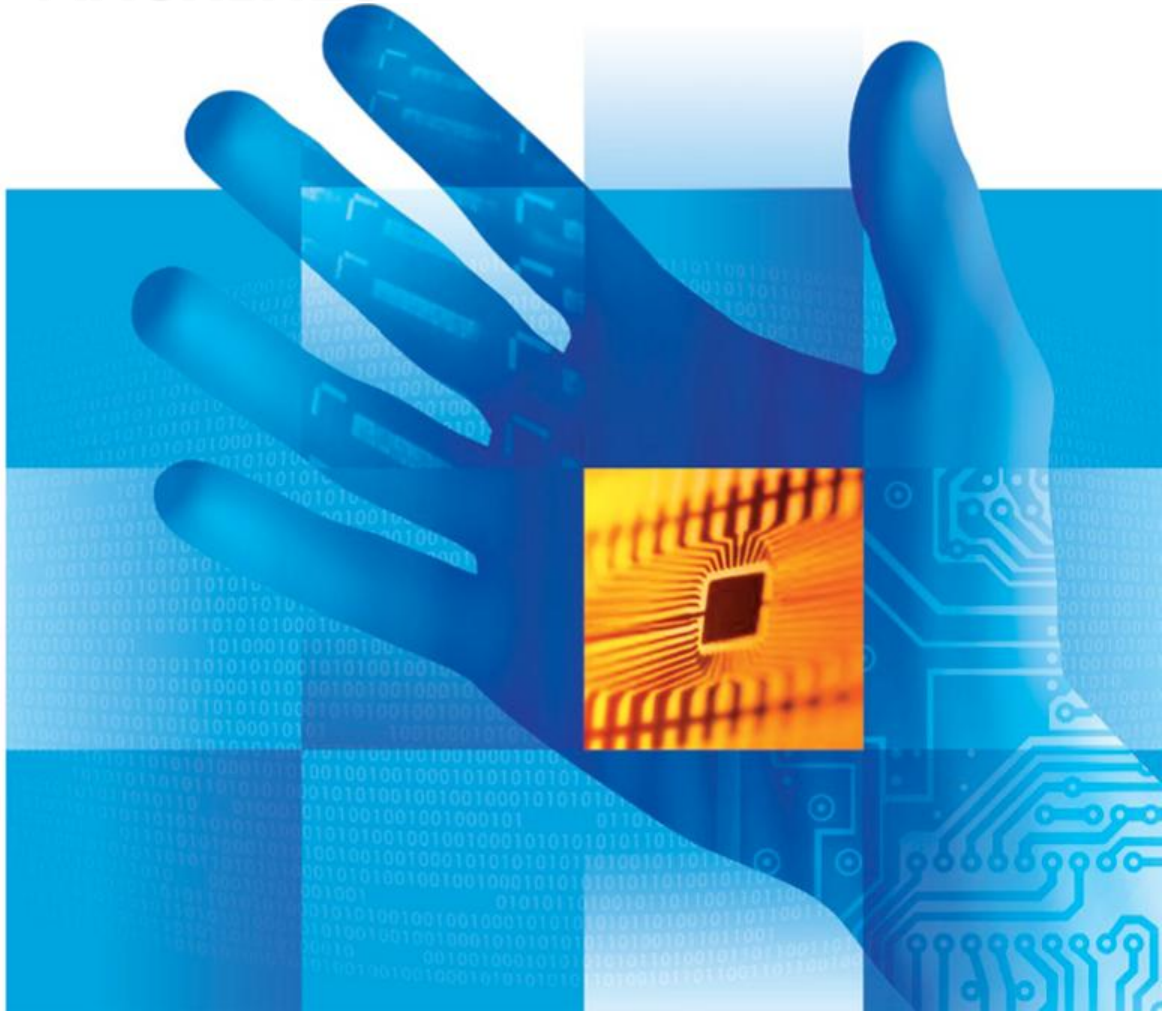
EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

10. DC AND SYNCHRONOUS MACHINES



Doc. Ing. Stanislav Kocman, Ph.D.

2. 4. 2018, Ostrava

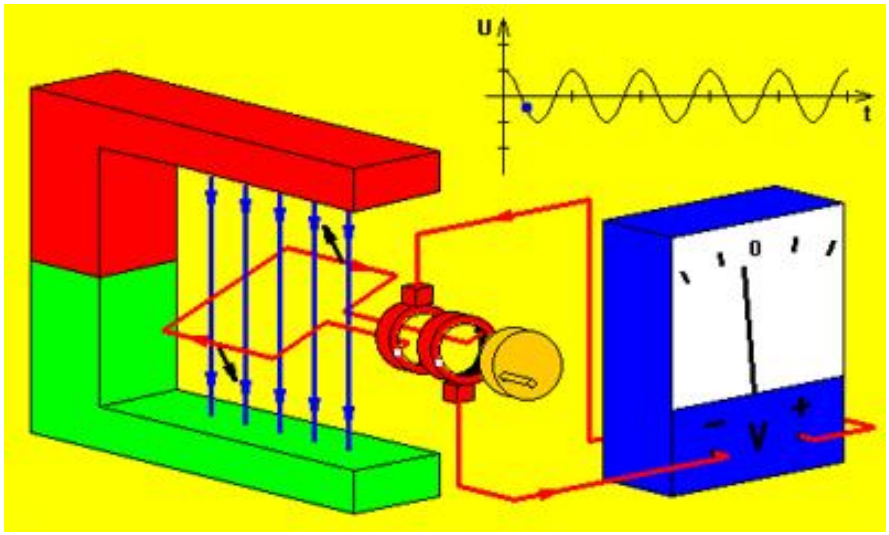
LECTURE PLAN

- principle and design of DC machine
- types of DC machines, areas of usage
- principle and design of synchronous machine
- usage of synchronous generators

