EEE363

Electrical Machines

Lecture # 3

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Example 26.1. *Draw a developed diagram of a simple 2-layer lap-winding for a 4-pole generator with 16 coils. Hence, point out the characteristics of a lap-winding.*

Solution. The number of commutator segments = 16

Number of conductors or coil sides $16 \times 2 = 32$; pole pitch = 32/4 = 8

Now remembering that (*i*) Y_B and Y_F have to be odd and (*ii*) have to differ by 2, we get for a progressive winding $Y_B = 9$; $Y_F = -7$ (retrogressive winding will result if $Y_B = 7$ and $Y_F = -9$). Obviously, commutator pitch $Y_C = -1$.

[Otherwise, as shown in Art. 26.26, for progressive winding

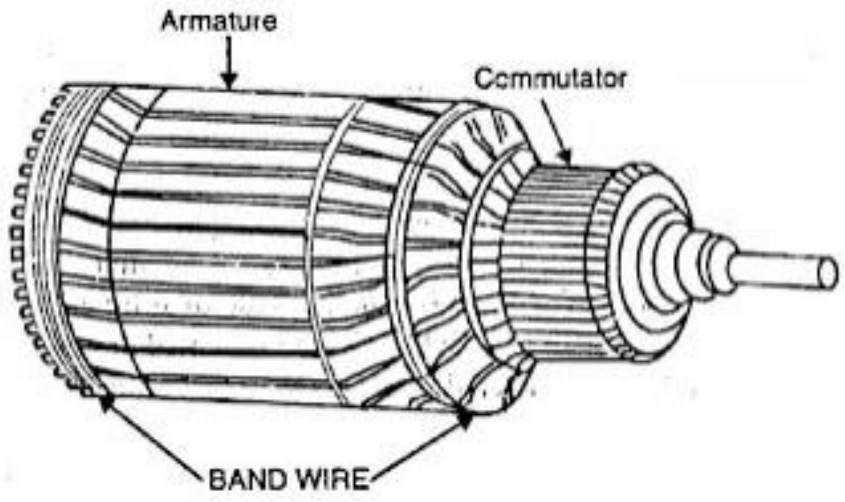
$$Y_F = \frac{Z}{P} - 1 = \frac{32}{4} - 1 = 7 \text{ and } Y_B = \frac{Z}{P} - 1 = \frac{32}{4} + 1 = 9]$$

The simple winding table is given as under :

