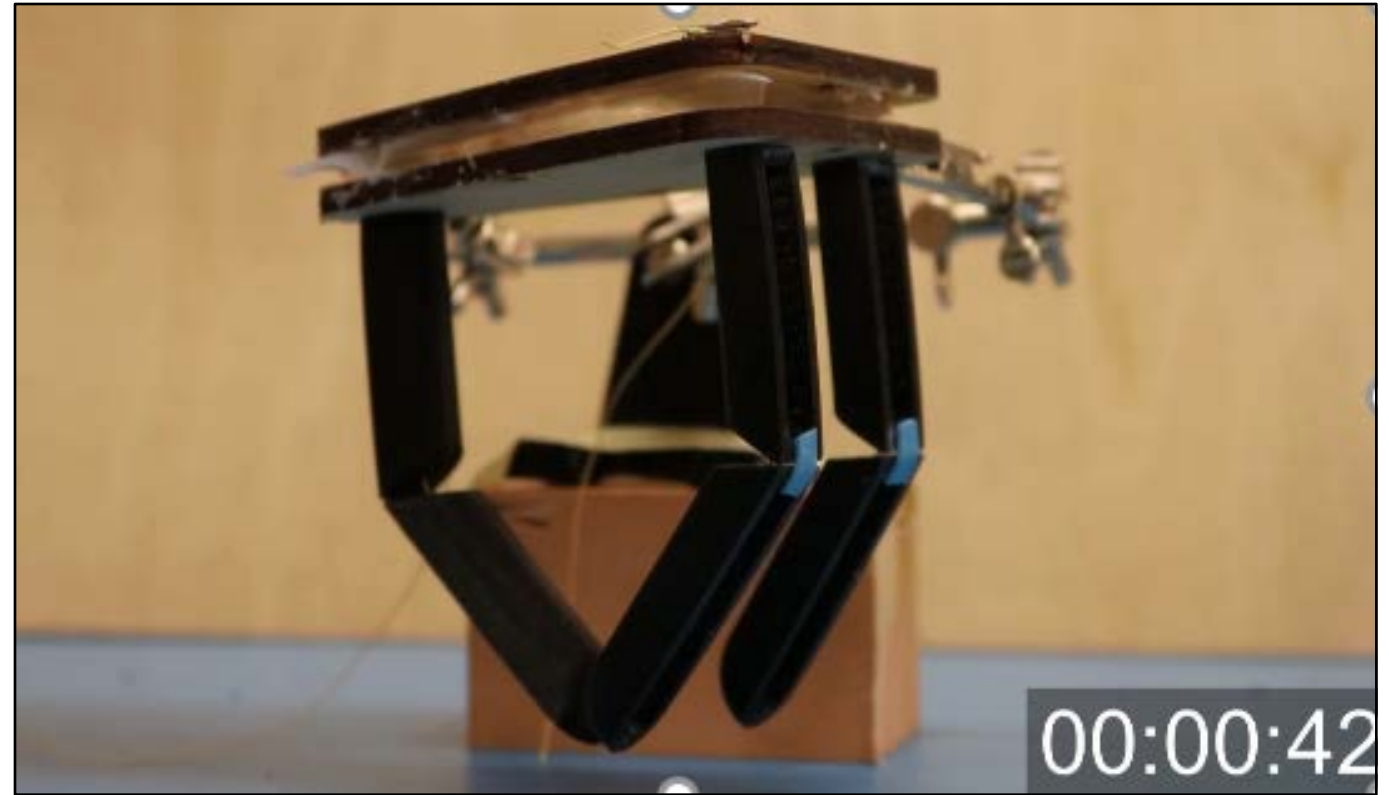


Actuators

- A mechanism that converts energy into mechanical motion
 - Hydraulic
 - Pneumatic
 - Electric
 - Magnetic
 - Mechanical
 - Bio-hybrid
 - Light-driven
 - Thermal

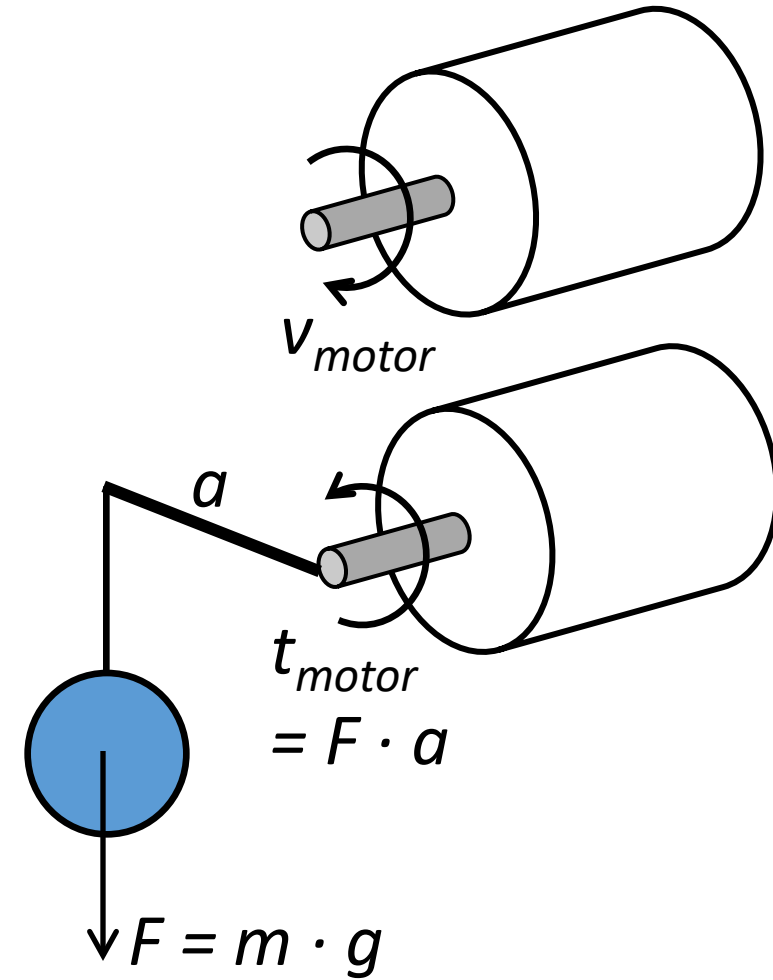
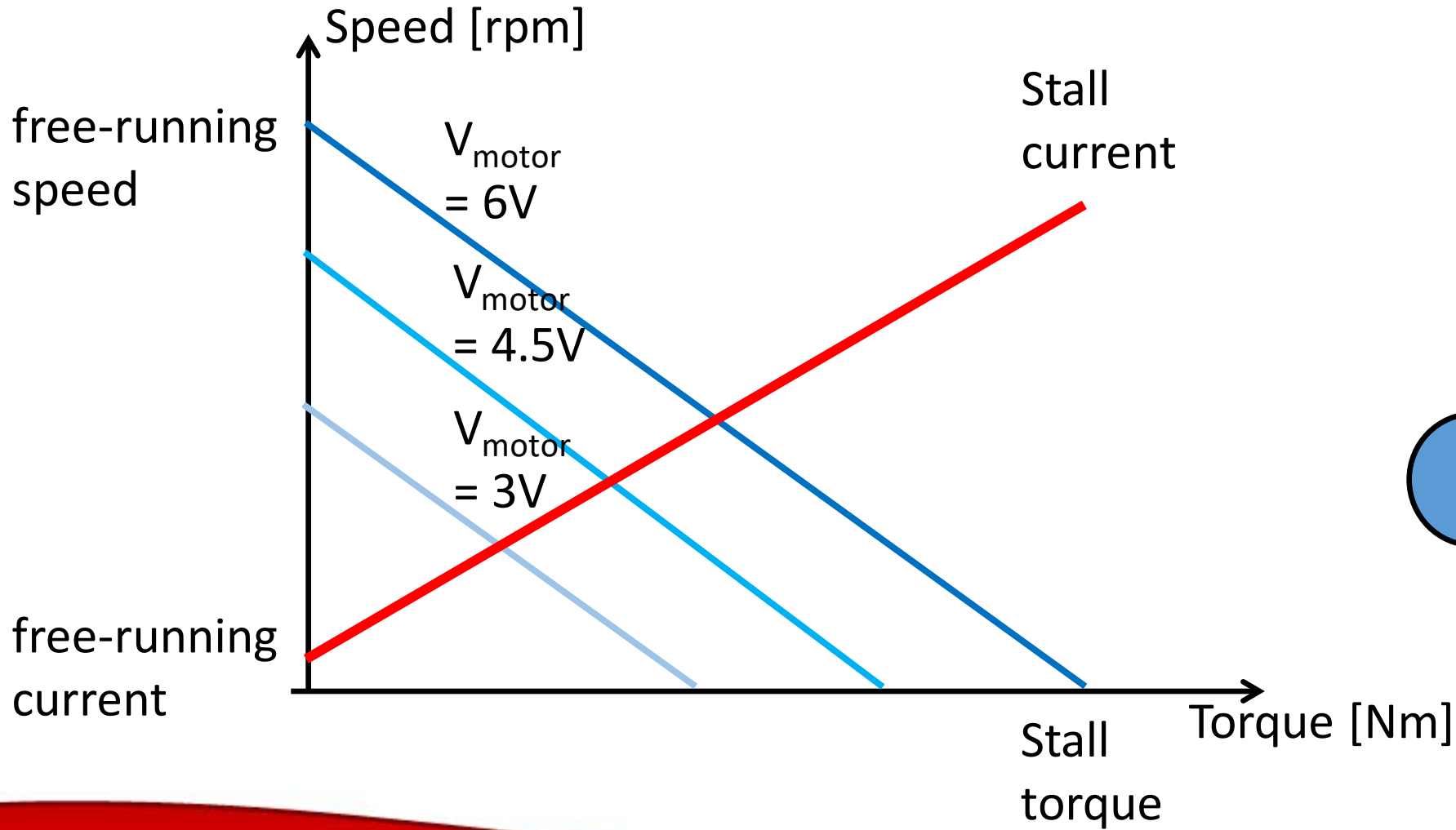


