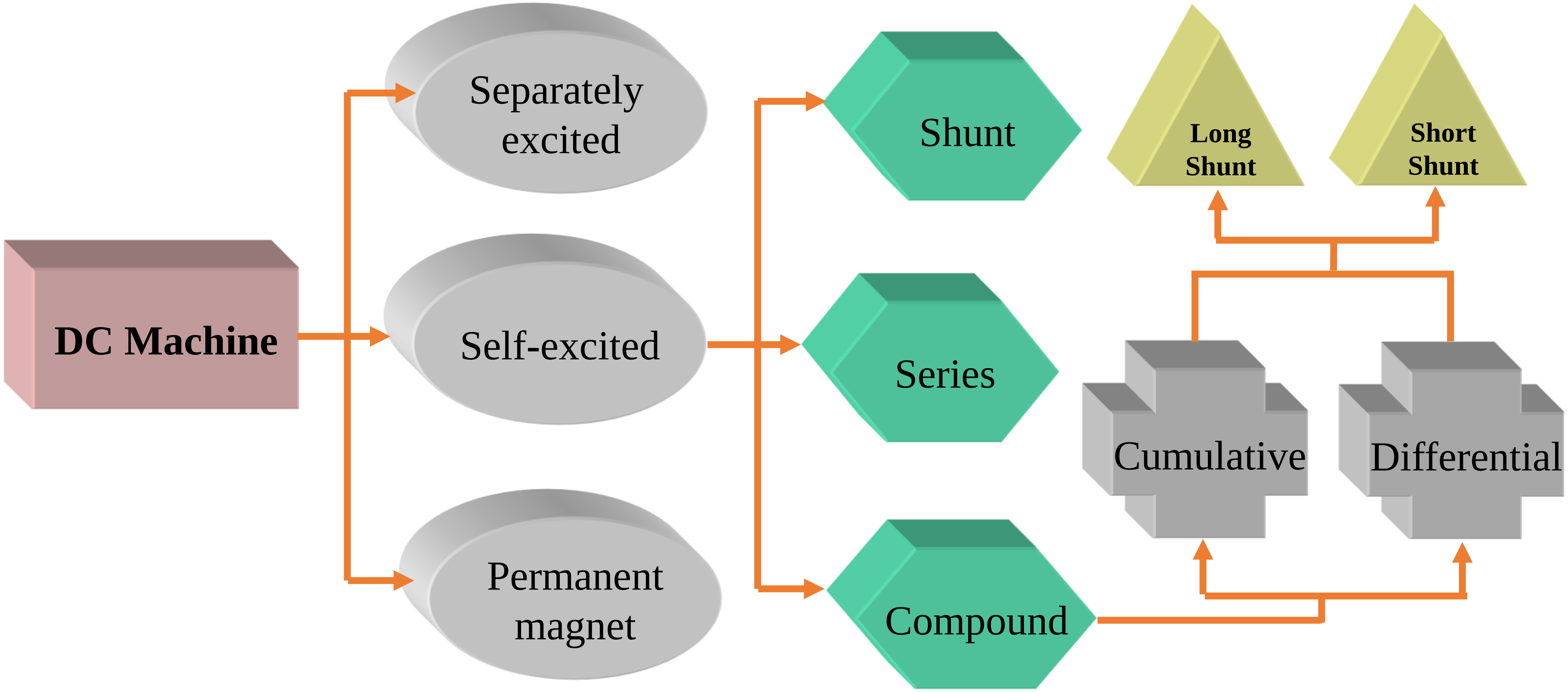
By: Dr. Parvesh Saini

# Content

**This lecture covers:**

- Types of DC Machine
- EMF Equation of DC Machine (Generator)
- BACK EMF (Motor)

