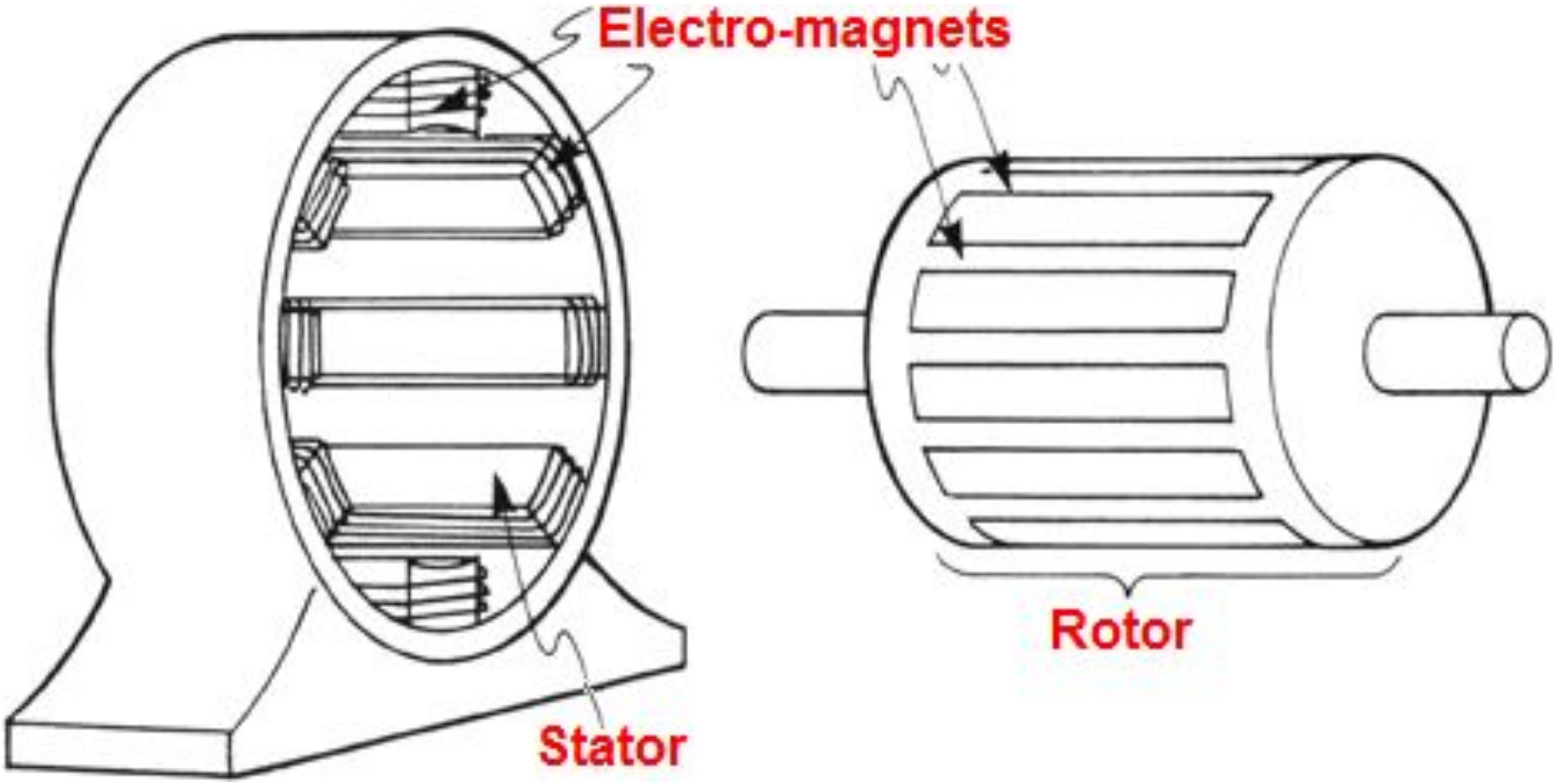
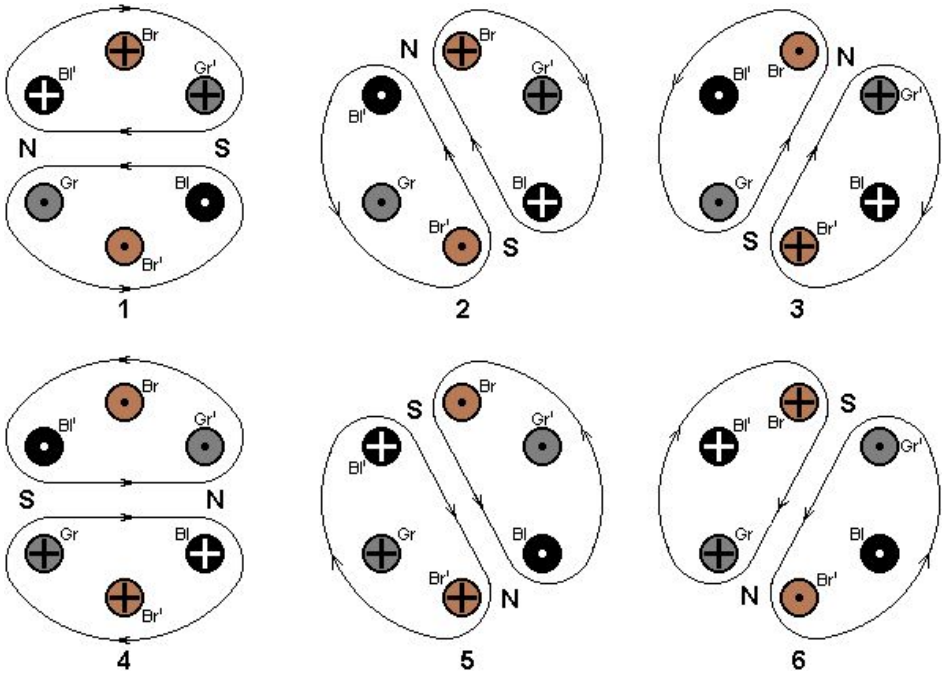