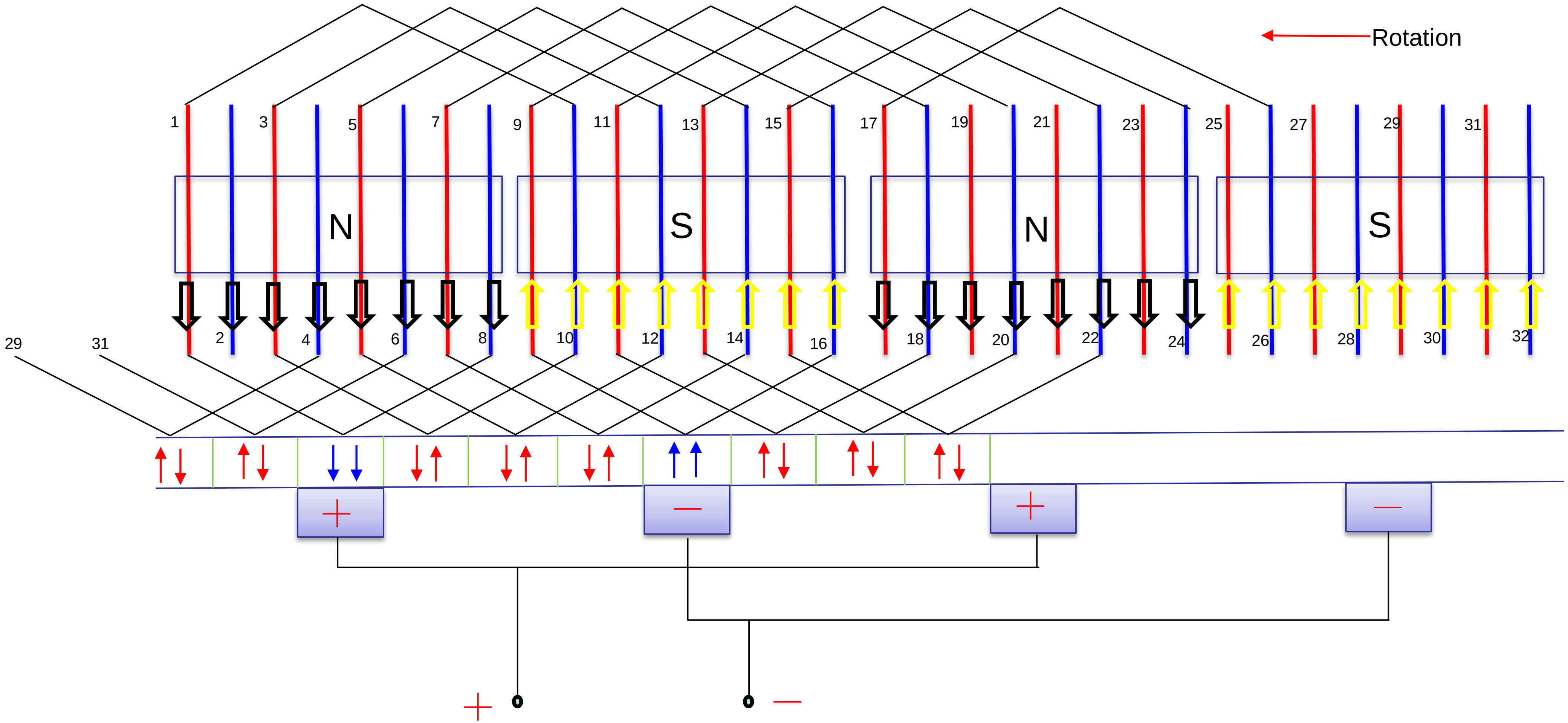
Back Connections		*Front Connections*
1 to (1 + 9) = 10	$\longrightarrow$	10 to (10 − 7) = 3
3 to (3 + 9) = 12	$\longrightarrow$	12 to (12 − 7) = 5
5 to (5 + 9) = 14	$\longrightarrow$	14 to (14 − 7) = 7
7 to (7 + 9) = 16	$\longrightarrow$	16 to (16 − 7) = 9
9 to (9 + 9) = 18	$\longrightarrow$	18 to (18 − 7) = 11
11 to (11 + 9) = 20	$\longrightarrow$	20 to (20 − 7) = 13
13 to (13 + 9) = 22	$\longrightarrow$	22 to (22 − 7) = 15
15 to (15 + 9) = 24	$\longrightarrow$	24 to (24 − 7) = 17
17 to (17 + 9) = 26	$\longrightarrow$	26 to (26 − 7) = 19
19 to (19 + 9) = 28	$\longrightarrow$	28 to (28 − 7) = 21