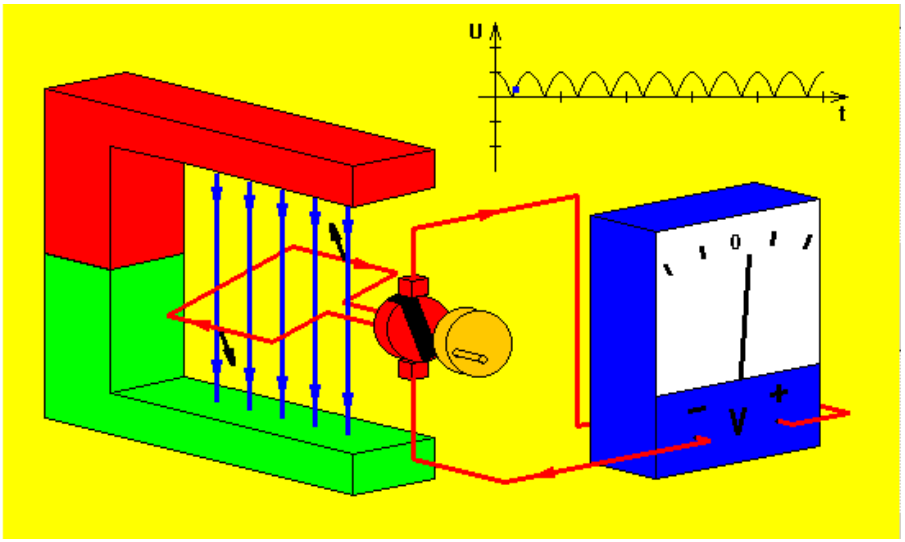
Principle and design of DC machine

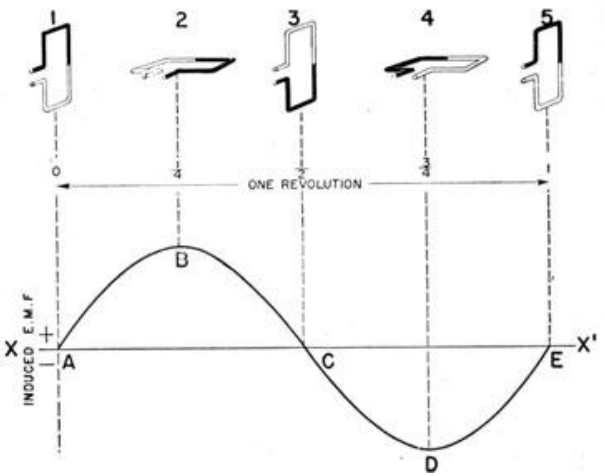
Principle of operation

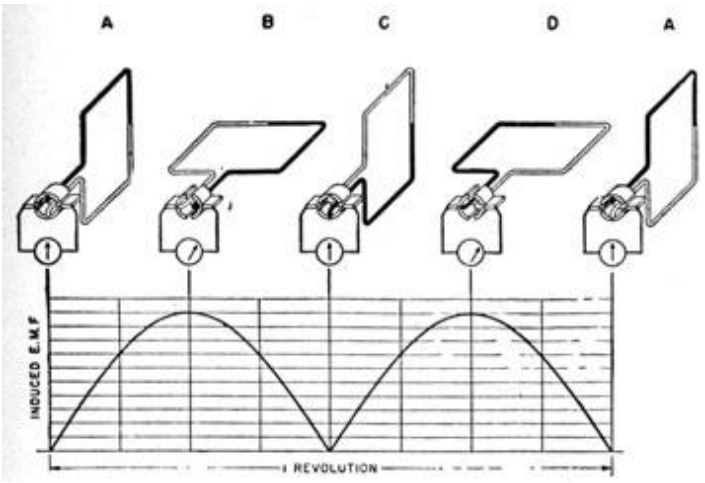
Without commutator (AC)



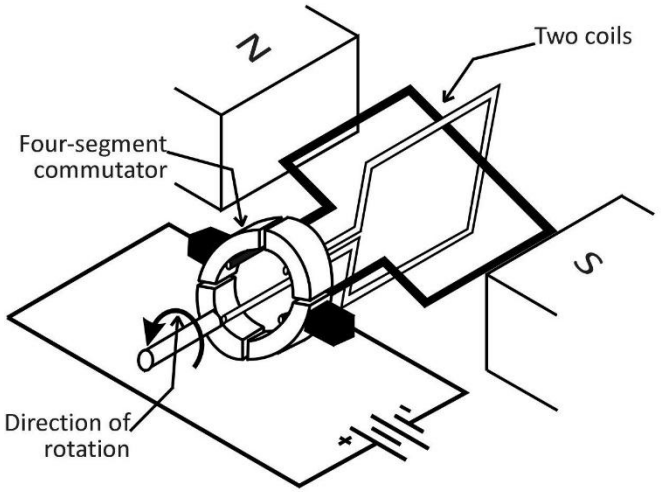
With commutator (DC)

