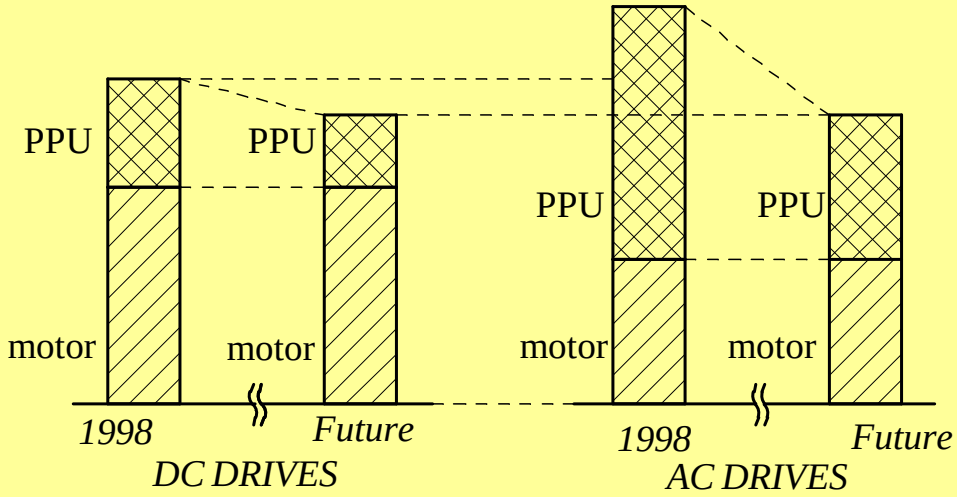
DC Motor Drives

- Introduction
- Classification
- Structure
- Operating Principle
- Armature Reaction
- DC Machine Equivalent Circuit