Actuators

- A mechanism that converts energy into mechanical motion

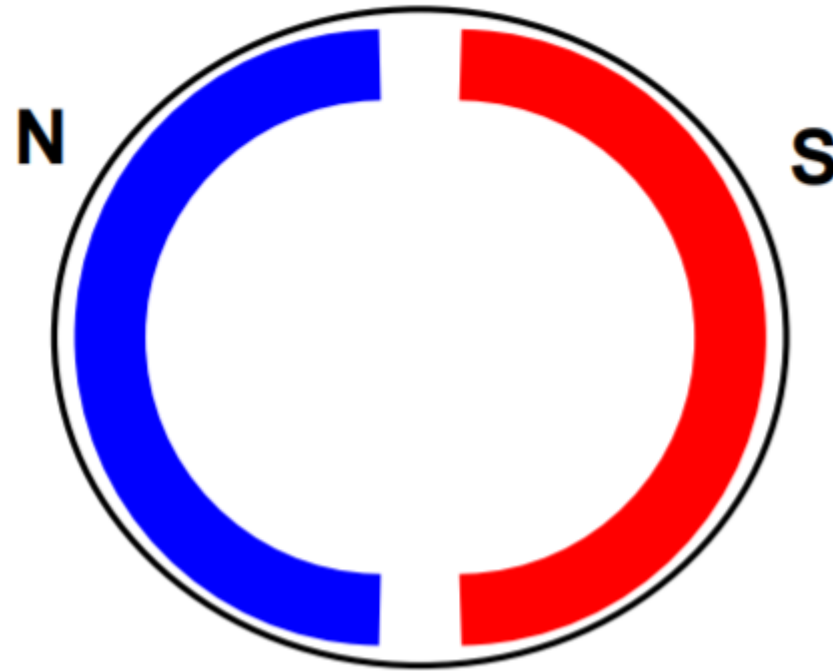


Brushed DC motor

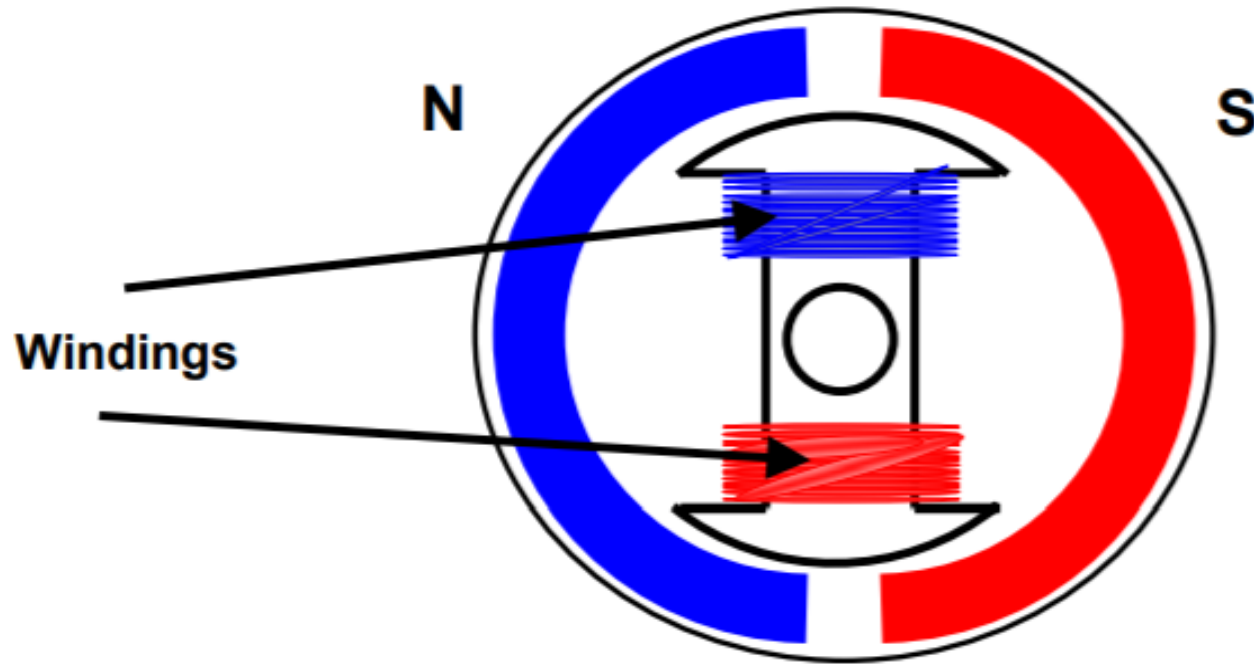


Brushed DC motor

permanent magnets

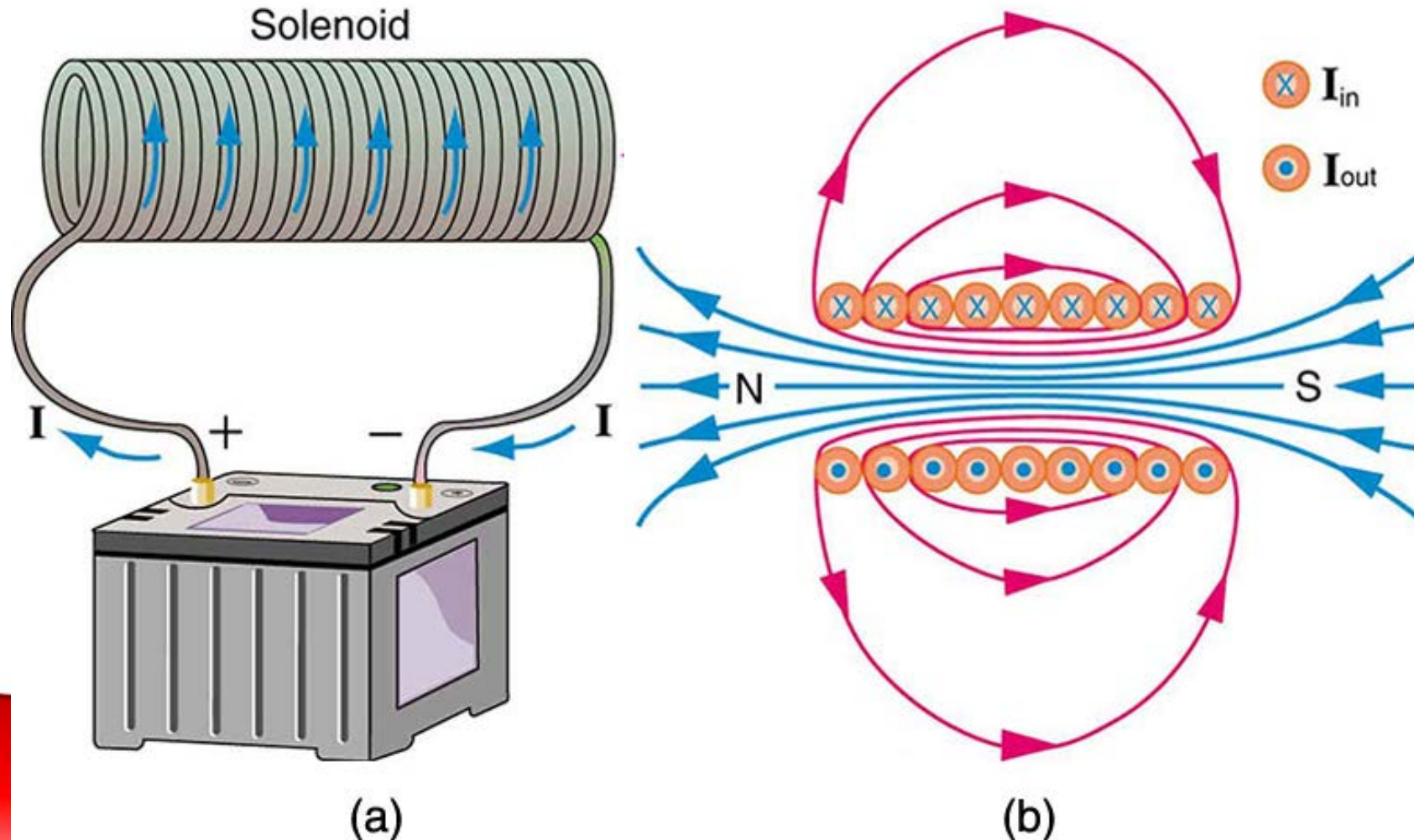


Brushed DC motor

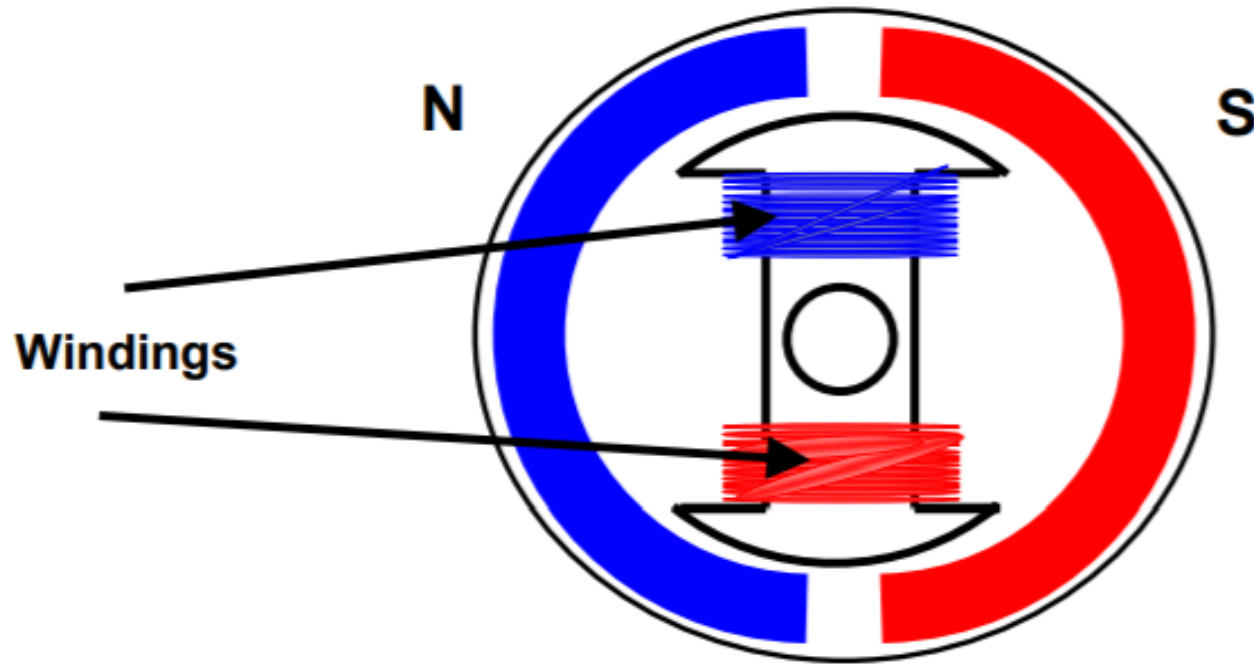


Brushed DC motor

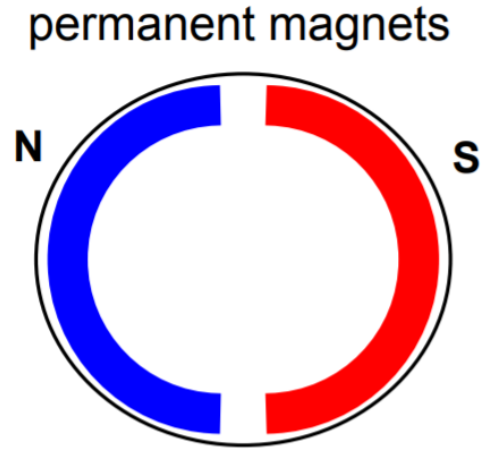
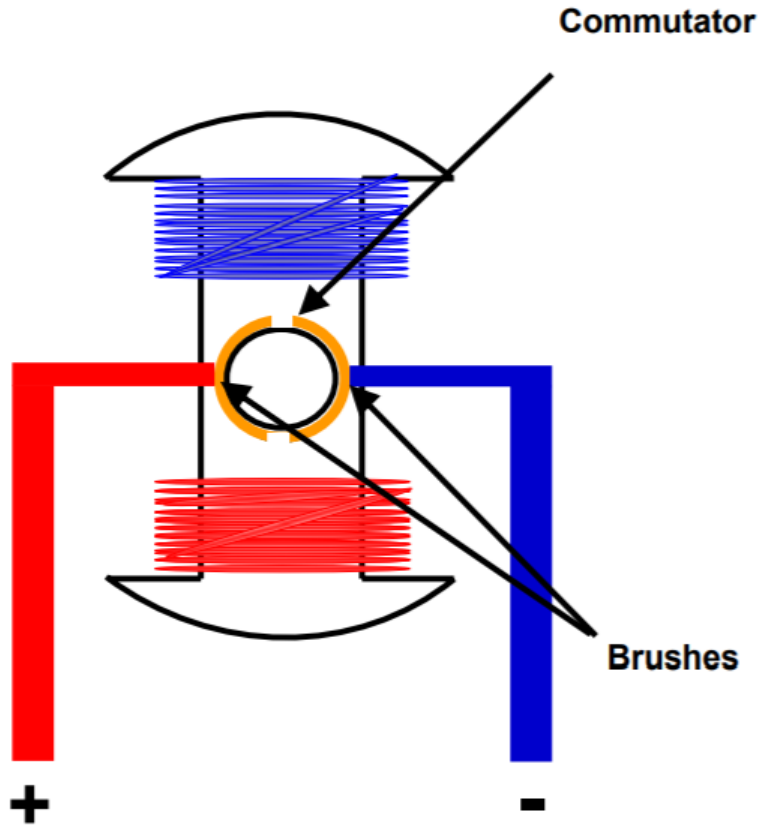
- Ampere's Right Hand Rule