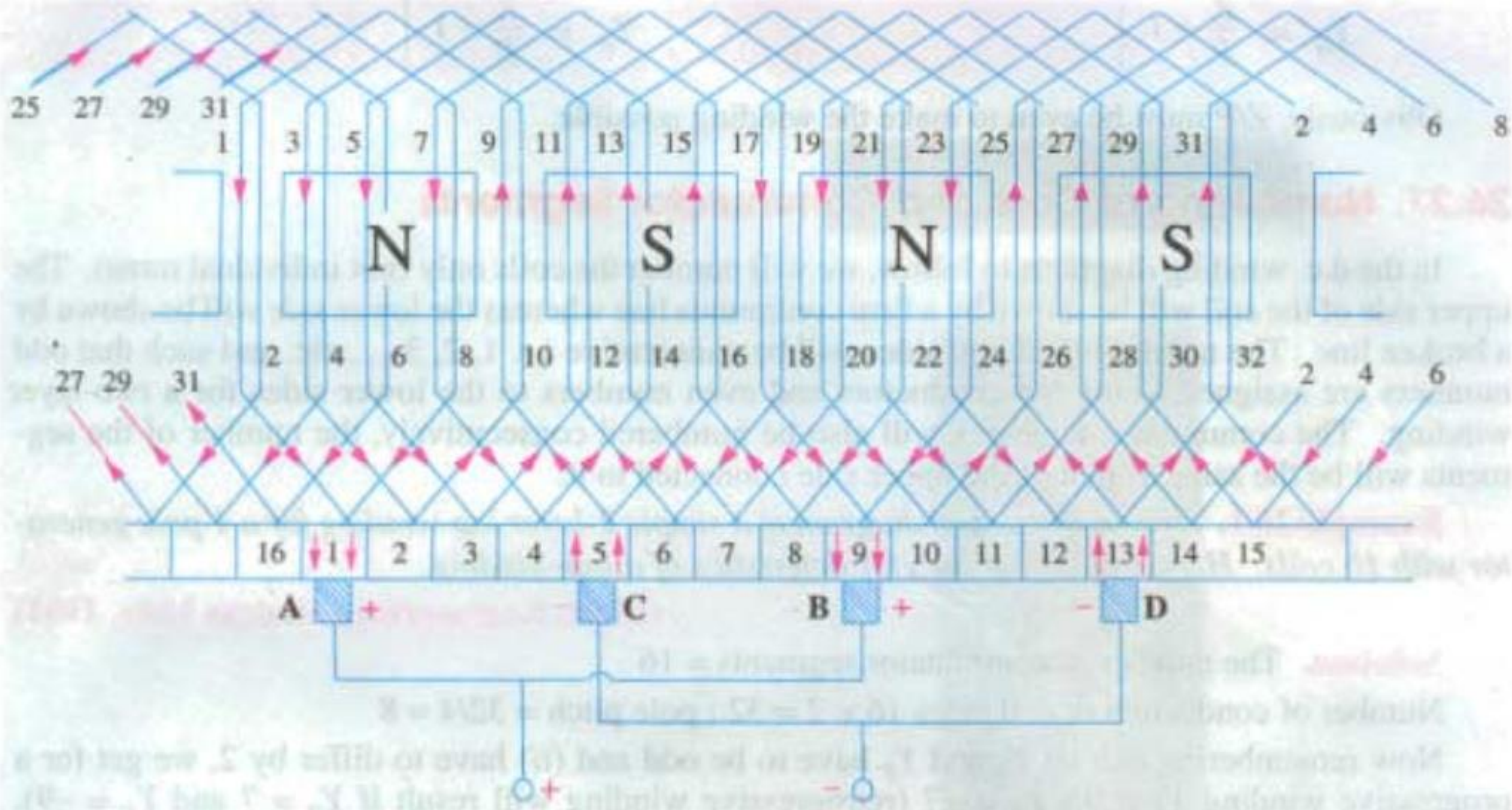
21 to (21 + 9) = 30	$\longrightarrow$	30 to (20 − 7) = 23
23 to (23 + 9) = 32	$\longrightarrow$	32 to (32 − 7) = 25
25 to (25 + 9) = 34 = (34 − 32) = 2	$\longrightarrow$	2 to (34 − 7) = 27
27 to (27 + 9) = 36 = (36 − 32) = 4	$\longrightarrow$	4 to (36 − 7) = 29
29 to (29 + 9) = 38 = (38 − 32) = 6	$\longrightarrow$	6 to (38 − 7) = 31
31 to (31 + 9) = 40 = (40 − 32) = 8	$\longrightarrow$	8 to (40 − 7) = 33 = (33 − 32) = 1

The winding ends here because we come back to the conductor from where we started.