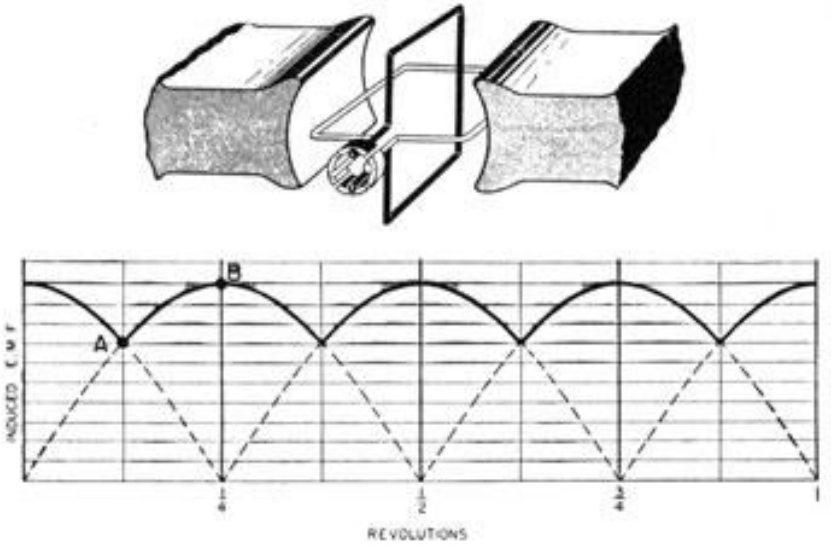






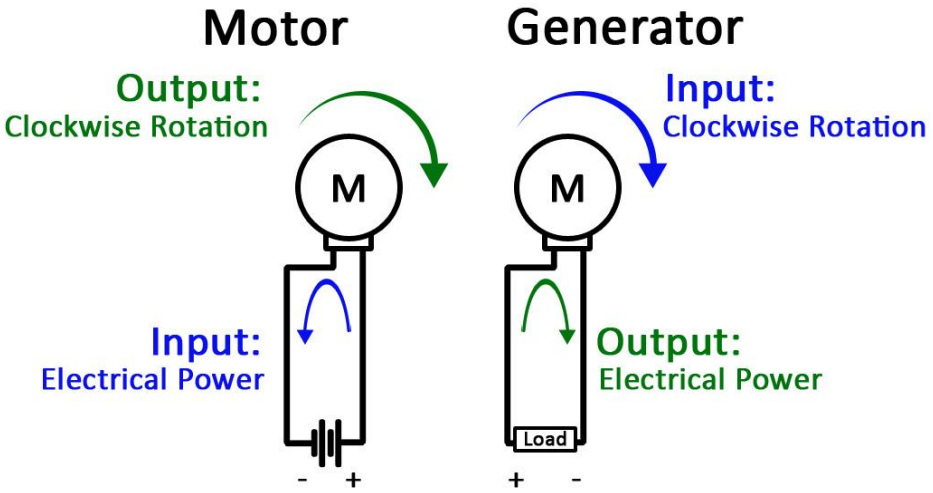
Example of four-segment commutator





The operation of the commutator

- **at the generator: it converts induced AC voltage into DC voltage**
- **at the motor: it changes the direction of current in coils to attain one-direction rotation**



Induced voltage in DC machine (generator)

in one wire on the rotor (armature)

$$V_{\text{ind}} = B_{\text{av}} l v$$

in windings on the rotor (armature)

$$V_{\text{ind}} = c \varphi \omega$$



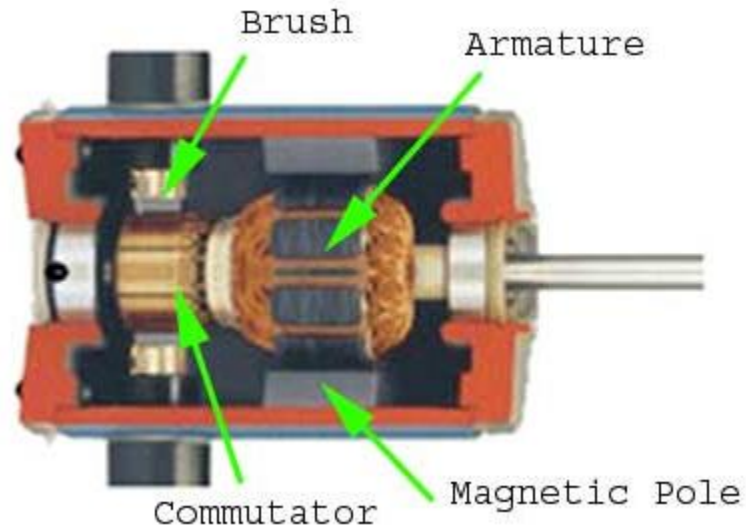
armature constant

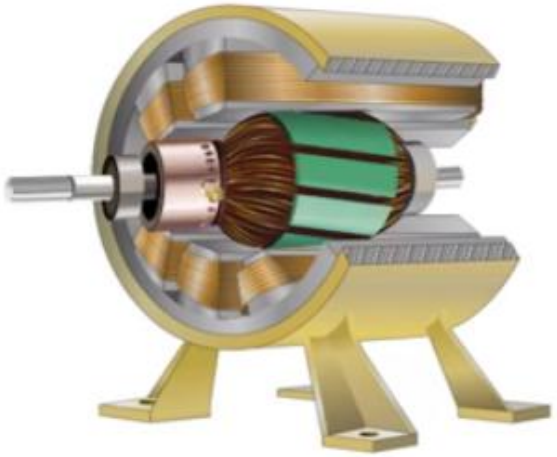
Torque in DC machine (motor)

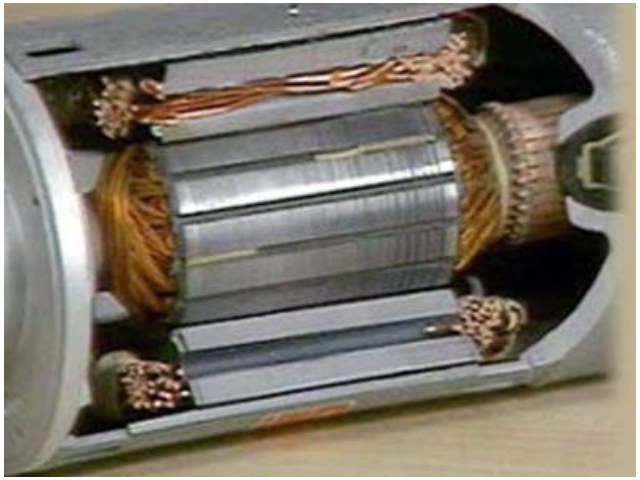
Torque acting on the rotor (armature)