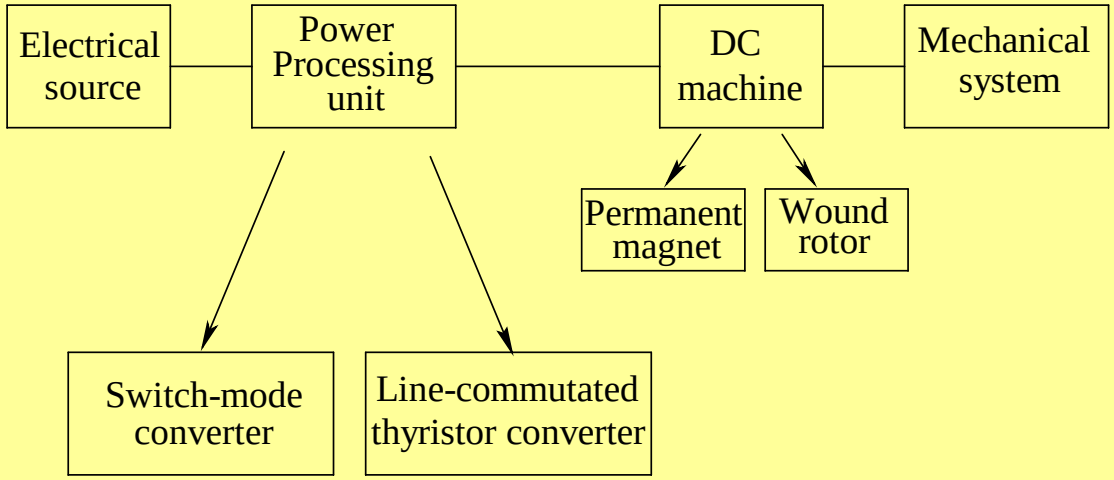
Introduction

- Cost

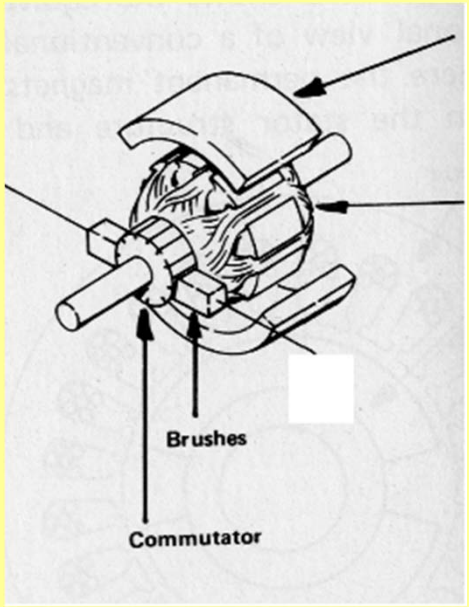


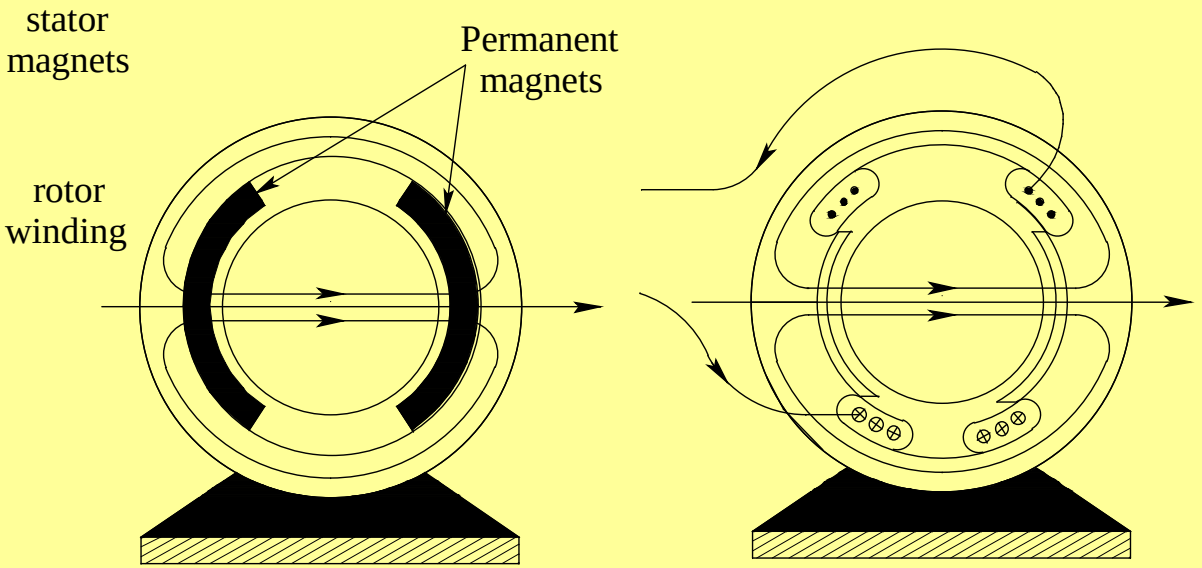
- Demise prematurely predicted, still used in speed control
- Merits
  - Ease of control
  - Cheaper Power Processing Unit
- Drawbacks
  - mechanical commutator and brushes require maintenance