Armature
Commutator
BAND WIRE

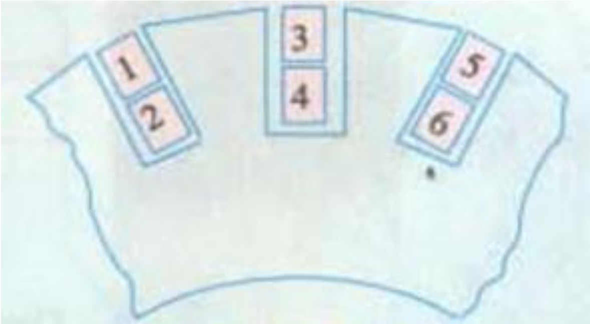
Winding diagram

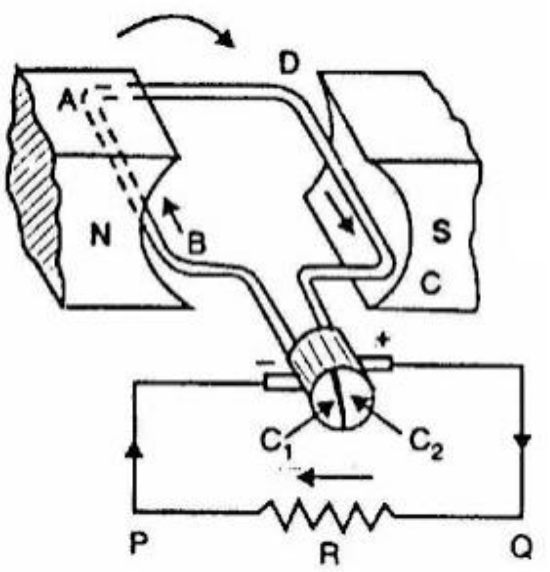



25 27 29 31
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31
2 4 6 8
N
S
N
S
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
27 29 31
2 4 6
16 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
A
C
B
D
+
−
+
−
+
−

