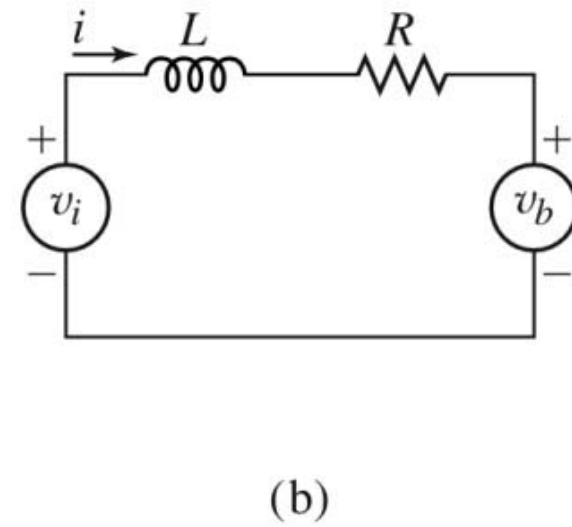
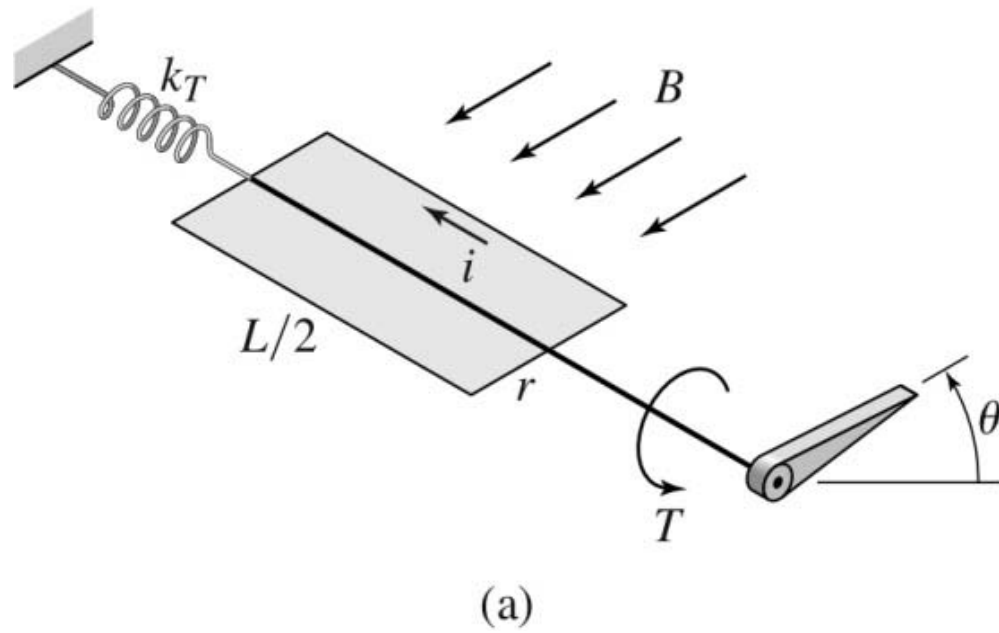


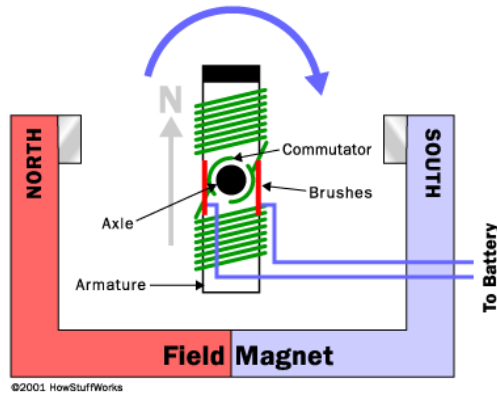
Electrical Systems III

D'Aarsonval Meter



DC Motors

Brushed DC Motor



Two wire control

Low cost of construction/ Simple and inexpensive control

No controller is required for fixed speeds

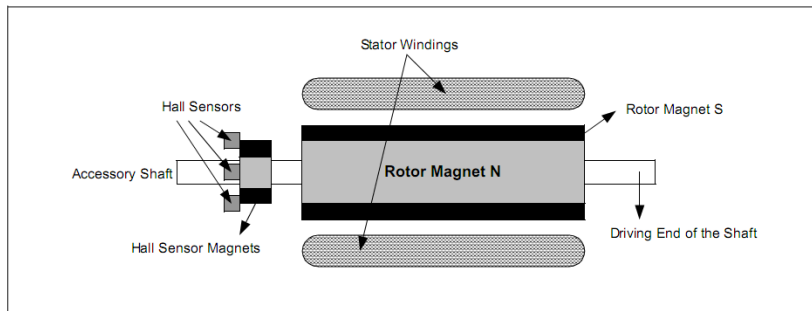
At higher speeds, brush friction increases, thus reducing useful torque

Poor heat dissipation due to internal rotor construction

Higher rotor inertia which limits the dynamic characteristics

Brush Arcing will generate noise causing EMI

Brushless DC (BLDC) Motor



High efficiency, no voltage drop across brushes

High output power/frame size.