# Classification of DC Machines

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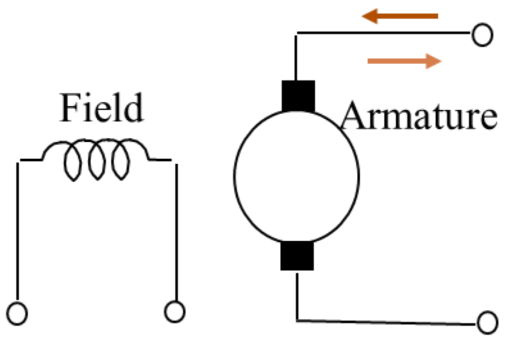
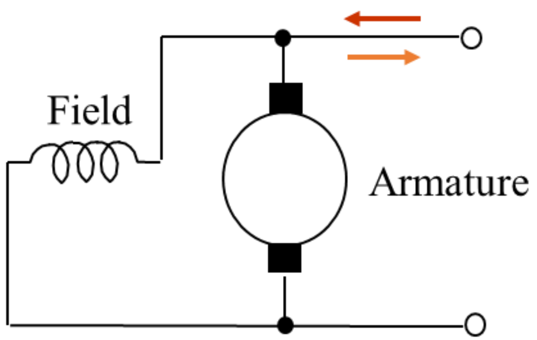
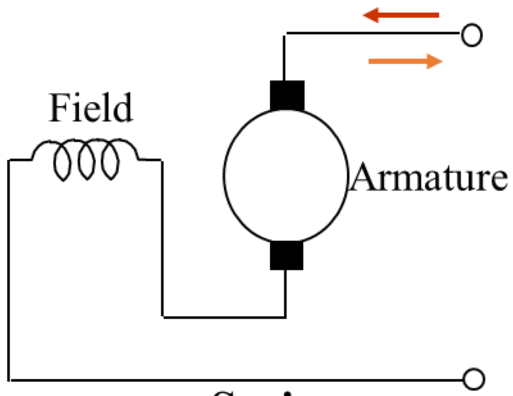
# Classification of DC Machines