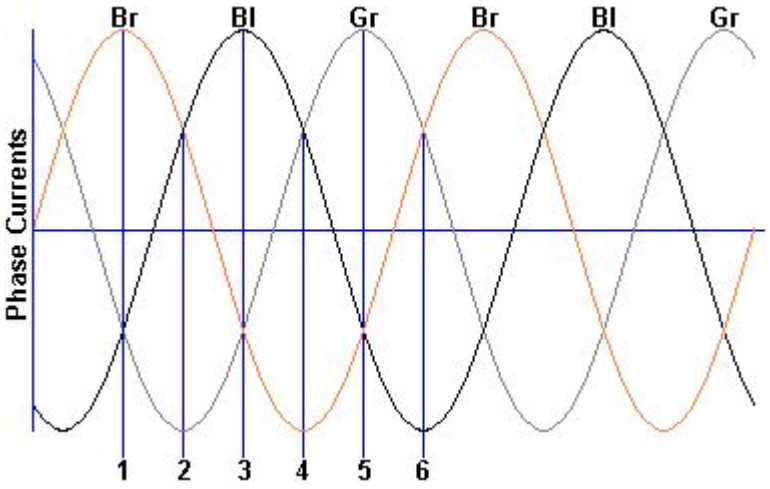
Unit 302: Principles of electrical science