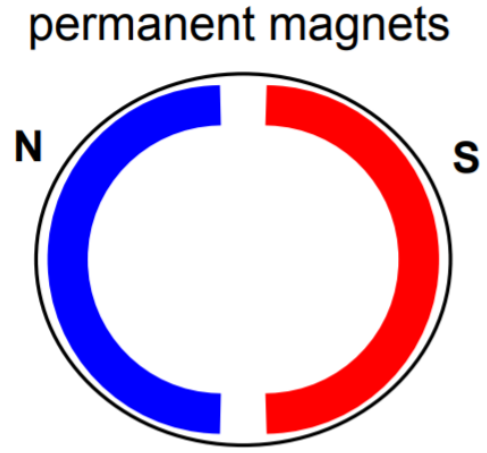
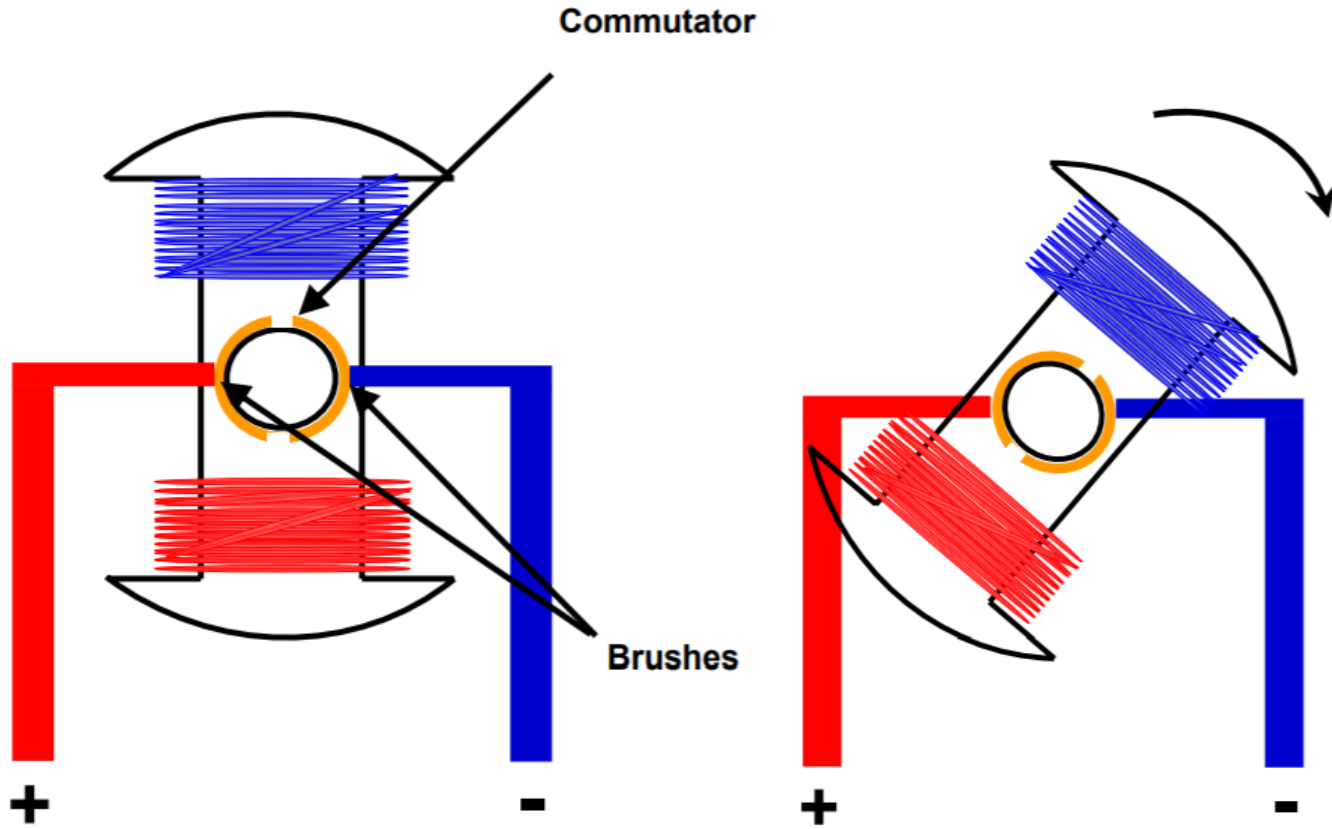
Brushed DC motor



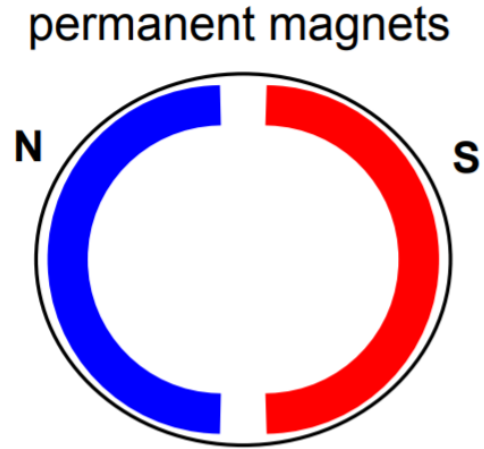
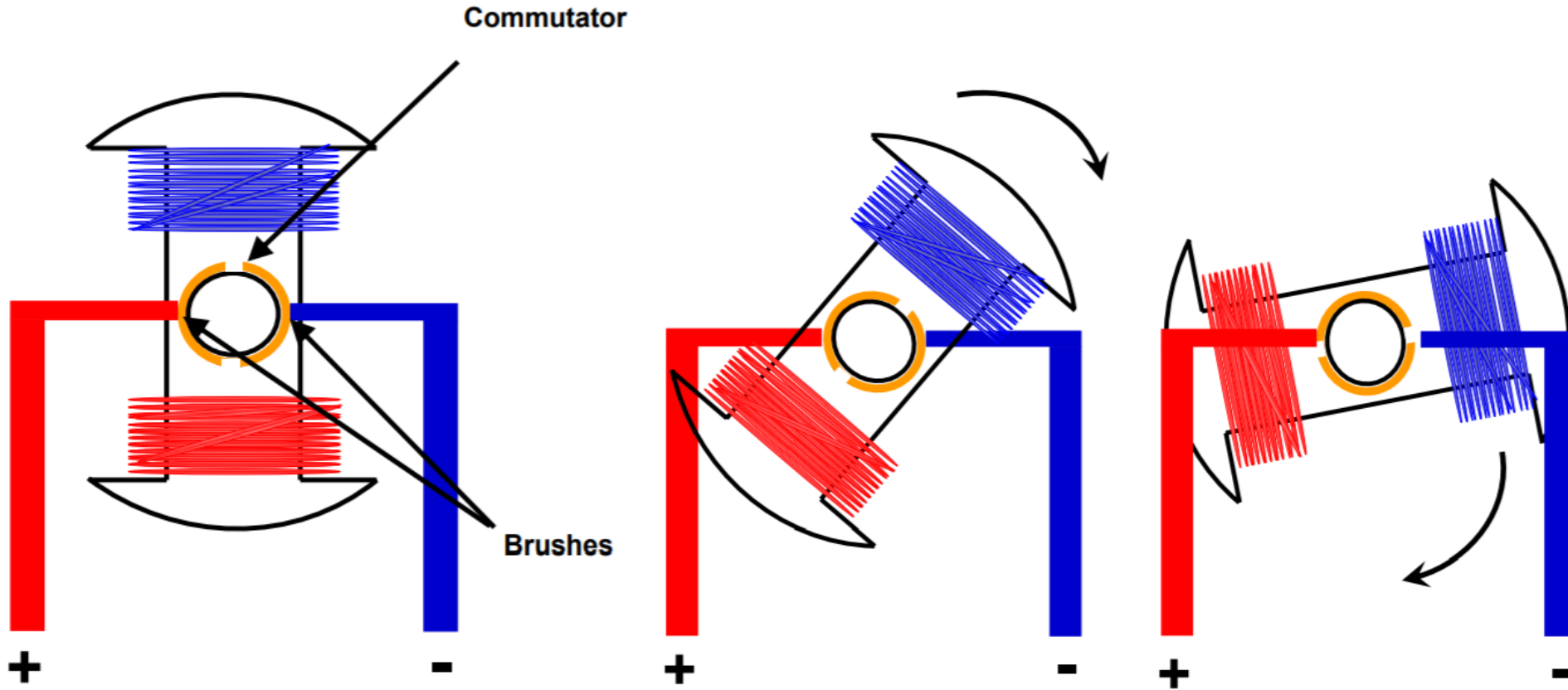
Brushed DC motor