Classification of DC drives



Structure of DC motors





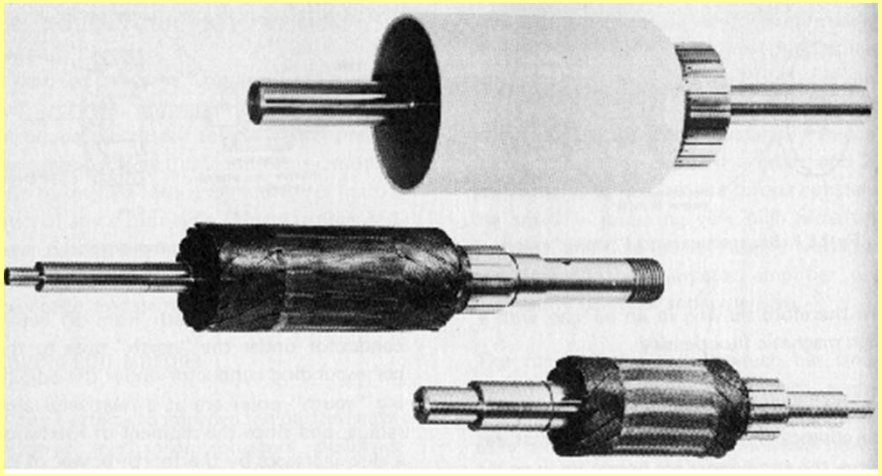
ϕ_f produced by permanent magnets

ϕ_f produced by stator winding current

- Stator
  - Establishes field flux, ϕ_f

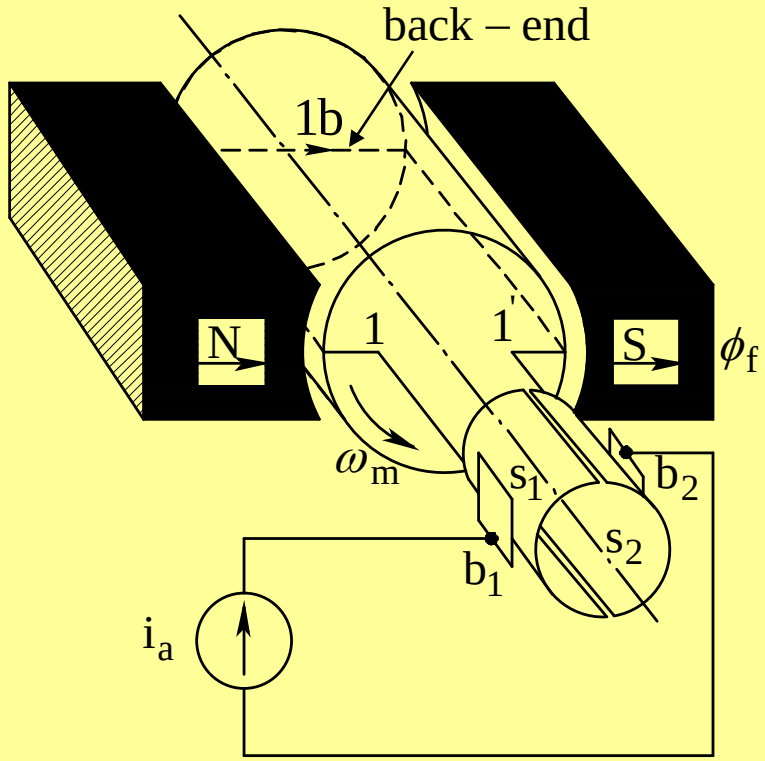
Structure of DC motors

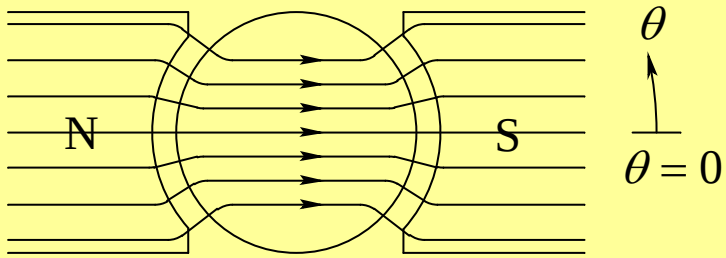
- Rotor
  - Armature winding
  - Commutator and brushes