**Separately excited**

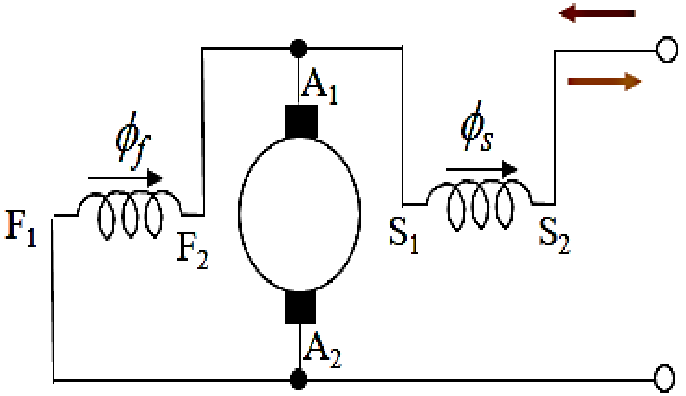



**Shunt**



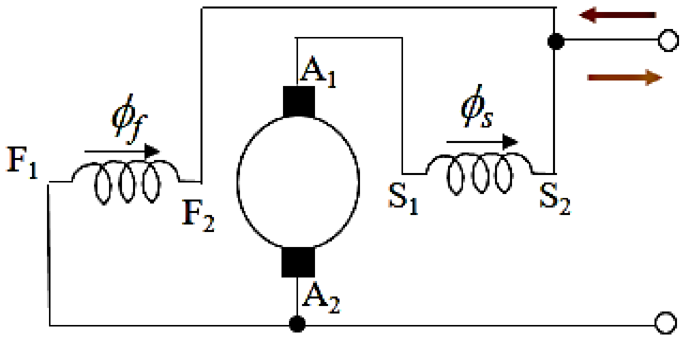

**Series**

**Motor operation**
**Generator operation**



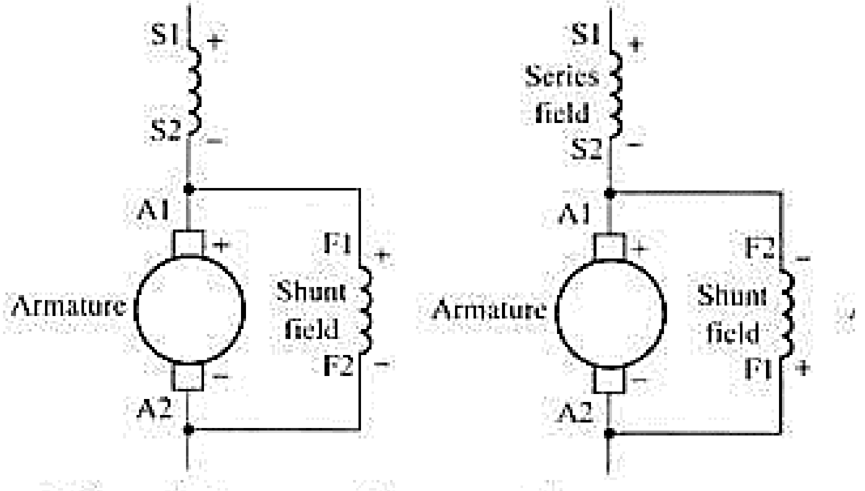

**Short-shunt**

**Shunt across armature**




**Long-shunt**

**Shunt across supply**




(a) Cummulative compound (b) Differential compound

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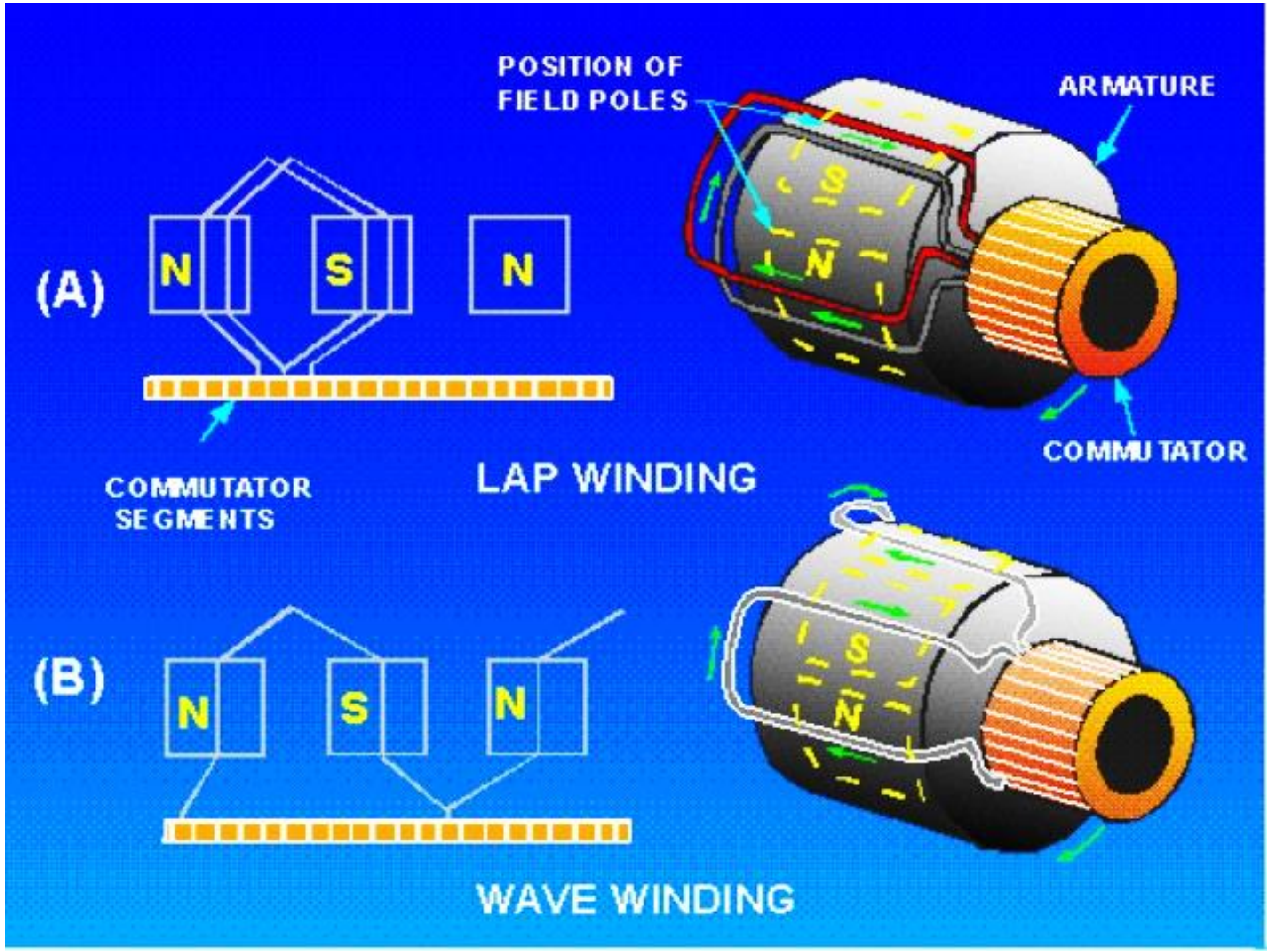
# Field Windings

- **Shunt Winding** - Connected in parallel with the armature.
- **Shunt winding** has large number of turns (high voltage winding, because it is connected in parallel with the armature)
- The current through the **shunt windings** is about 5% of the rated armature current. (thin wires)
- **Series Windings** - Connected in series with the armature.
- Series windings has small number of turns (carries high current, thick wires)
- In **short shunt** connection the shunt field is connected directly across the armature terminals.
- In this instance the load current flows through the series field winding so that the load current and series field current are one and same.
- **Long shunt**, where the **shunt** is in parallel with both armature and series field . Since the **shunt** winding is done in such a way as to assist both armature and series field producing cumulative effect. this machine is known as cumulative compound motor.