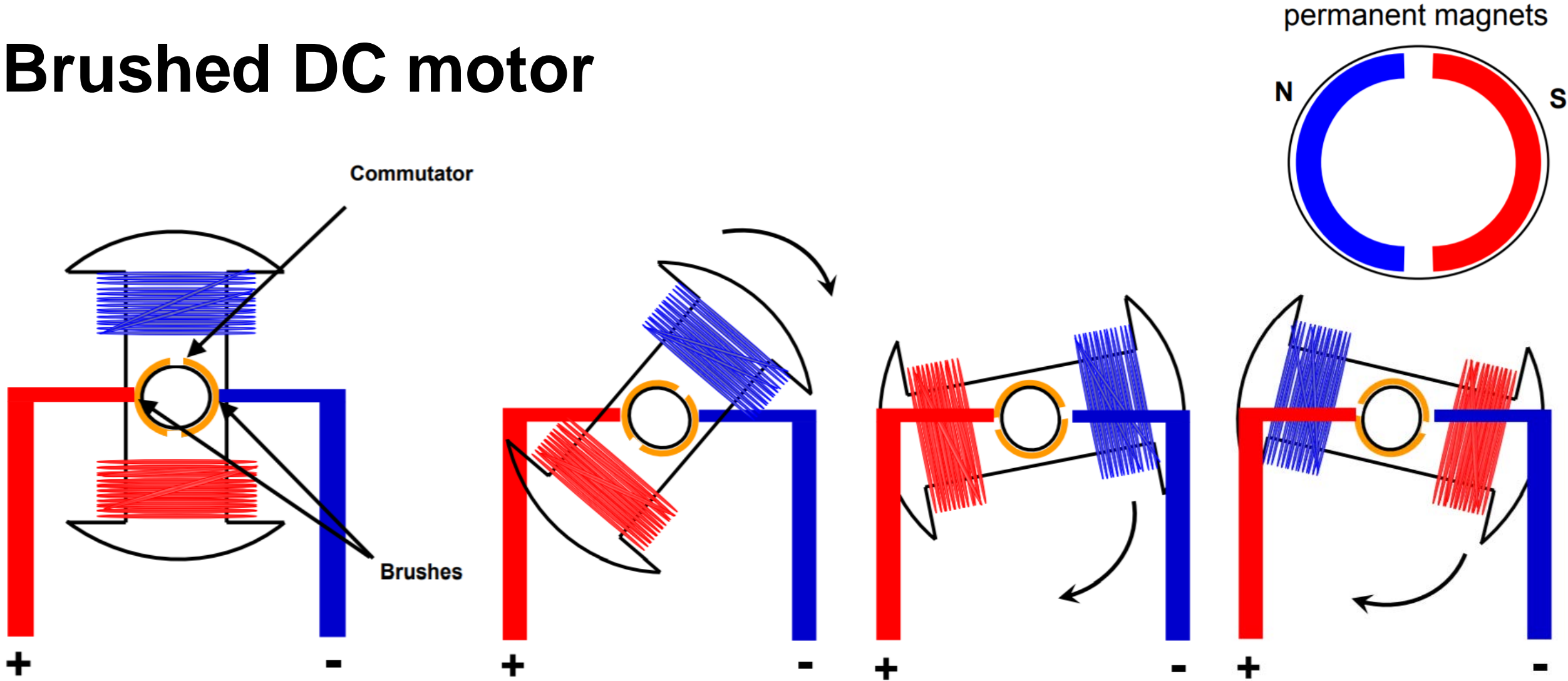
Brushed DC motor



Brushed DC motor

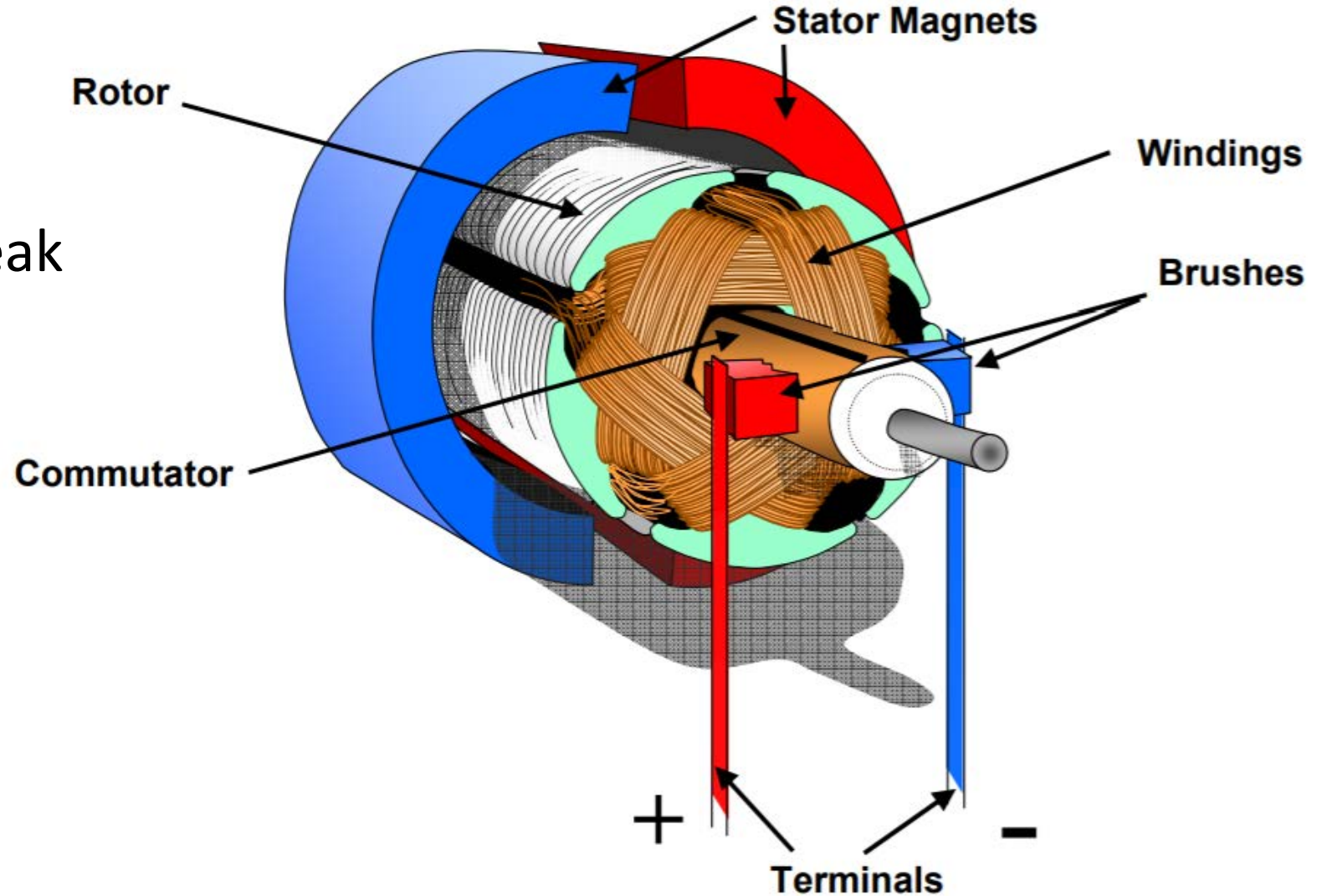


Brushed DC motor

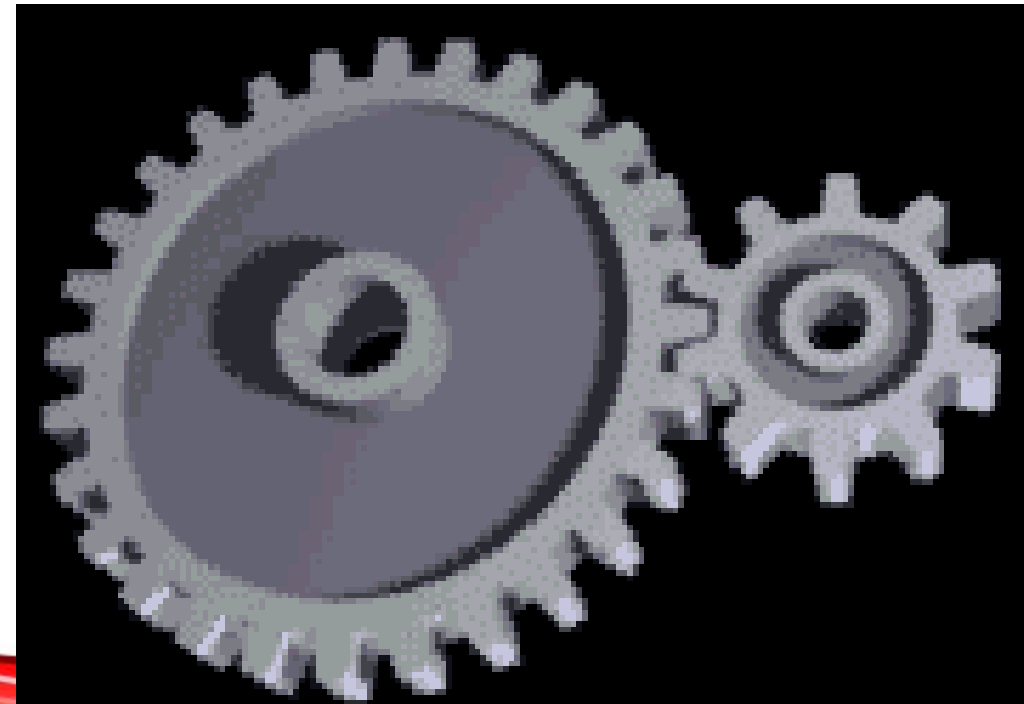
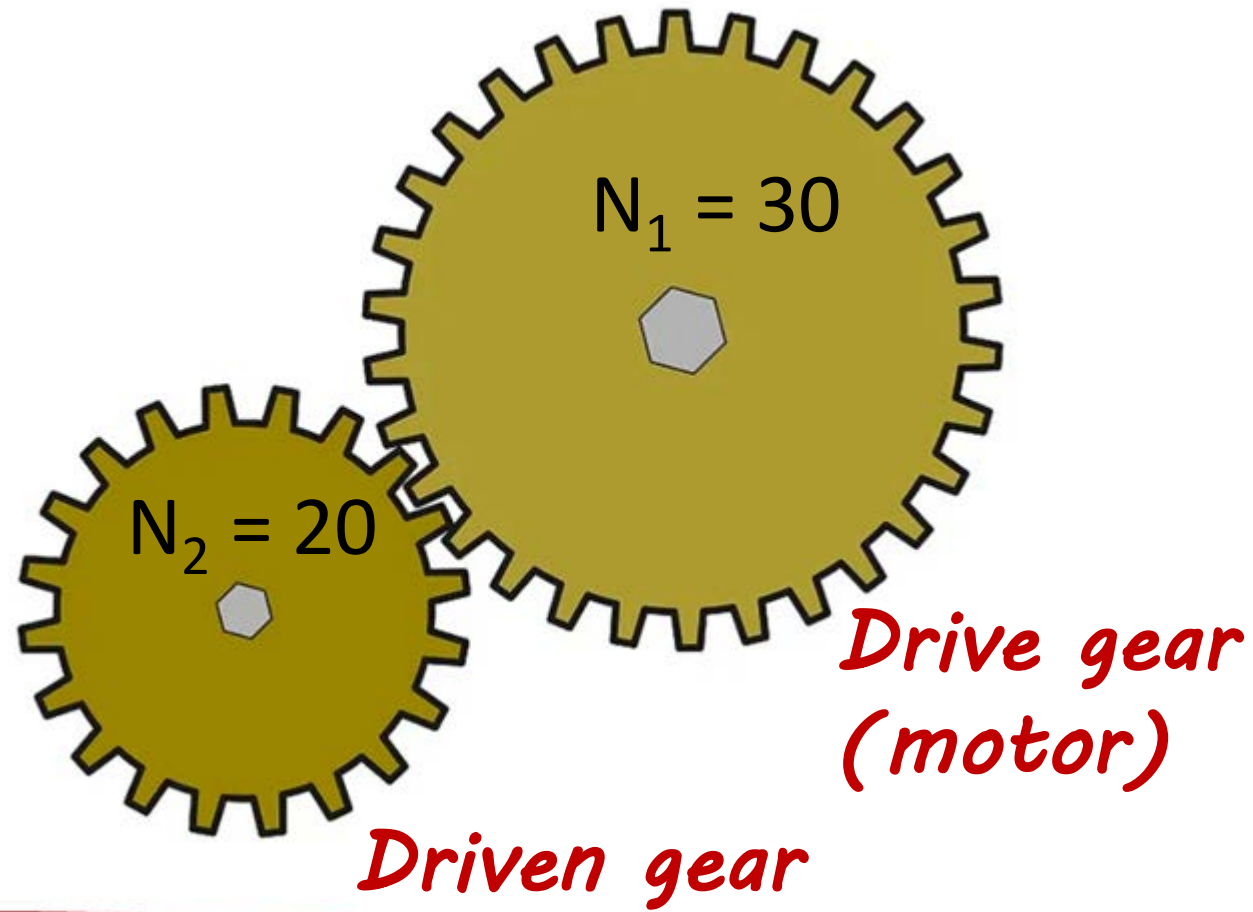


Brushed DC motor

- Standard motors are very fast and very weak
- Gear trains!