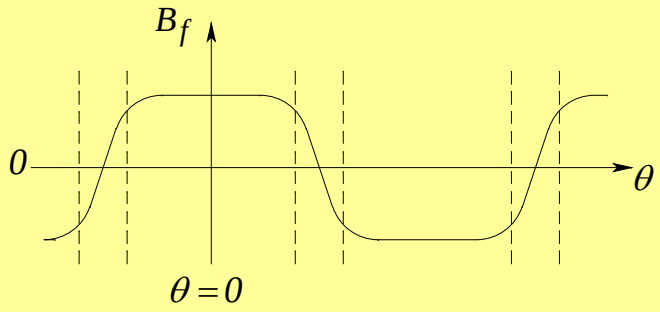


Operating Principles of a DC Motor

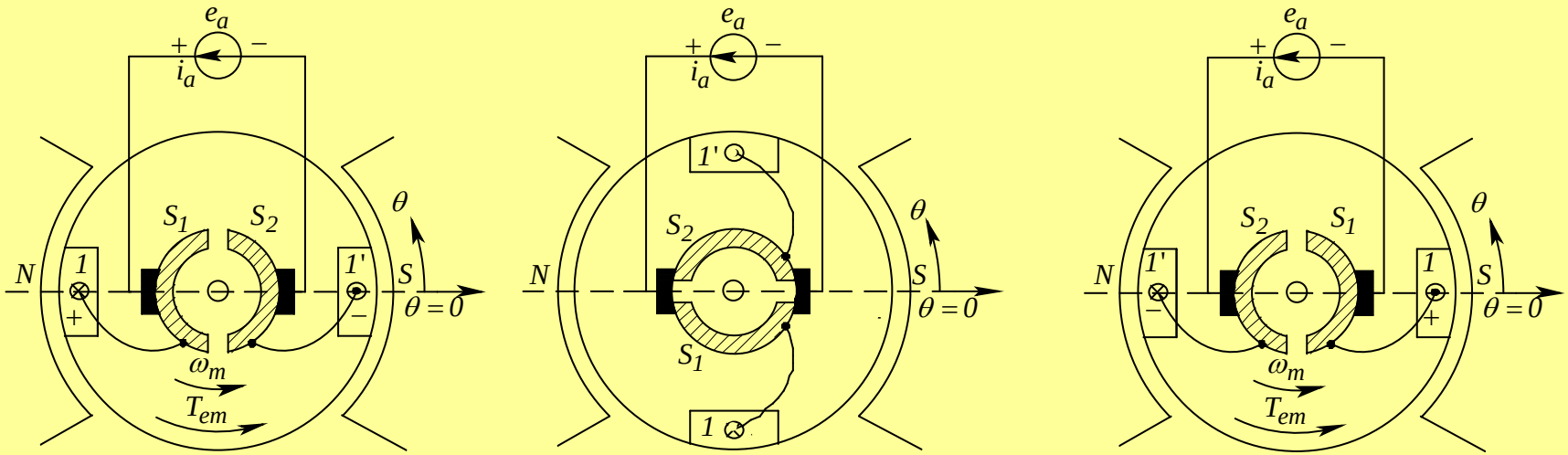
- Field flux density in the airgap





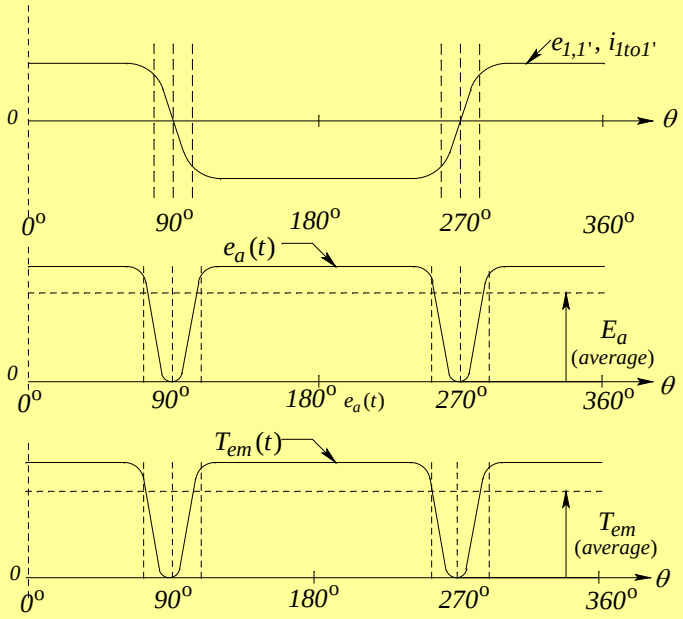


Operating principles - Commutator Action

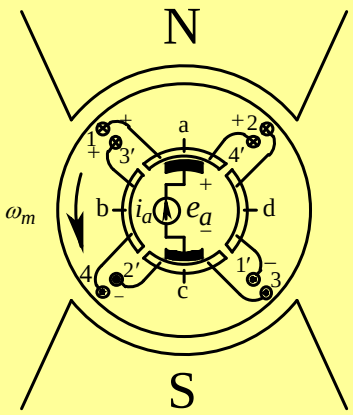


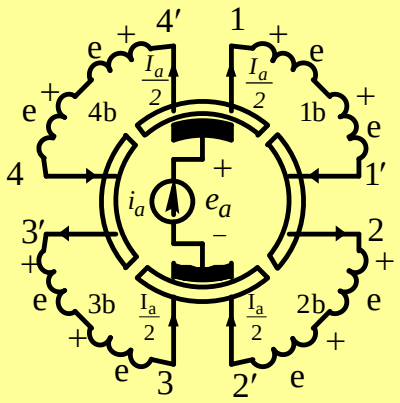
$$T_{em} = 2 B_f \ell i_a r$$

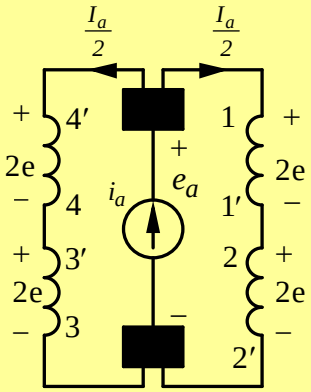