$$T = c \varphi I_a$$

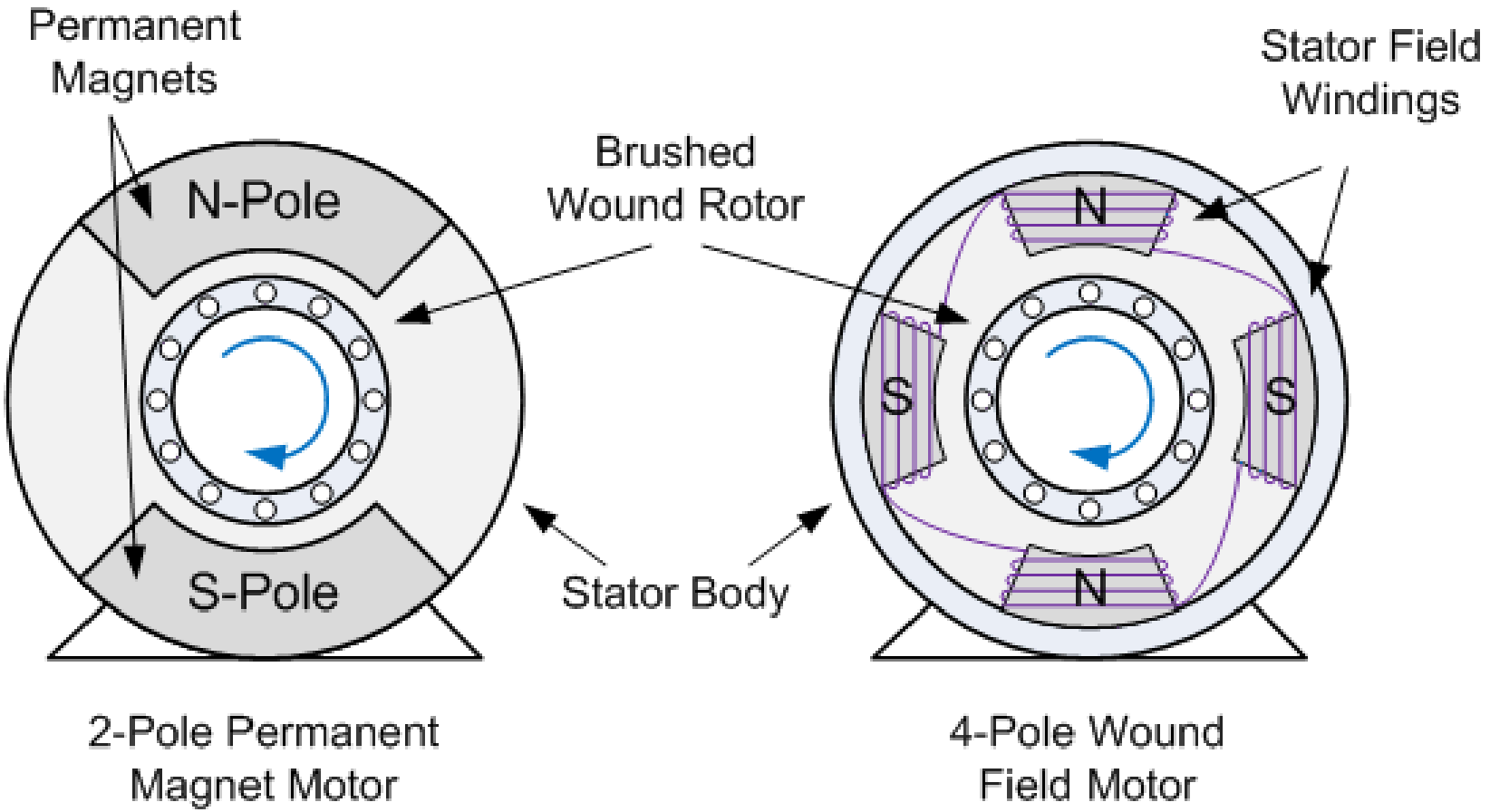
Design of DC machine



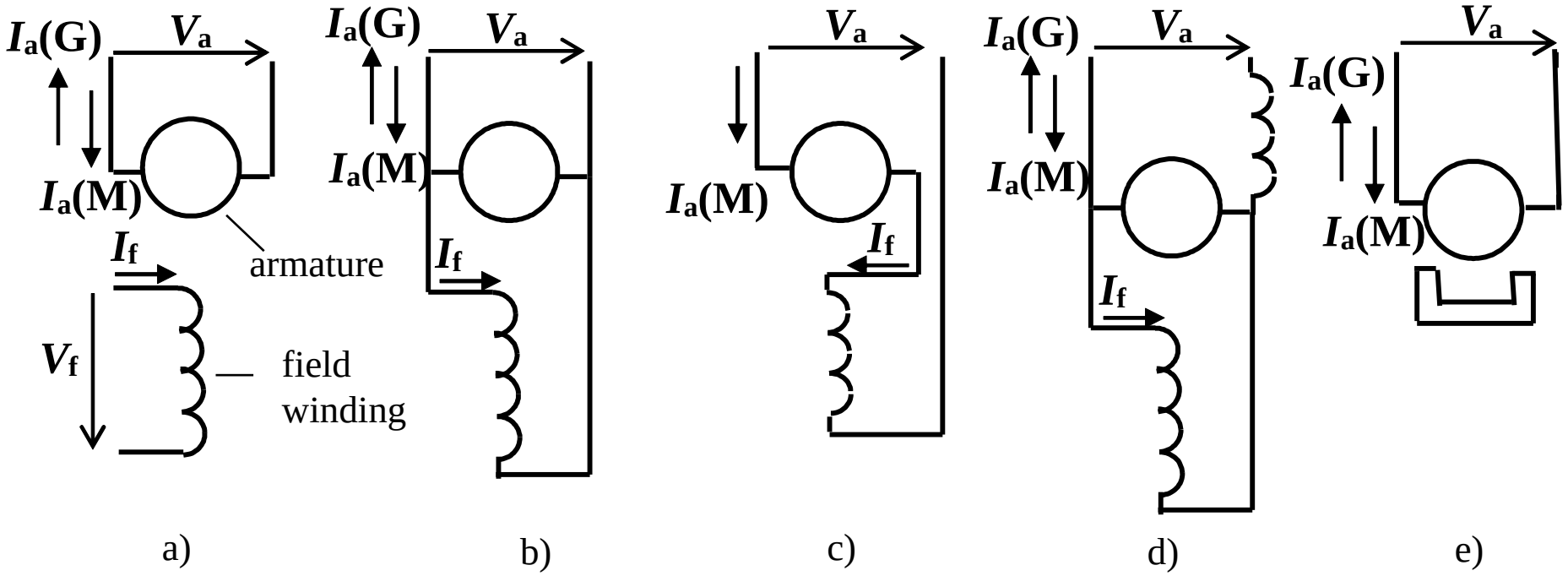




Design of DC machine



Types of DC machines



a) **separately excited**

b) **shunt-connected**

c) **series-connected**

d) **compound-connected**

e) **with permanent magnets**

Usage of DC machines