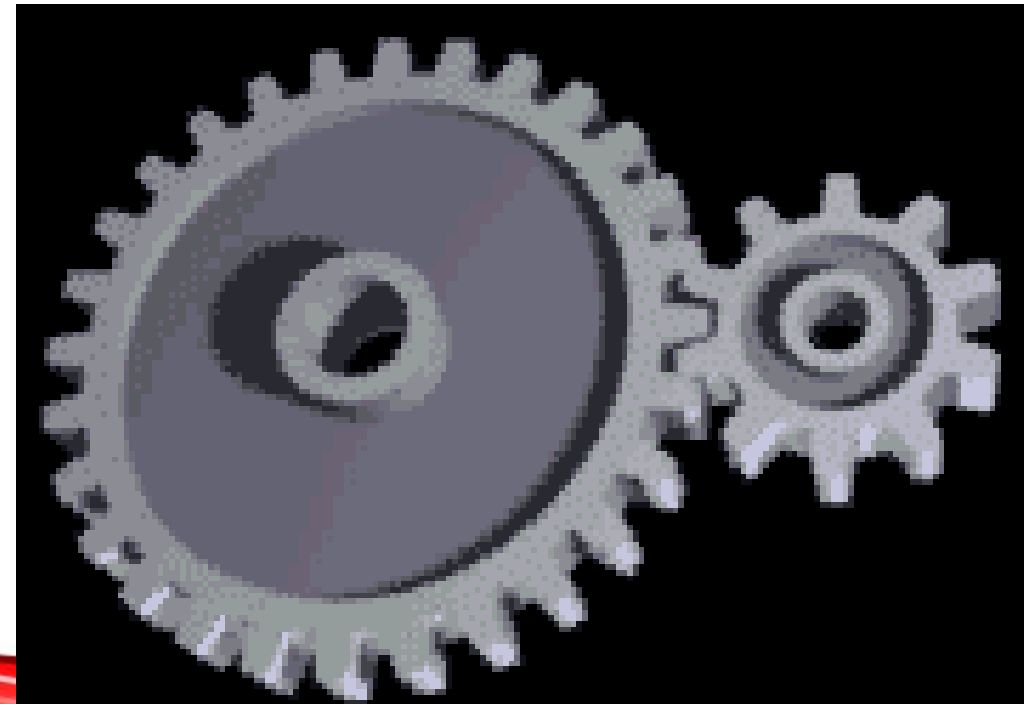
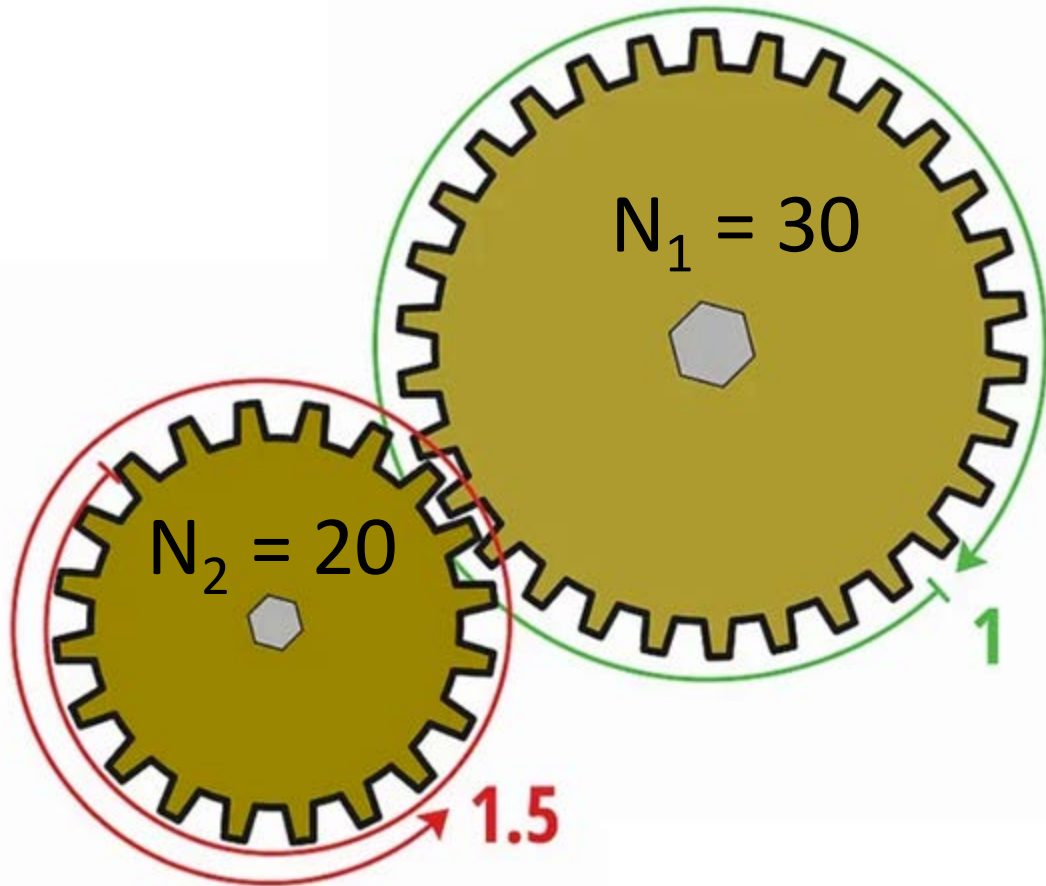