$$e_a = 2 B_f \ell (r \omega_m)$$



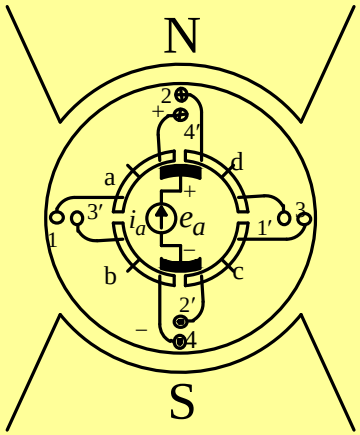
Four Coil Example

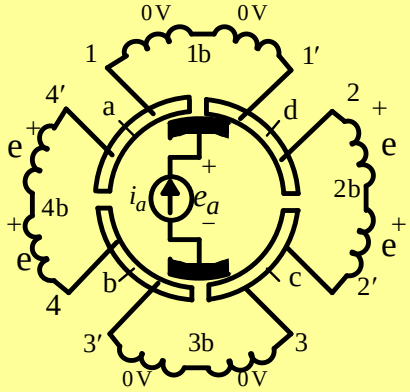


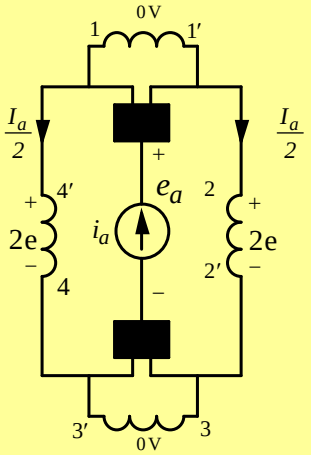




$at\ \theta = 0^o$

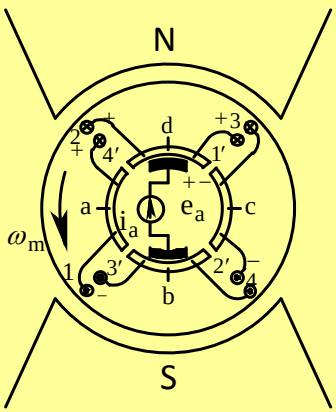


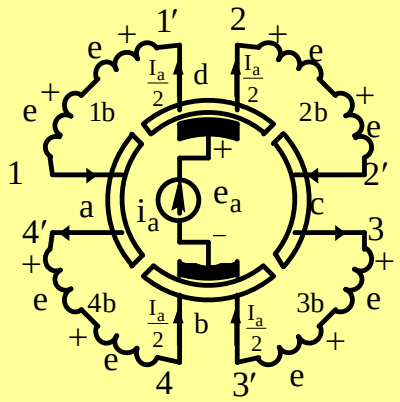


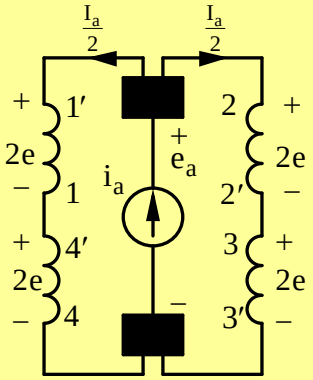


CCW rotation by 45°

Four Coil Example (cont'd)