a) separately excited: motors in variable speed drives, mining machines, electric cars, ships, aircrafts…

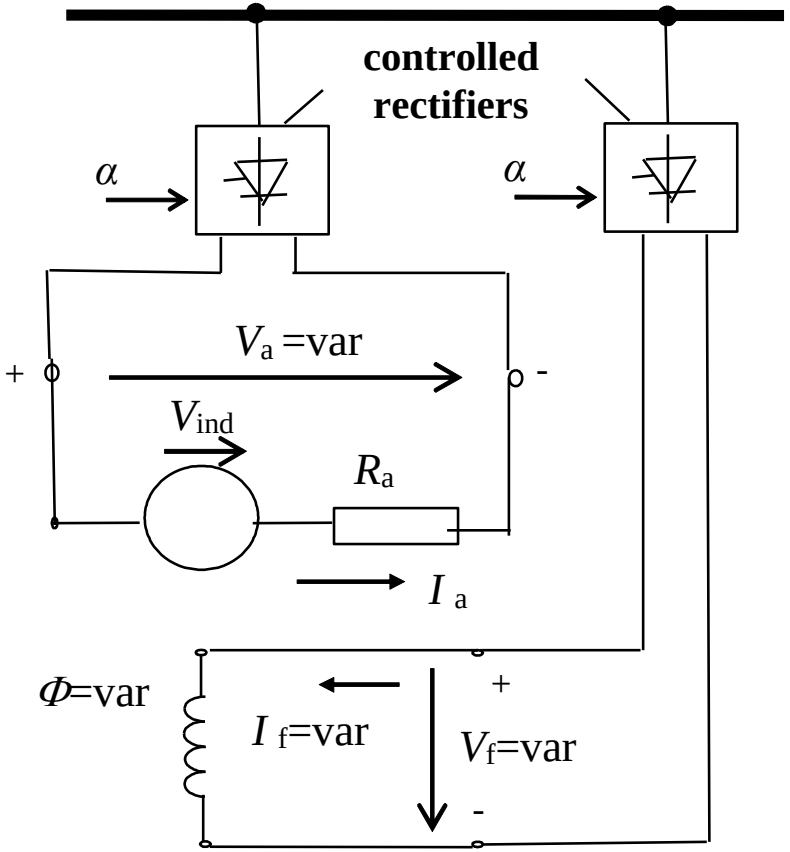
b) shunt-connected: field excitation for synchronous generators

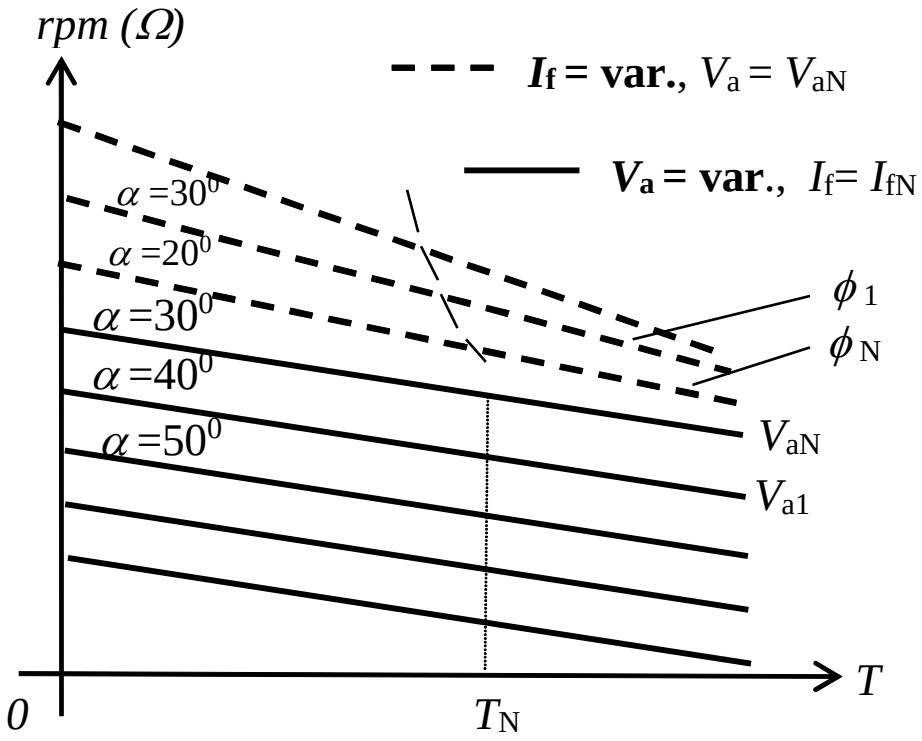
c) series-connected: motors in electrical traction, lift trucks, universal AC/DC motors (drills, grinders, cleaners…), engine starters…