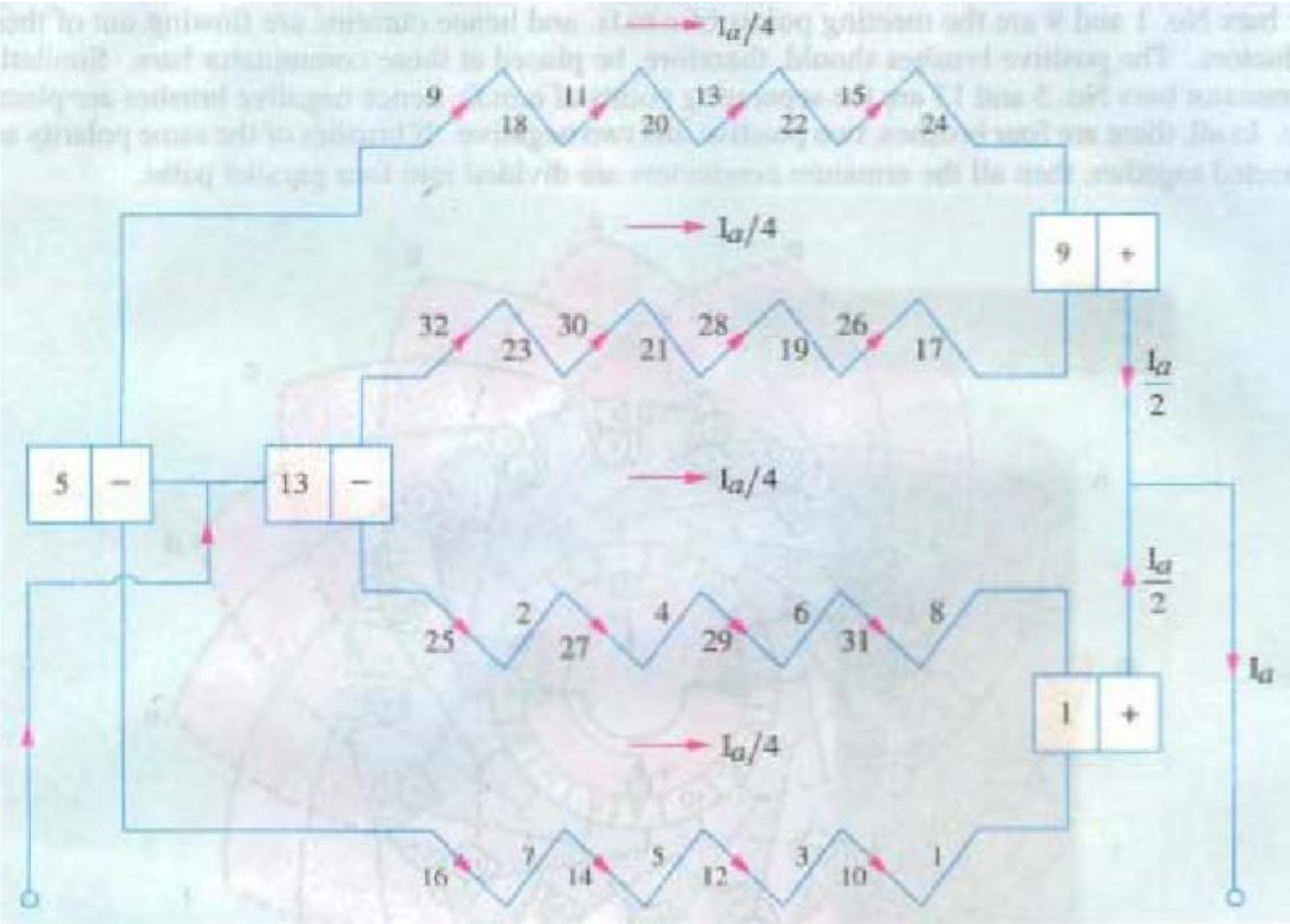
Two layer winding

One at the upper level, another at the lower





Parallel paths



EMF equation

φ= flux/pole in Wb
Z = total number of armature conductors
P = number of poles
A = number of parallel paths = 2 ... for wave winding
= P ... for lap winding
N = speed of armature in r.p.m.
E_g = e.m.f. of the generator = e.m.f./parallel path

Flux cut by one conductor in one revolution of the armature,

$$d\varphi = P\varphi \text{ webers}$$

Time taken to complete one revolution,

$$dt = 60/N \text{ second}$$

$$\text{e.m.f generated/conductor} = \frac{d\varphi}{dt} = \frac{P\varphi}{60/N} = \frac{P\varphi N}{60} \text{ volts}$$

e.m.f. of generator,

$$E_g = \text{e.m.f. per parallel path}$$

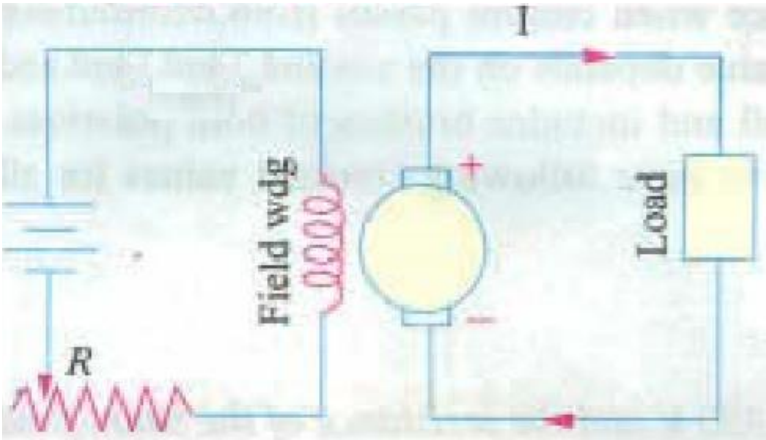
$$= (\text{e.m.f/conductor}) \times \text{No. of conductors in series per parallel path}$$