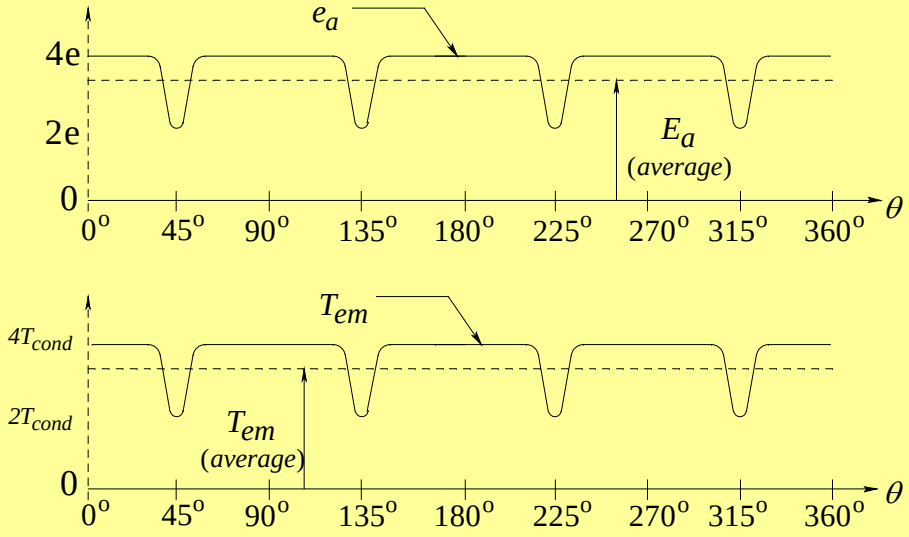




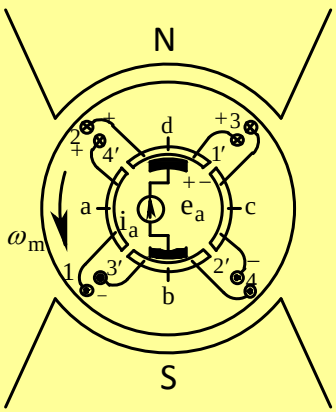


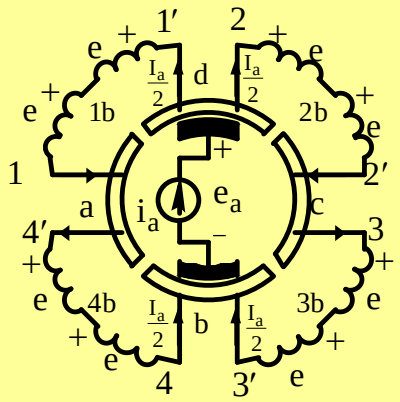
CCW rotation by 90°

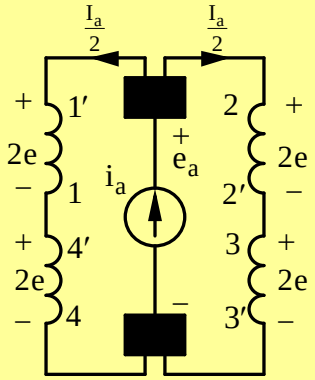
Torque and emf pulsations can be reduced by increasing the number of conductors



Four Coil Example (cont'd)