d) compound-connected: motors in special applications

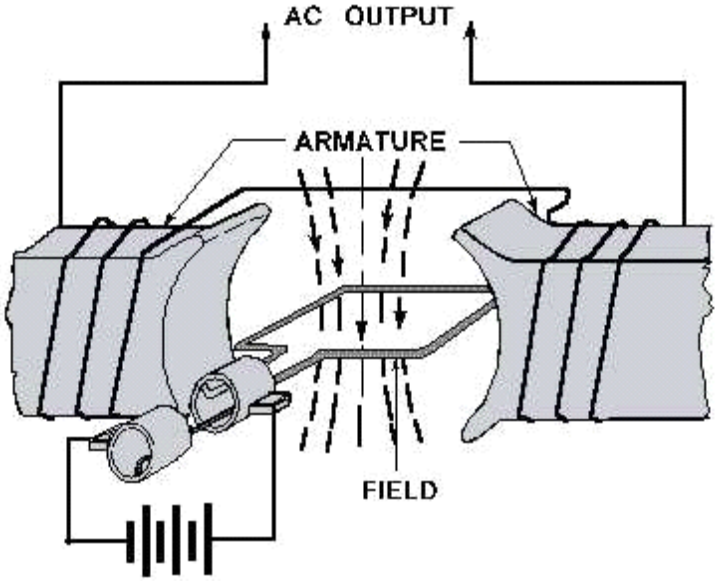
e) with permanent magnets: motors for car drives, cameras, air-conditions, domestic appliances…

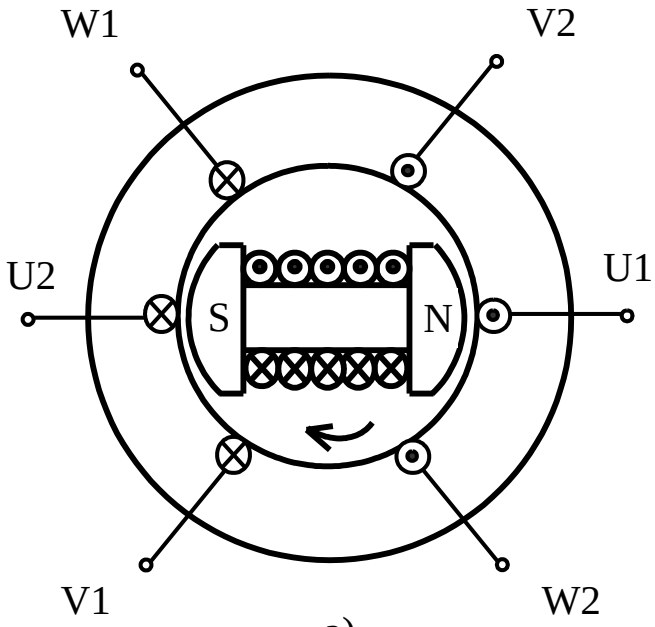
Example of using DC motor for speed control of mechanical loads



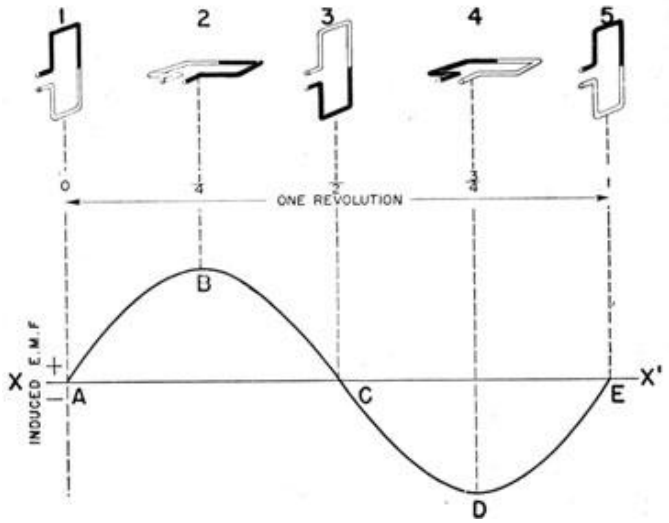


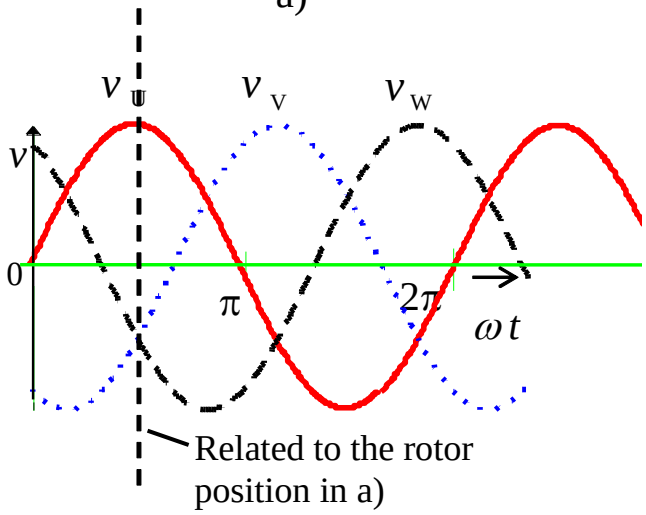
Principle of synchronous machine





a)