$$= \frac{P\varphi N}{60} \times \frac{Z}{A}$$

$$E_g = \frac{P\varphi ZN}{60\ A}$$

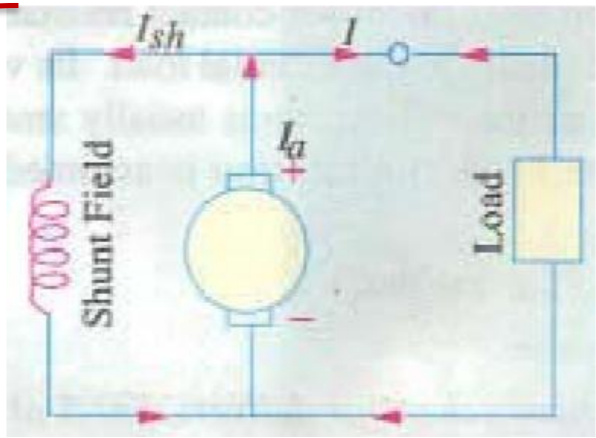
Types of Generator

- Separately excited
- Self excited

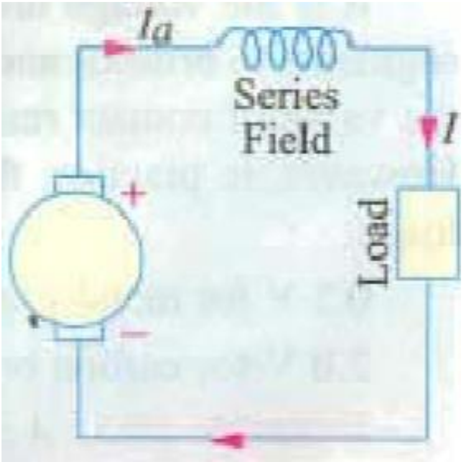


Separately excited

Self excited

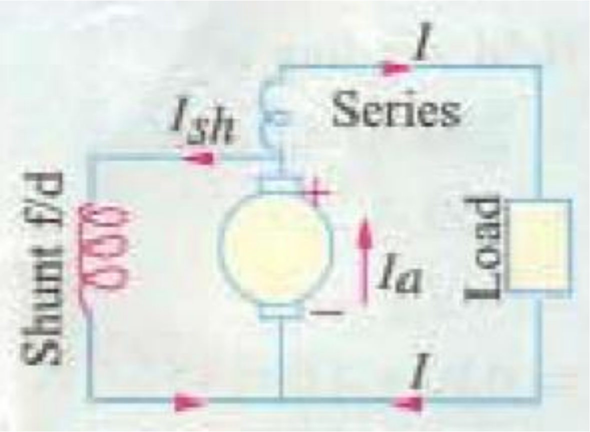


Shunt excitation

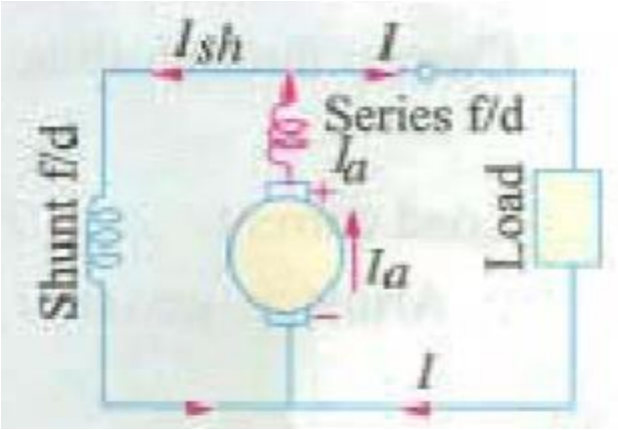


Series excitation

Self excited contd…



Short shunt



Long shunt

Compound excitation