Gear Trains



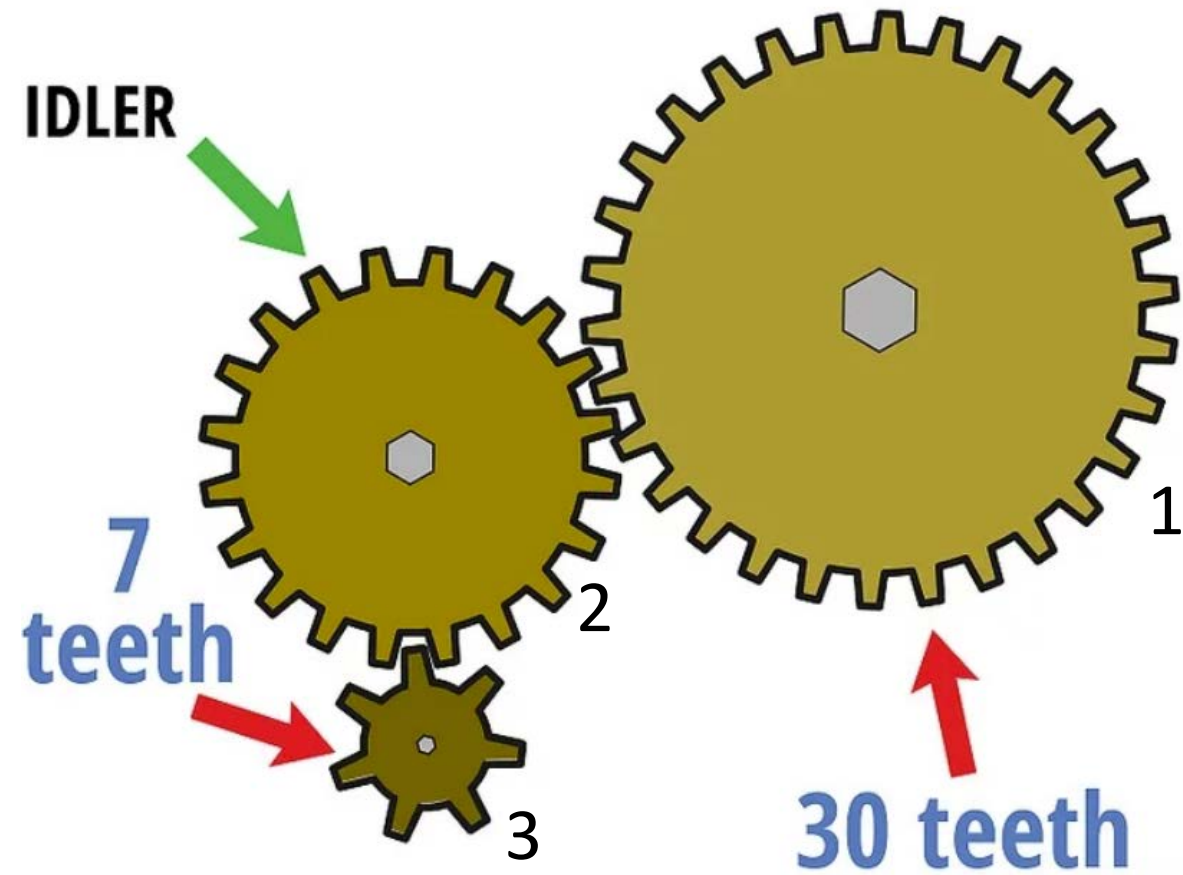
Gear Trains

$$v_2 = v_1 \cdot \frac{N_1}{N_2}$$

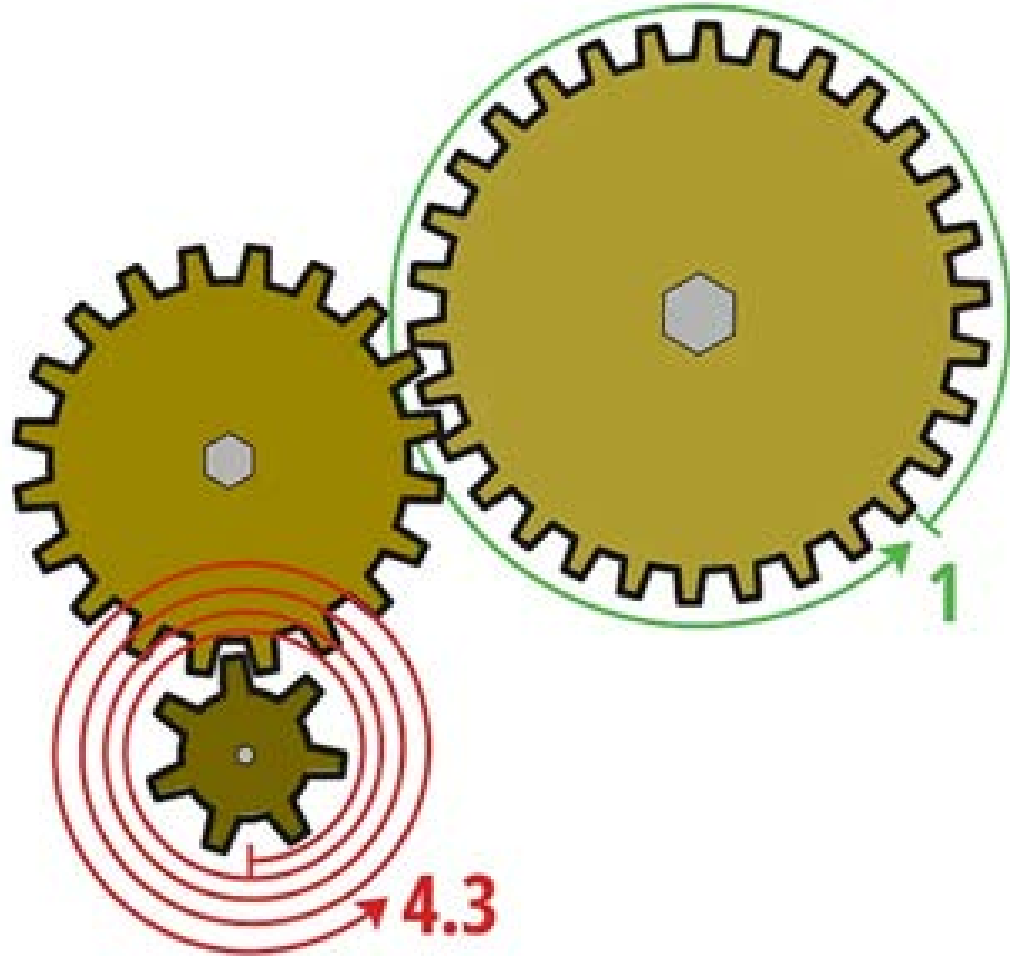


Gear Trains

$$v_3 = v_1 \cdot \frac{N_1}{N_3}$$



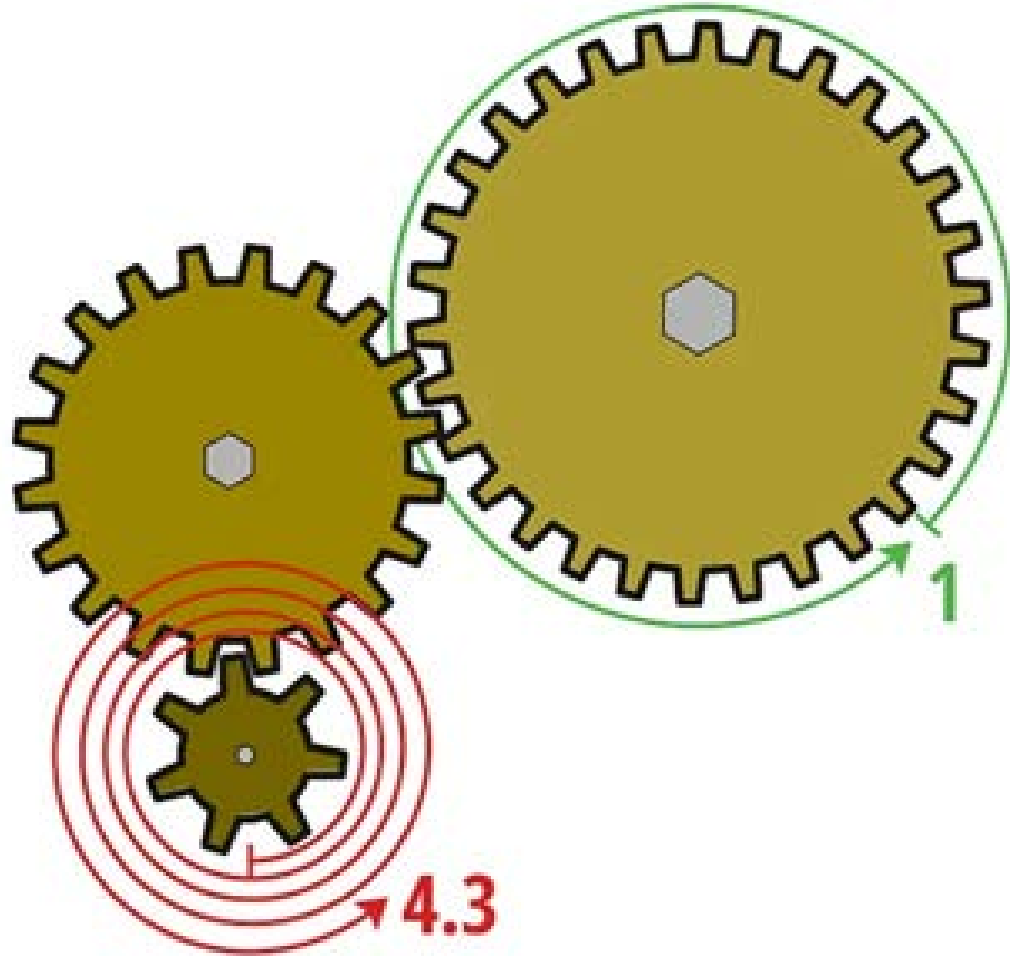
Gear Trains



$$v_3 = v_1 \cdot \frac{N_1}{N_3}$$

$$v_3 = v_1 \cdot \frac{N_1}{N_2} \cdot \frac{N_2}{N_3}$$

Gear Trains

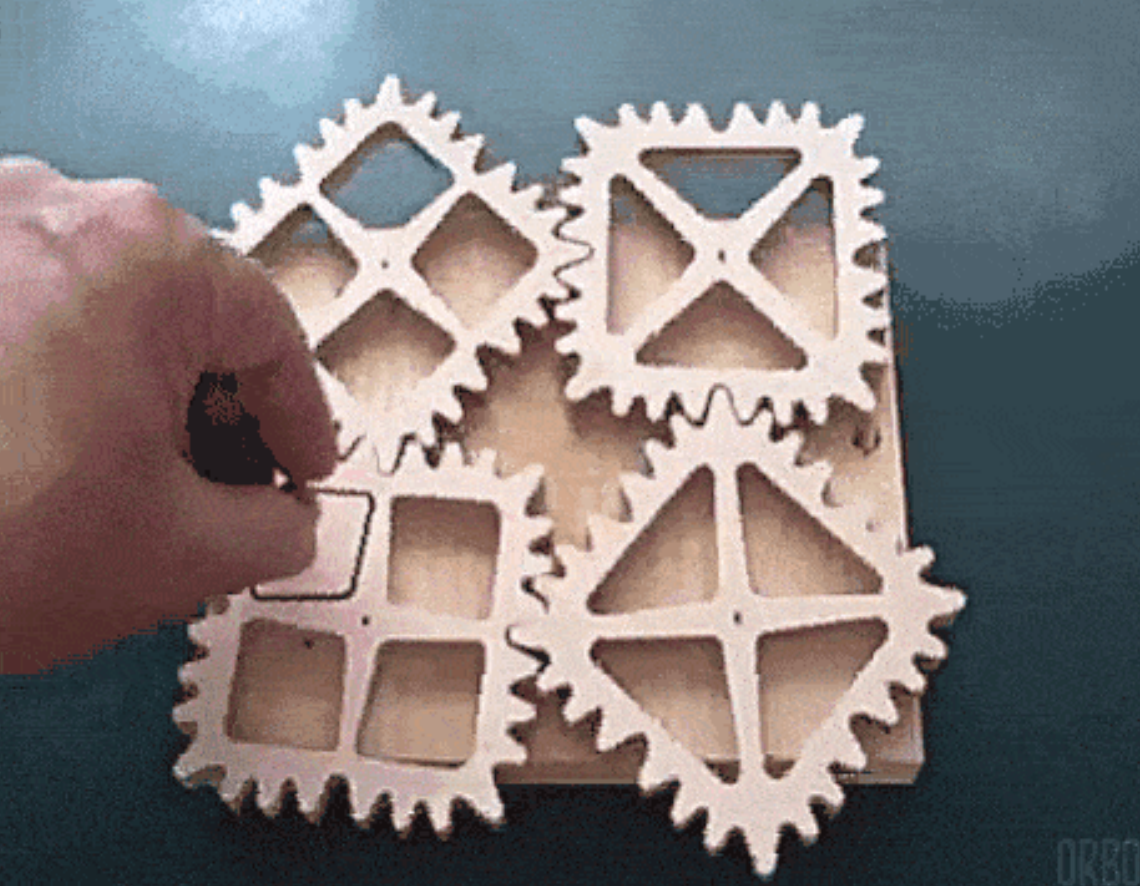
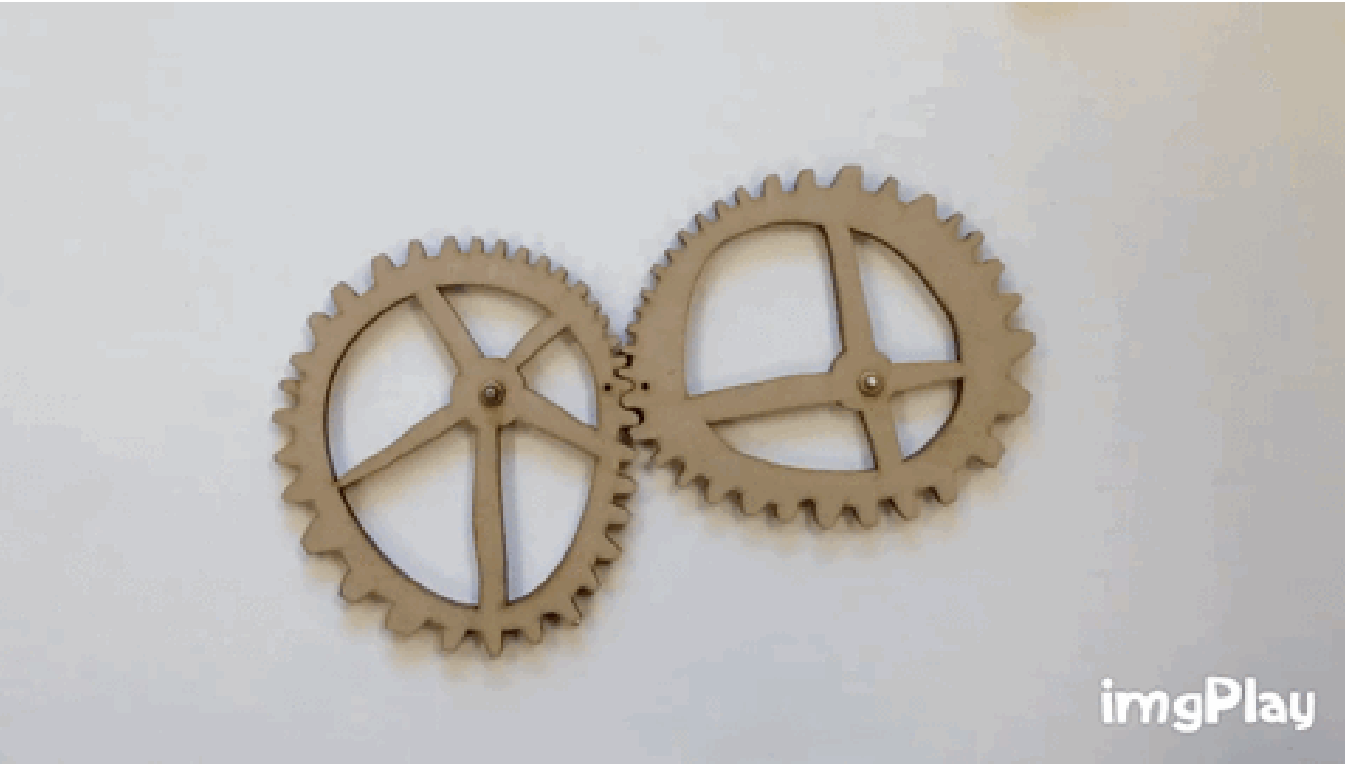


$$v_3 = v_1 \cdot \frac{N_1}{N_3}$$

$$\tau_3 = \tau_1 \cdot \frac{N_3}{N_1}$$

(real gears have loss - rule of thumb: loose ~10% per contact point)

Gear Trains

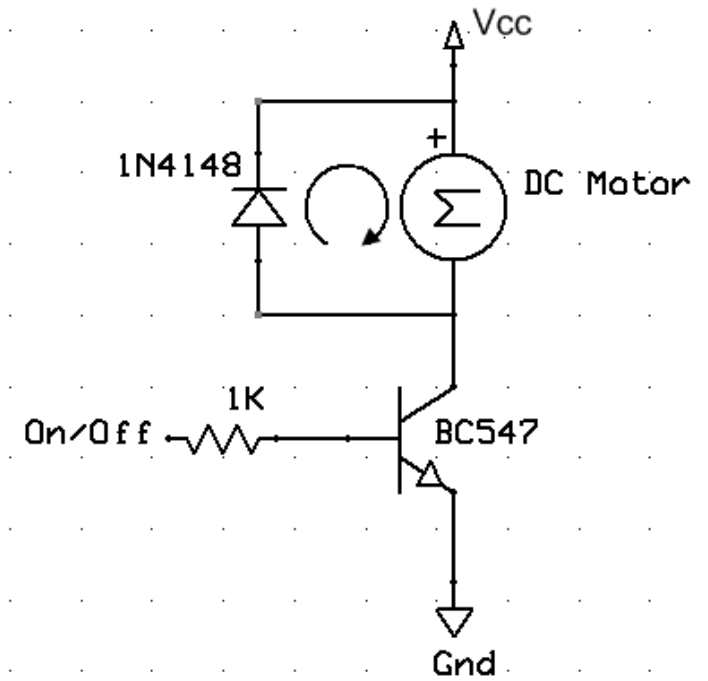
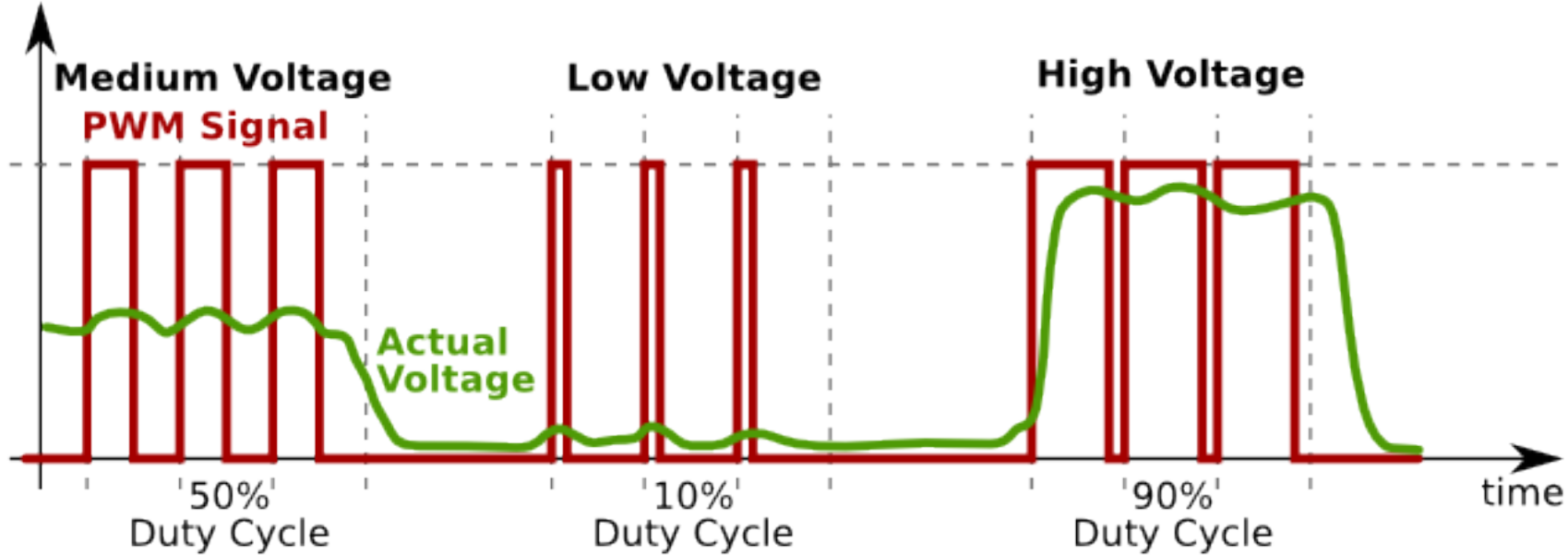