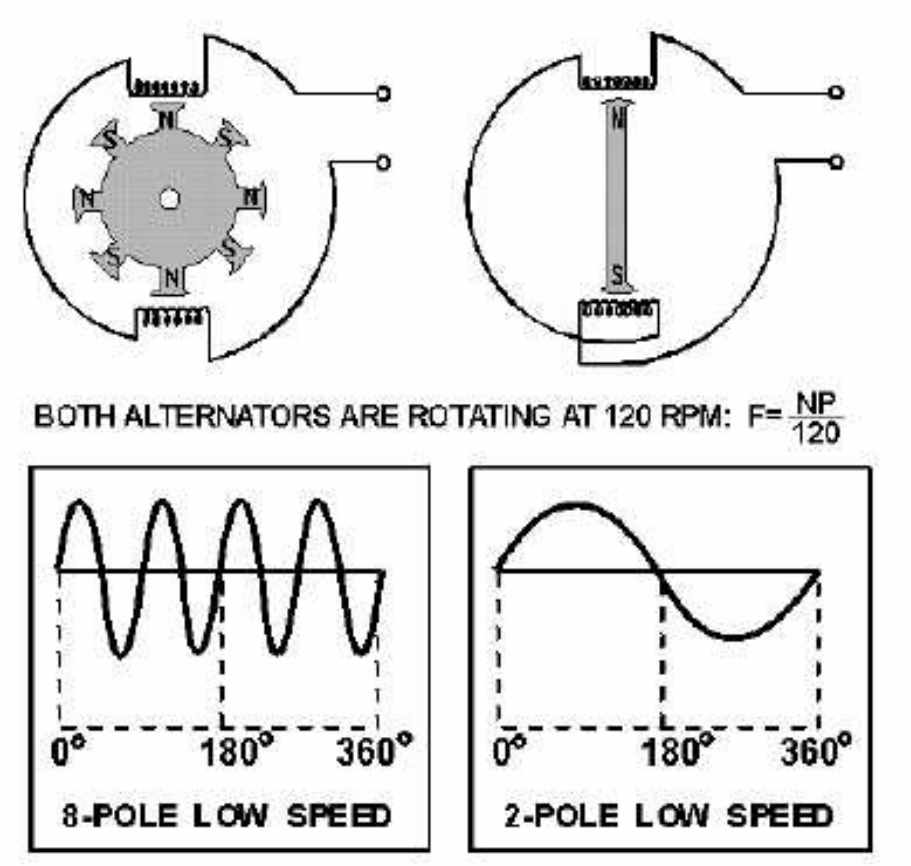




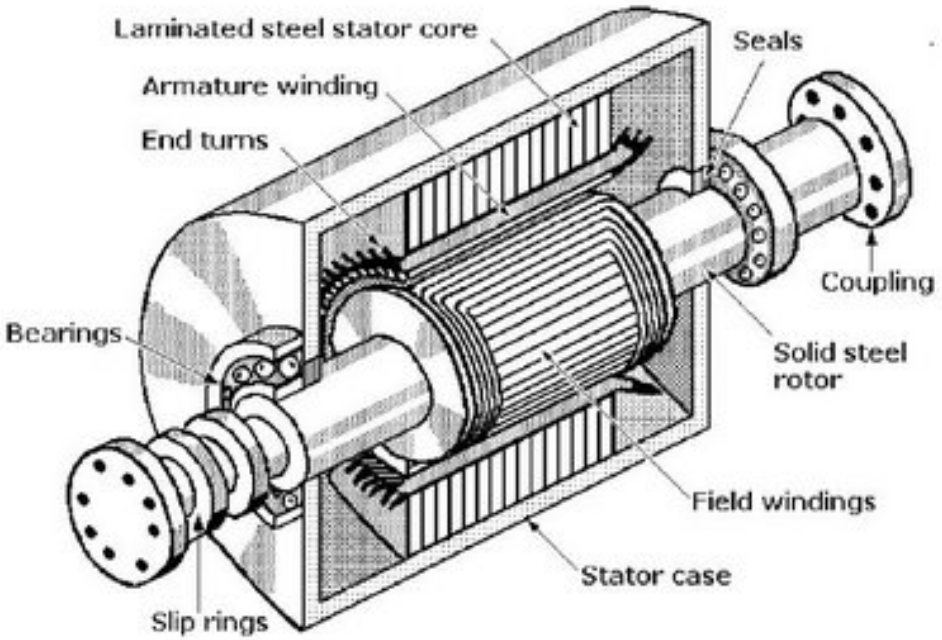
b)

Frequency of induced voltage into stator (armature)

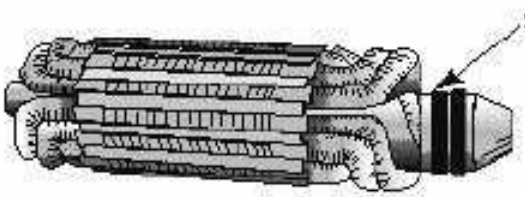
- **for 2-pole generator:** $f = \frac{n}{60}\ (\mathrm{Hz}, \mathrm{min}^{-1})$
- **for 2*p*-pole generator:** $f = p \cdot \frac{n}{60}$ ← **rpm**



Design of synchronous machine

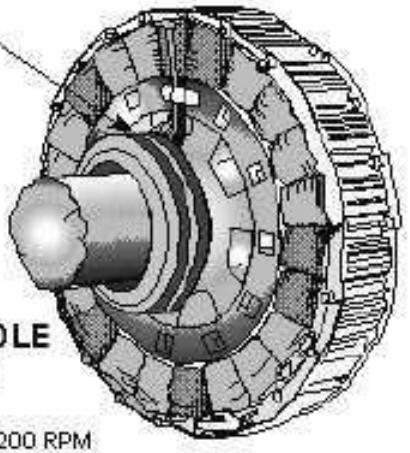


Cutaway view of a synchronous AC generator with a solid cylindrical rotor capable of high-speed rotation.