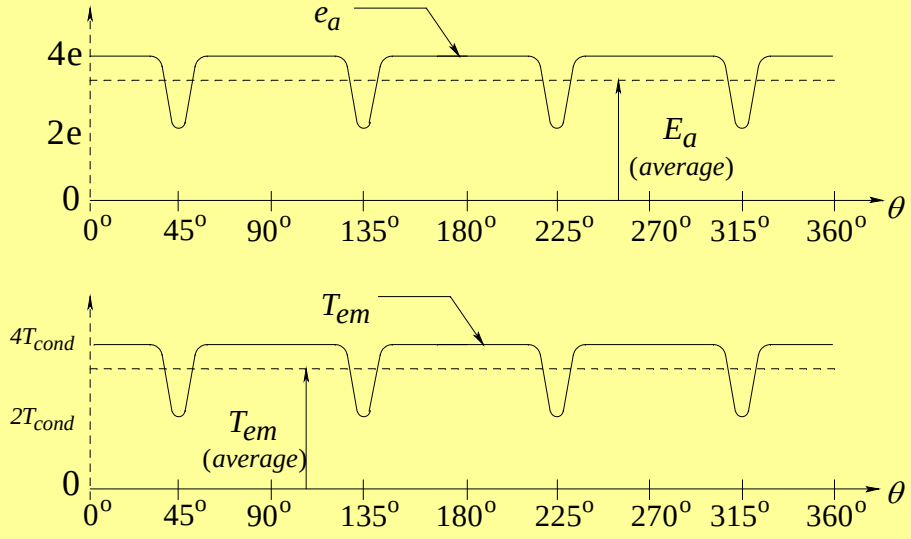






CCW rotation by 90^o

Torque and emf pulsations can be reduced by increasing the number of conductors



Summary of Operating Principles

- ♦ i_a divides equally between two parallel circuits
- ♦ Torque produced on each conductor has the same direction
- ♦ Direction of i_a determines direction of torque

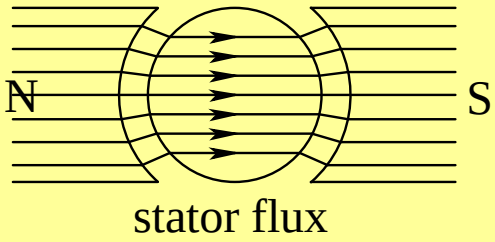
- ♦ Induced voltage in each circuit is equal to the sum of voltages induced in each coil.
- ♦ Polarity of induced emf depends only on the direction of rotation.

Net Torque, $T_{em} = n_a B_f \left(\frac{i_a}{2}\right) lr = \left(\frac{n_a}{2} lrB_f\right) i_a = k_T i_a$

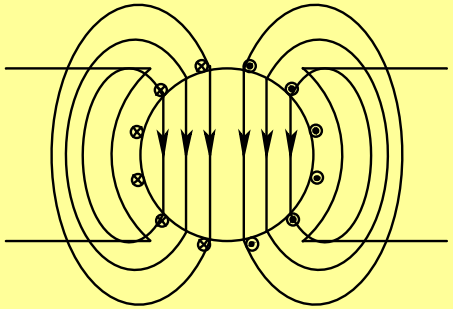
& $e_a = \left(\frac{n_a}{2}\right) B_f l(\omega_m r) = \left(\frac{n_a}{2} lrB_f\right) \omega_m = k_E \omega_m$