Driving a DC motor



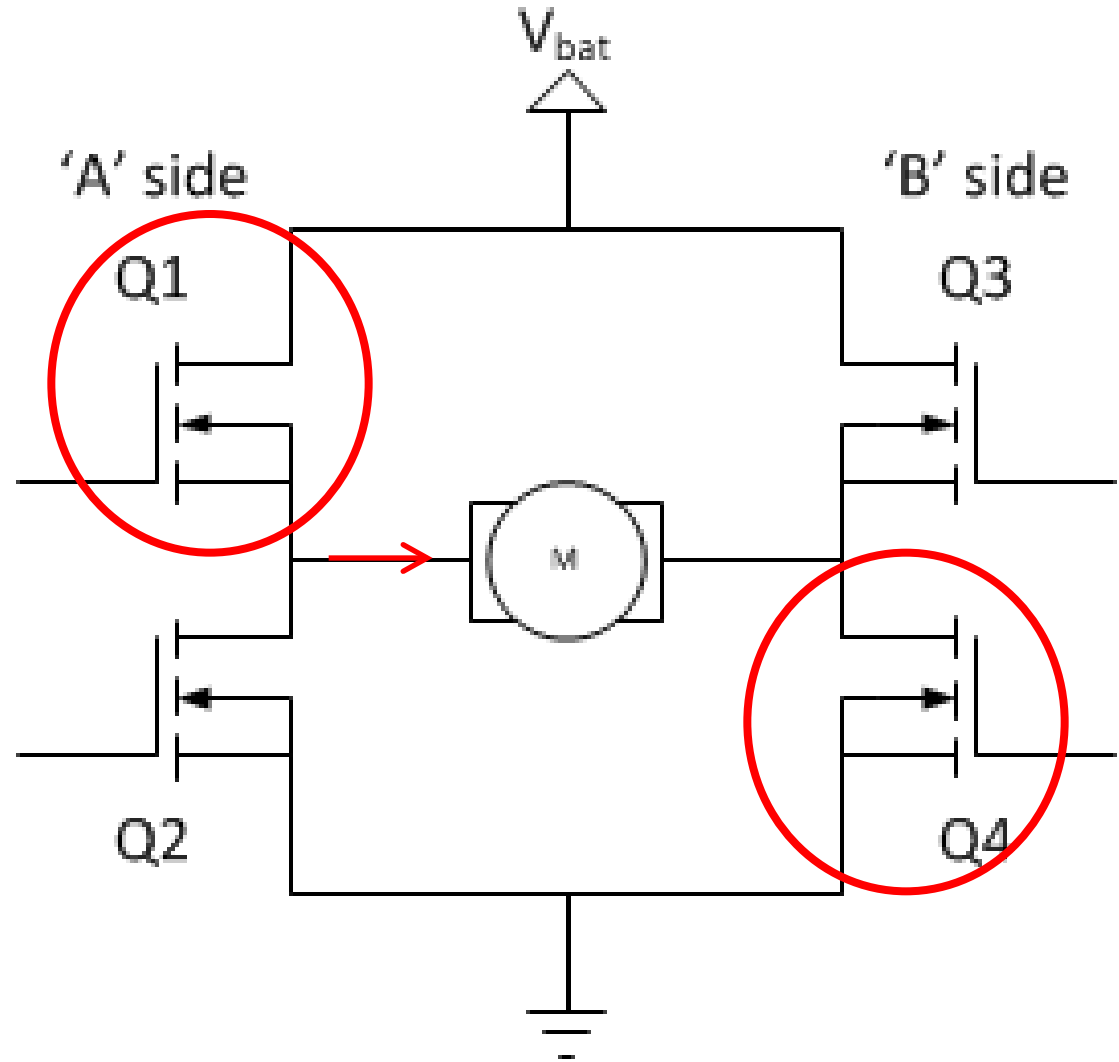
Driving a DC motor

- Analog voltage



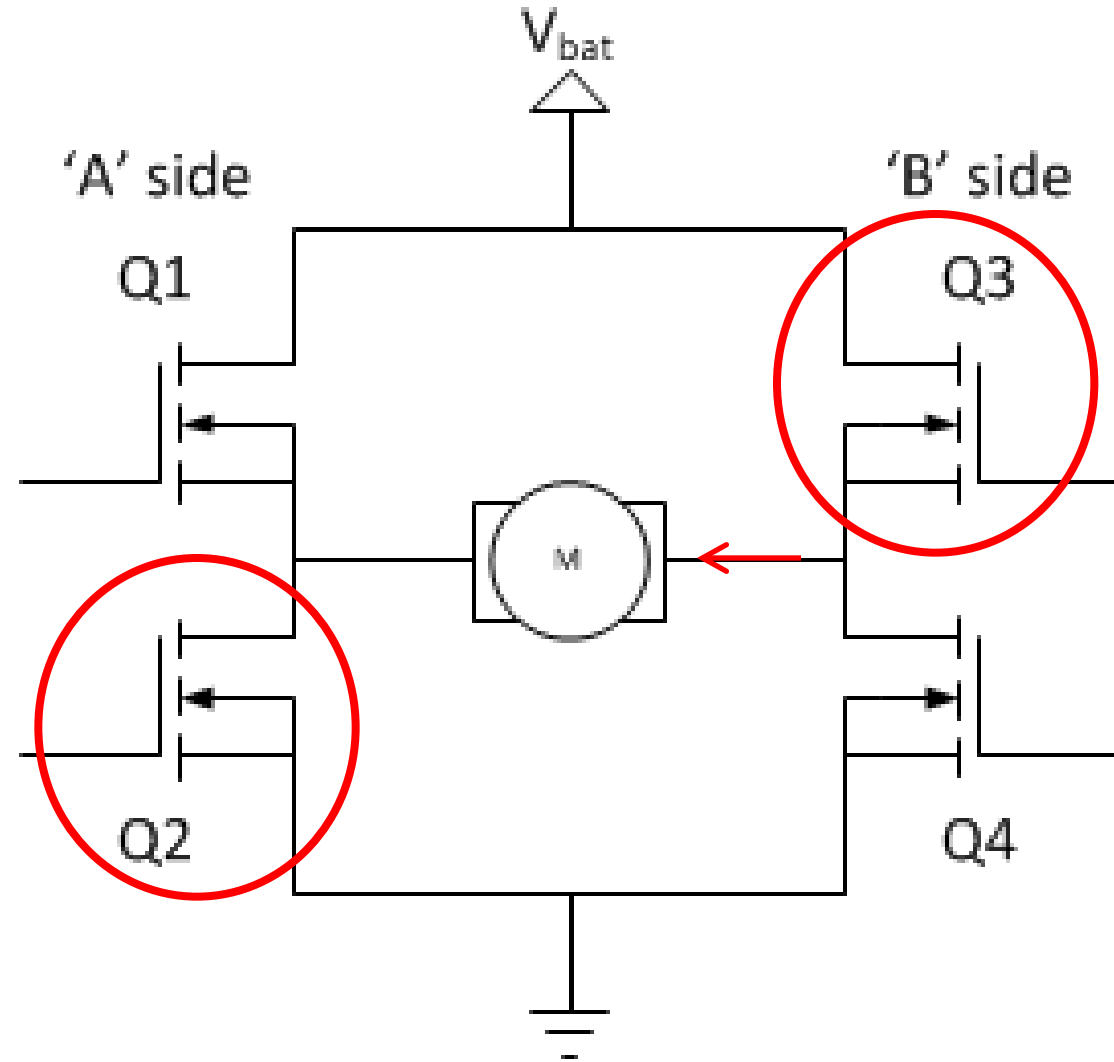
Driving a DC motor

- Analog voltage
- H-Bridge



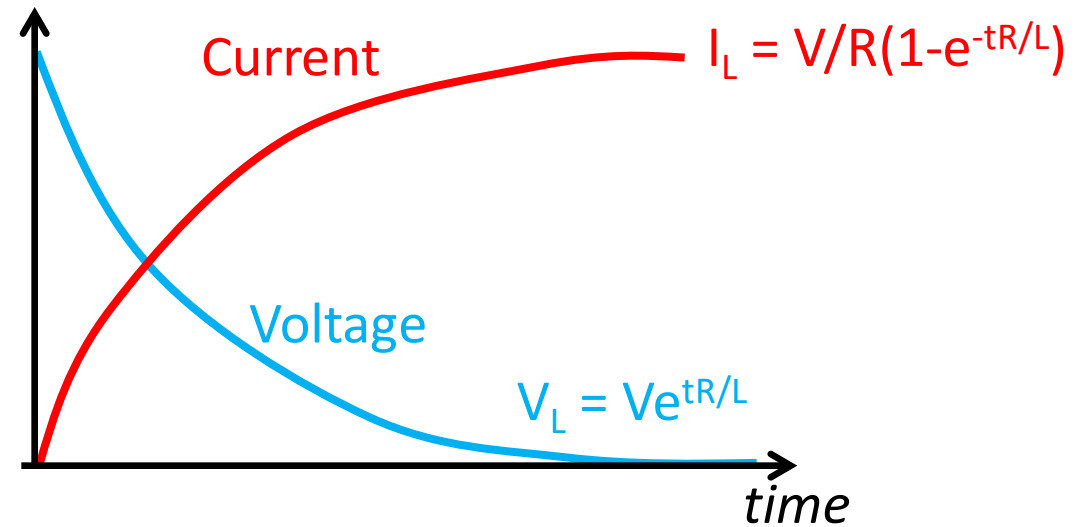
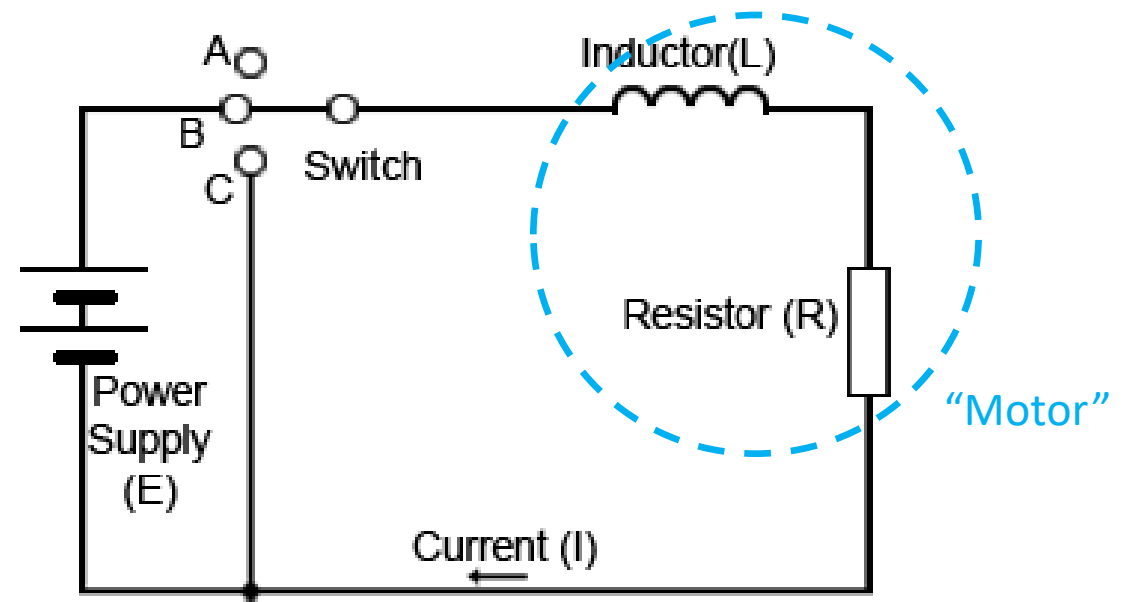
Driving a DC motor