Three-phase AC machines

Motor construction







Synchronous speed

$$N(\text{rps}) = \frac{F}{P} \qquad N(\text{rpm}) = \frac{F \times 60}{P}$$

Where:

N	=	Revolutions rps is revolutions per second rpm is revolutions per minute
F	=	Frequency in Hertz (Hz)
P	=	The number of pairs of poles

EXAMPLE 1 – A four-pole AC three-phase machine is fed with a supply at a frequency of 50Hz. Calculate synchronous speed in:

) rps

) rpm

NB: the machine has four poles, so that is two pairs of poles.

a)

$$\text{rps} = \frac{F}{P}$$

$$= \frac{50}{2}$$

$$= \mathbf{25\ rps}$$

EXAMPLE 1 – A four-pole AC three-phase machine is fed with a supply at a frequency of 50Hz. Calculate synchronous speed in:

) rps

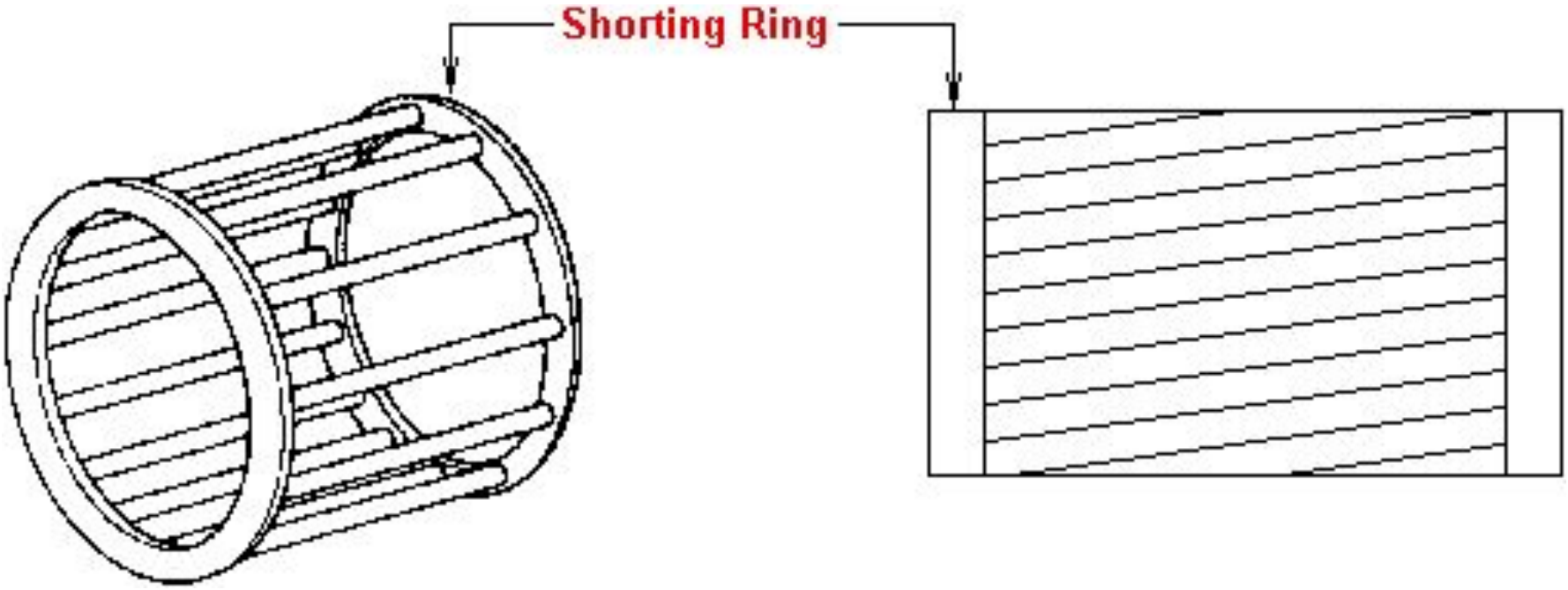
) rpm

b)

$$\text{rpm} = \frac{F \times 60}{P}$$

$$= \frac{50 \times 60}{2}$$

$$= \mathbf{1500\ revs\ per\ minute}$$



Slip

Slip is defined in two ways:

- per unit slip
- % slip

and can be calculated as follows:

$$\text{Per unit slip} = \frac{(n_s - n_r)}{n_s} \qquad \% \text{ slip} = \frac{(n_s - n_r)}{n_s} \times 100$$

Where: n_s = Synchronous speed

n_r = Rotor speed

EXAMPLE 2 – A two-pole induction motor runs at 2880 rpm when connected to the 50 Hz mains supply. Calculate the:

) per unit slip

) percentage slip.

$$\text{Sync speed, } n_s = \frac{F \times 60}{P}$$

$$= \frac{50 \times 60}{1}$$

$$= \mathbf{3000\ rpm}$$

a)

$$\text{Per unit slip, } S = \frac{(n_s - n_r)}{n_s}$$

$$= \frac{(3000 - 2880)}{3000}$$

$$= \mathbf{0.04}$$

EXAMPLE 2 – A two-pole induction motor runs at 2880 rpm when connected to the 50 Hz mains supply. Calculate the:

) per unit slip

) percentage slip.

b)

$$\text{Sync speed, } n_s = \mathbf{3000\ rpm}$$

$$\%\ \text{slip} = \frac{(n_s - n_r)}{n_s} \times 100$$

$$= \frac{(3000 - 2880)}{3000} \times 100$$

$$= \mathbf{4\%}$$

EXAMPLE 3 – A four-pole 50Hz induction motor has a per-unit slip of 0.03 on full load. Calculate the full load speed.