# EMF Equation of DC Generator

The basic essential parts of an electrical generator are:
(i) A magnetic field. and
(ii) A conductor/conductors which can so move to cut the flux.




Let
$p$ = number of poles,
$\varphi$ = flux/pole, webers (Wb),
$Z$ = total number of armature conductors, = number of slots × number of conductors/slot,
$N$ = rotational speed of armature, r.p.m.,
$a$ = number of parallel paths in armature

**a = p ...... for lap winding**

**a = 2 ...... for wave winding.**

$E_g$ = generated e.m.f. *per parallel path in armature*.

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Average e.m.f. generated per conductor = $\frac{d\phi}{dt}$ volt.

Now, flux cut per conductor in one revolution, $d\phi = p\phi$ Wb.

Number of revolutions/second = $\frac{N}{60}$

$\therefore$ Time for one revolution, $dt = \frac{60}{N}$ seconds

Hence, according to Faraday's laws of electromagnetic induction,

E.m.f. generated per conductor = $\frac{p\phi N}{60}$ volts.

**The number of conductors connected in series in each parallel path = Z/a.**

**Therefore, the average induced e.m.f across each parallel path or the armature terminals is given by the equation shown below:**

In general, generated e.m.f.

$$E_g = \frac{\phi Z N}{60} \times \left(\frac{p}{a}\right) \text{ volt} = \frac{p\phi Z N}{60a}$$

**For a lap wound generator :**

Number of parallel paths, $a = p$

Number of conductor (*in series*) in one path $= \dfrac{Z}{p}$

$$\therefore \text{ E.m.f. generated } per\ path = \frac{\phi p N}{60} \times \frac{Z}{p} = \frac{\phi Z N}{60} \text{ volt.}$$

**For a wave wound generator :**

**Number of Parallel paths, a = 2**

Number of conductor (in series) in one path $= \dfrac{Z}{2}$

$$\therefore \text{ E.m.f. generator per path} = \frac{p\phi N}{60} \times \frac{Z}{2} = \frac{p\phi Z N}{120} \text{ volt.}$$

# Back EMF Equation in DC Motor

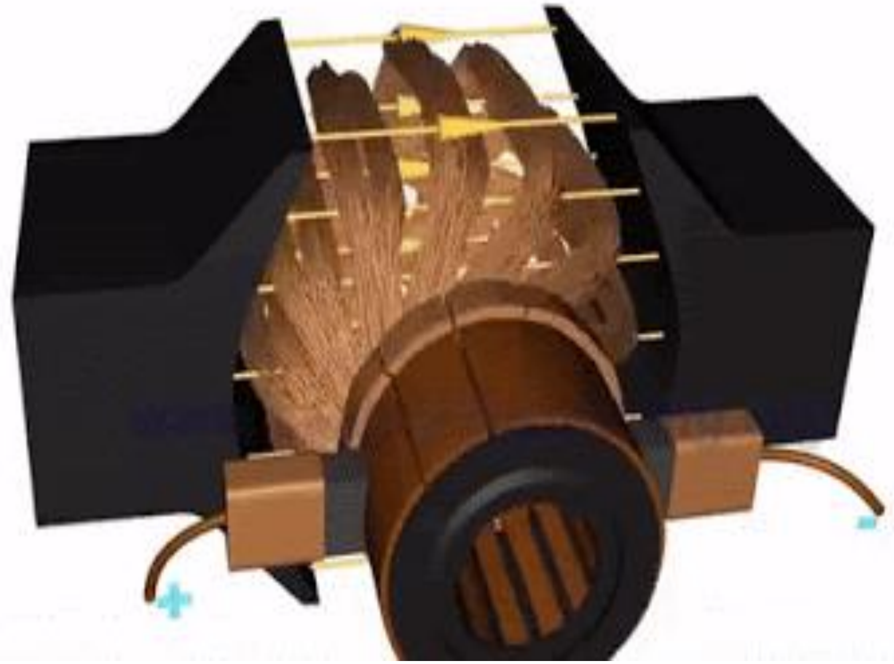
**As the armature rotates, a voltage is generated in its coils.**

**In the case of a generator, the emf of rotation is called the Generated emf or Armature emf and is denoted as Er = Eg.**

**In the case of a motor, the emf of rotation is known as Back emf or Counter emf and represented as Er = Eb.**

If the DC Machine is working as a Motor, the induced emf is given by the equation shown below:

$$E_b = \frac{p\phi ZN}{60a} \quad Volts$$



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# Thank You