- Analog voltage
- H-Bridge



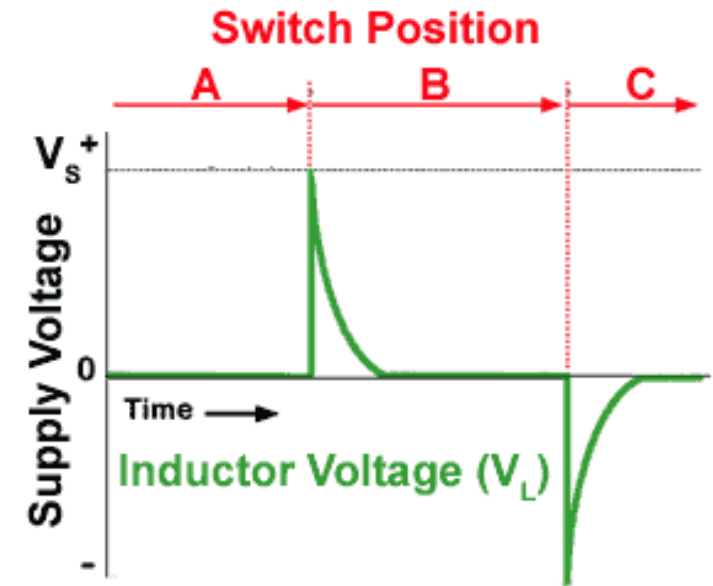
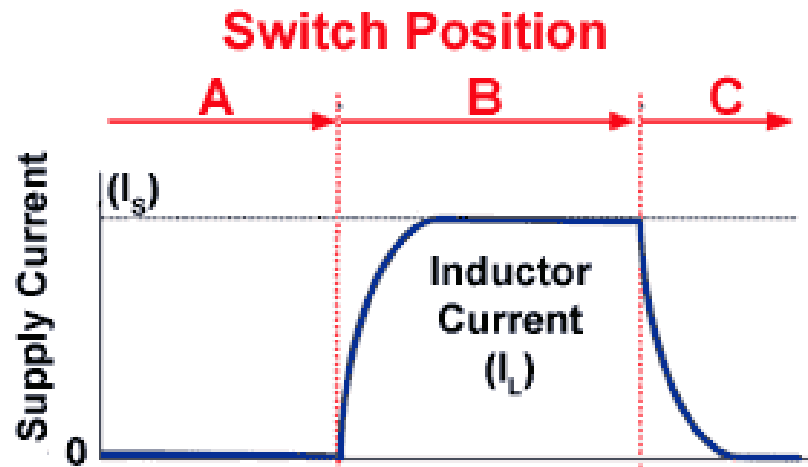
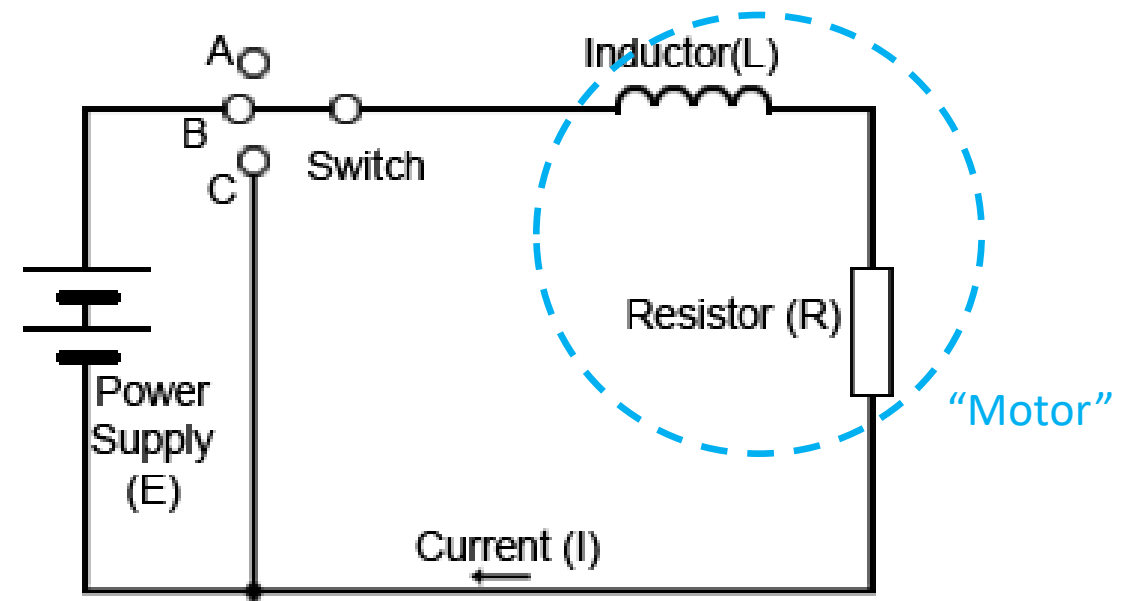
Driving a DC motor

- Analog voltage
- H-Bridge
- Electromotive Force (EMF)



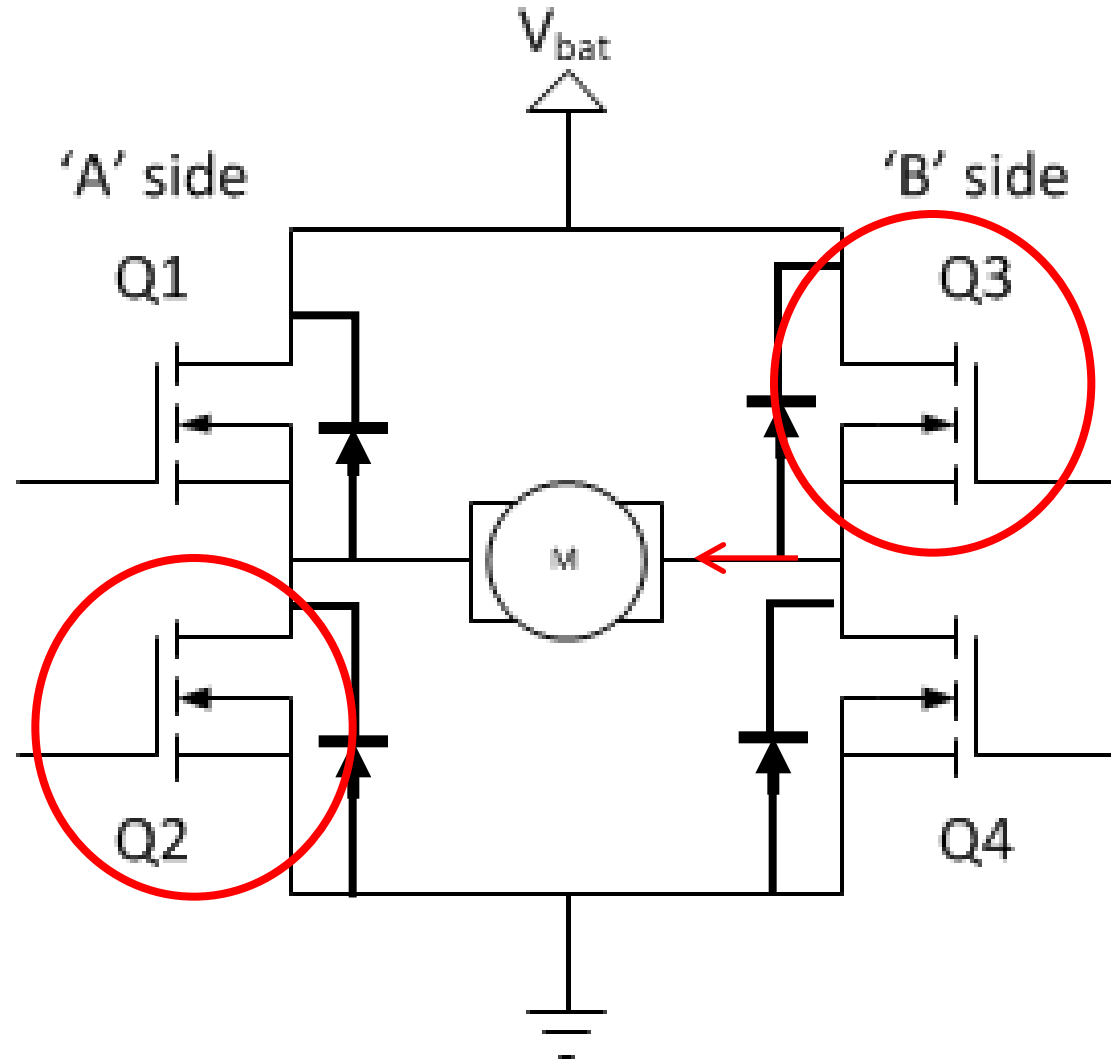
Driving a DC motor

- Analog voltage
- H-Bridge
- Electromotive Force (EMF)



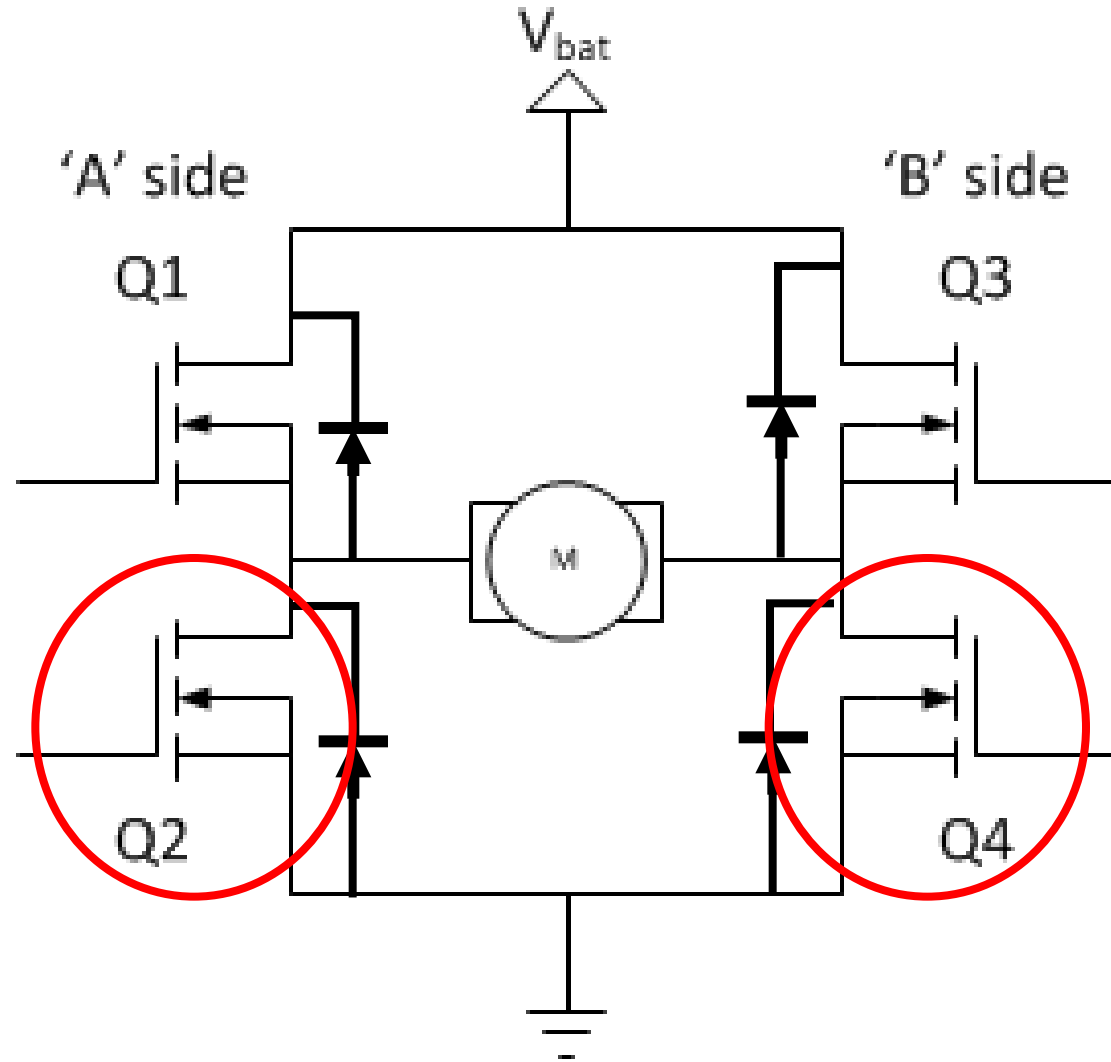
Driving a DC motor

- Analog voltage
- H-Bridge
- Electromotive Force (EMF)



Driving a DC motor

- H-Bridge
- PWM



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