$$\text{Sync speed, } n_s = \frac{F \times 60}{P}$$

$$= \frac{50 \times 60}{2}$$

$$= \mathbf{1500\ rpm}$$

EXAMPLE 3 – A four-pole 50Hz induction motor has a per-unit slip of 0.03 on full load. Calculate the full load speed.

$$\text{Per unit slip, } S = \frac{(n_s - n_r)}{n_s}$$

$$S \times n_s = n_s - n_r$$

$$S \times n_s + n_r = n_s$$

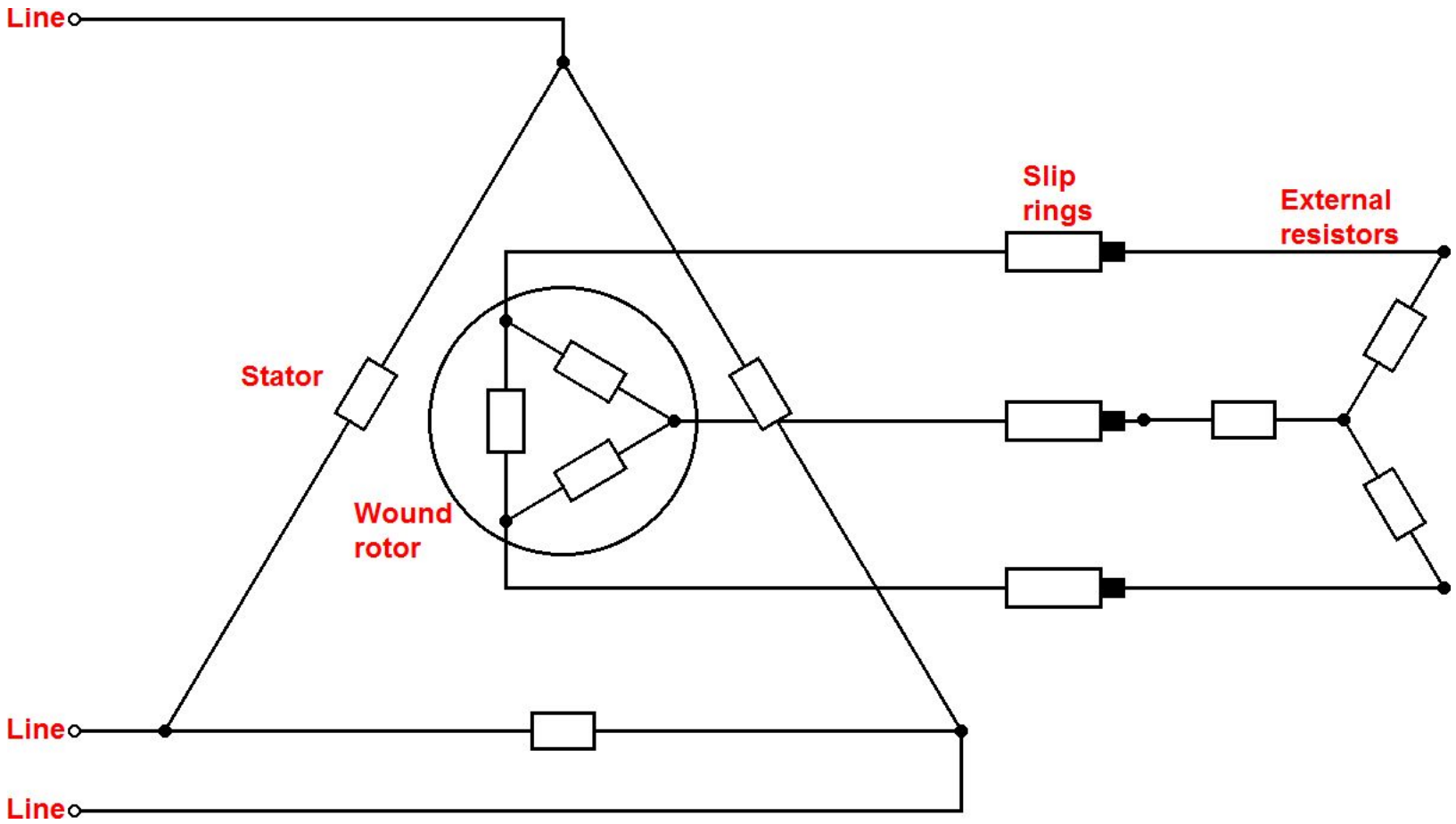
$$n_r = n_s - S \times n_s$$

$$= 1500 - (0.03 \times 1500)$$

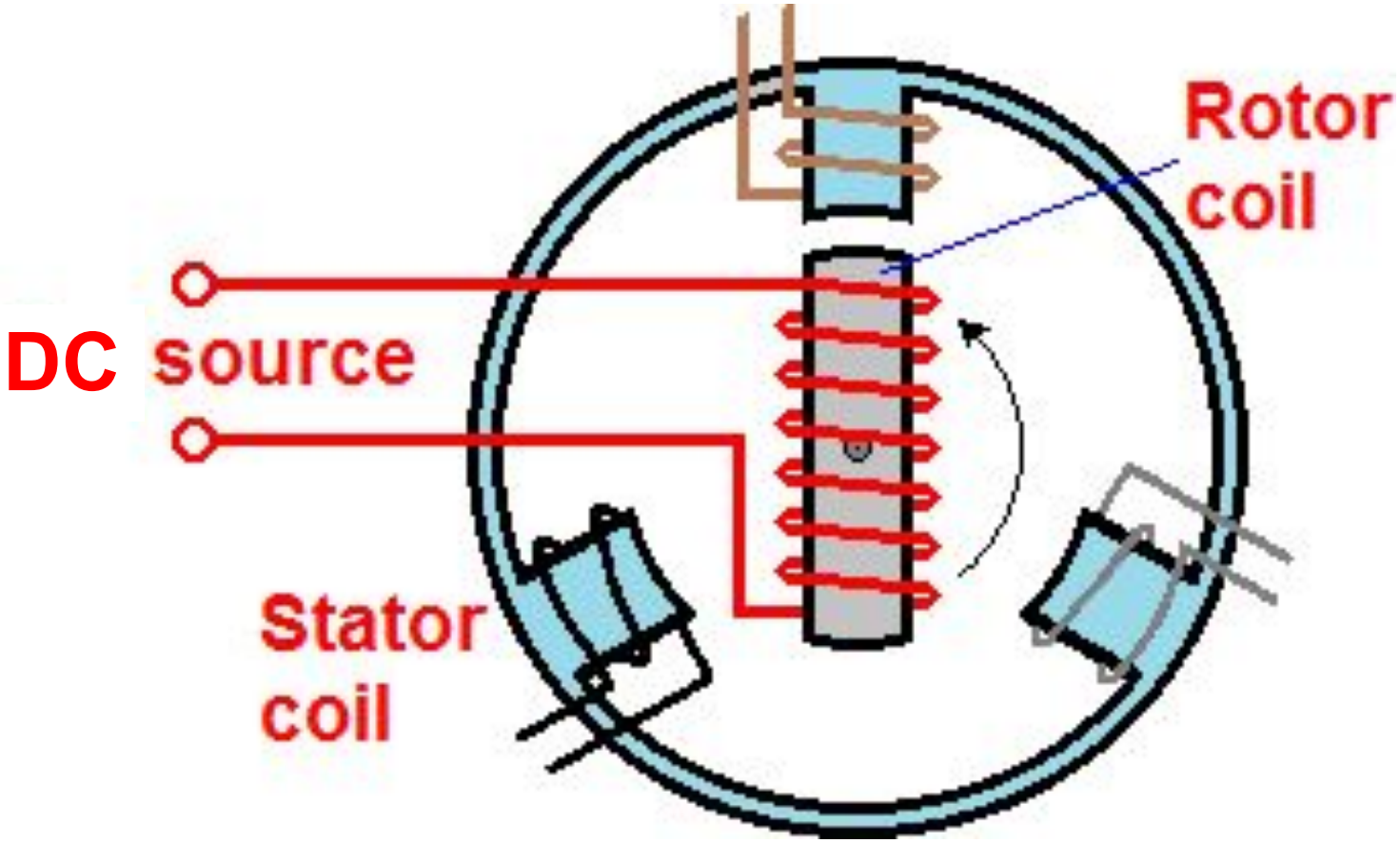
$$= 1500 - 45$$

$$= \mathbf{1455\ rpm}$$

Wound rotor motor



AC three phase generator



Any questions?