TURBINE DRIVEN ROTOR

HIGH SPEED = 1200 RPM OR MORE

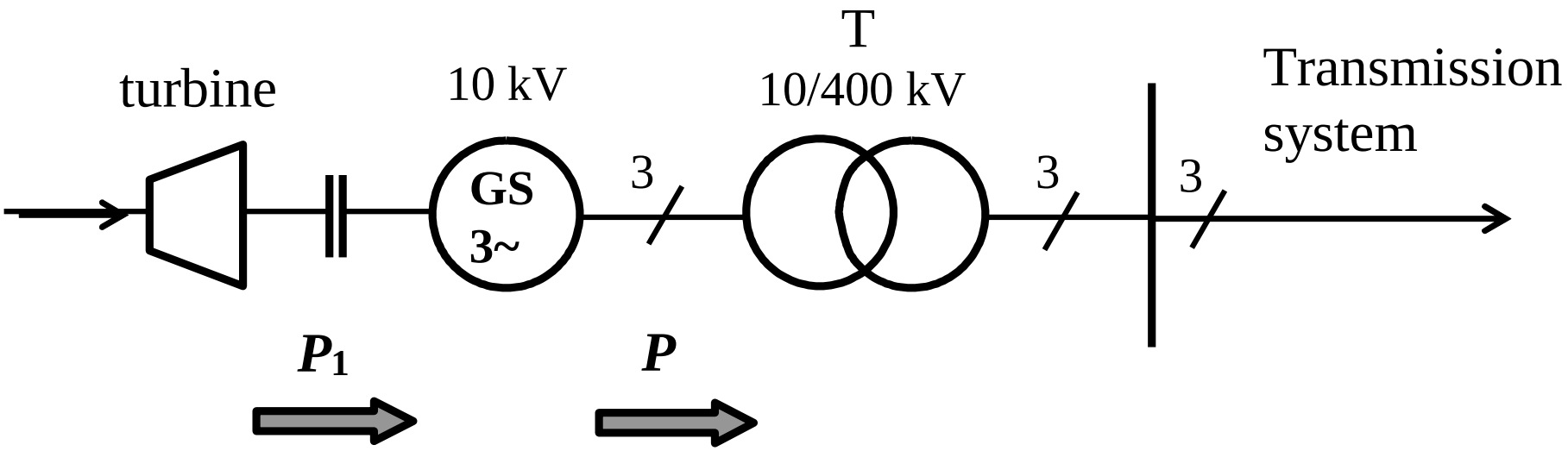


SALIENT-POLE ROTOR

LOW SPEED = 1200 RPM OR LESS

Usage of synchronous generators

- **Turbo-alternators (turbine driven rotor)**
- **Hydro-alternators (salient-pole rotor)**

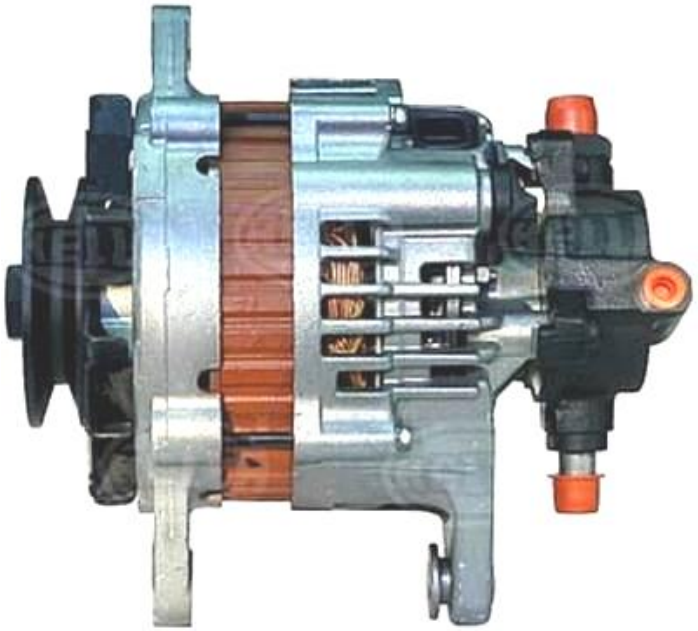


Three-phase alternators

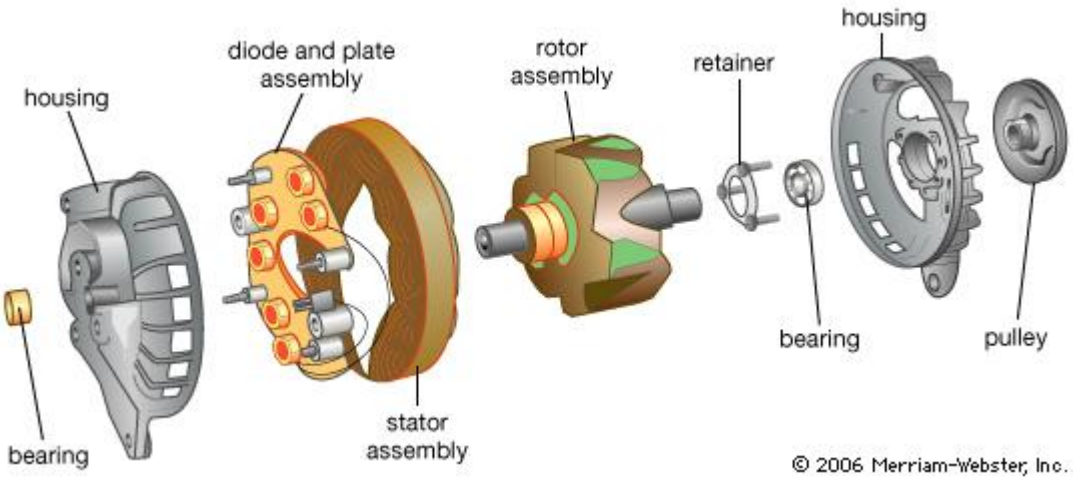




Three-phase alternator for automobile







Brushless DC motor
(special synchronous motor)