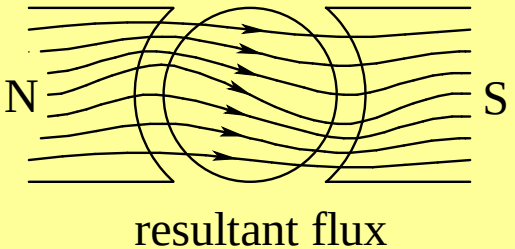
In M.K.S. Units $k_E = k_T$

Armature reaction



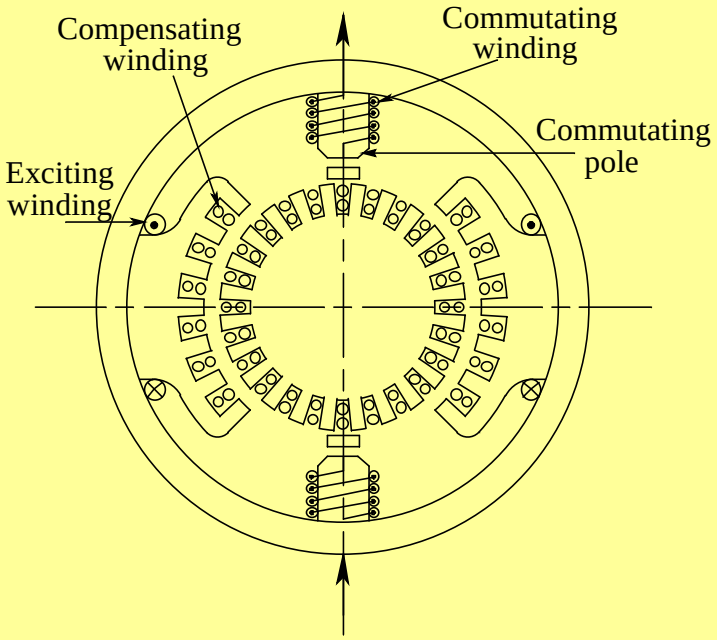
stator flux


rotor flux

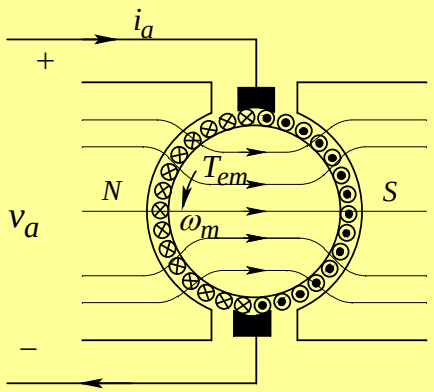


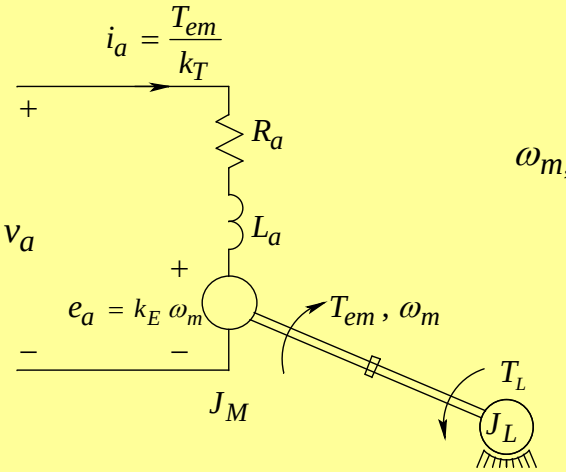
resultant flux

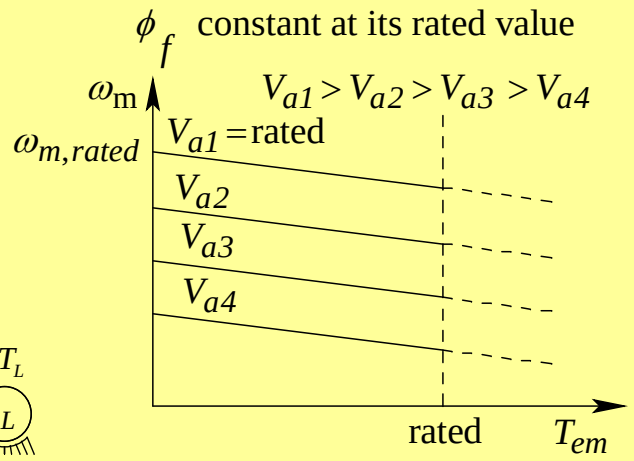
- Assuming magnetic structure does not saturate:
  - Increased torque in some conductors is compensated by decreased torque in other conductors
  - Same reasoning holds for induced emf
- Compensating winding to reduce the effect of armature reaction



DC Machine Equivalent Circuit







Basic equations

$$e_a = k_E \omega_m$$

$$v_a = e_a + R_a i_a + L_a \frac{d i_a}{dt}$$

$$T_{em} = k_T i_a$$

$$\frac{d\omega_m}{dt} = \frac{1}{J_{eq}}(T_{em} - T_L)$$

Steady State

$$I_a = \frac{T_{em}(= T_L)}{k_T}$$

$$\omega_m = \frac{V_a - I_a R_a}{k_E}$$

Summary

DC Motor Drives

- Introduction
- Classification
- Structure
- Operating Principle
- Armature Reaction
- DC Machine Equivalent Circuit