Because BLDC has the windings on the stator, which is connected to the case, the heat dissipation is better

Higher speed range – no mechanical limitation imposed by brushes/commutator

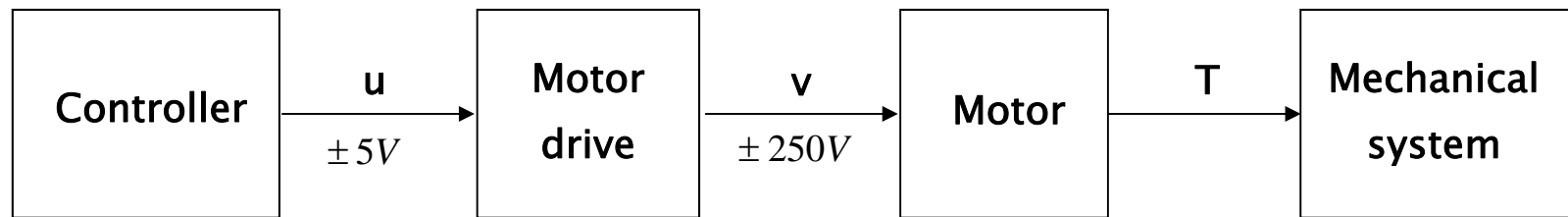
Higher cost of construction

Electric Controller is required to keep the motor running

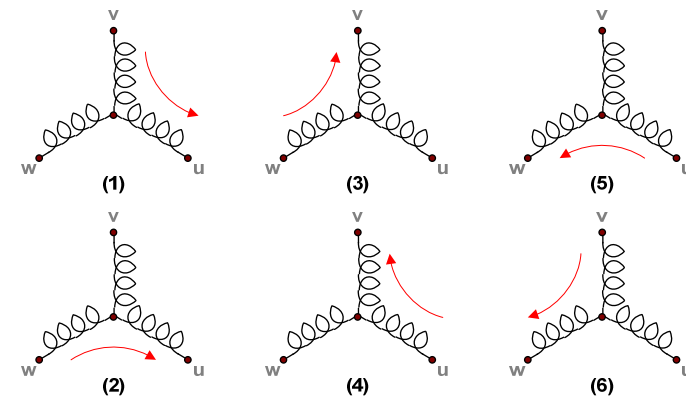
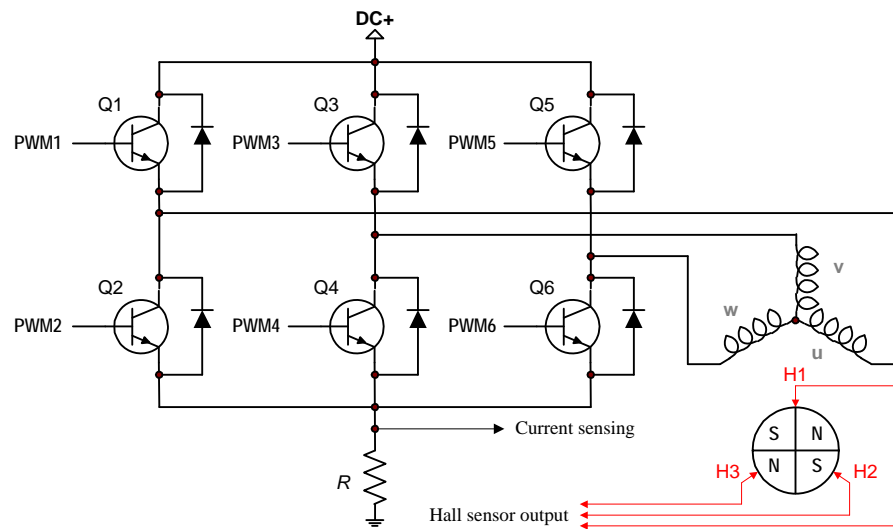
Other Motors:

Constitution of DC Servomotor System

Motor drive system :

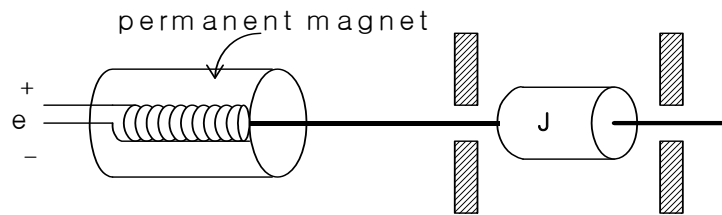


3 phase BLDC motor driver :



Constitution of DC Servomotor System

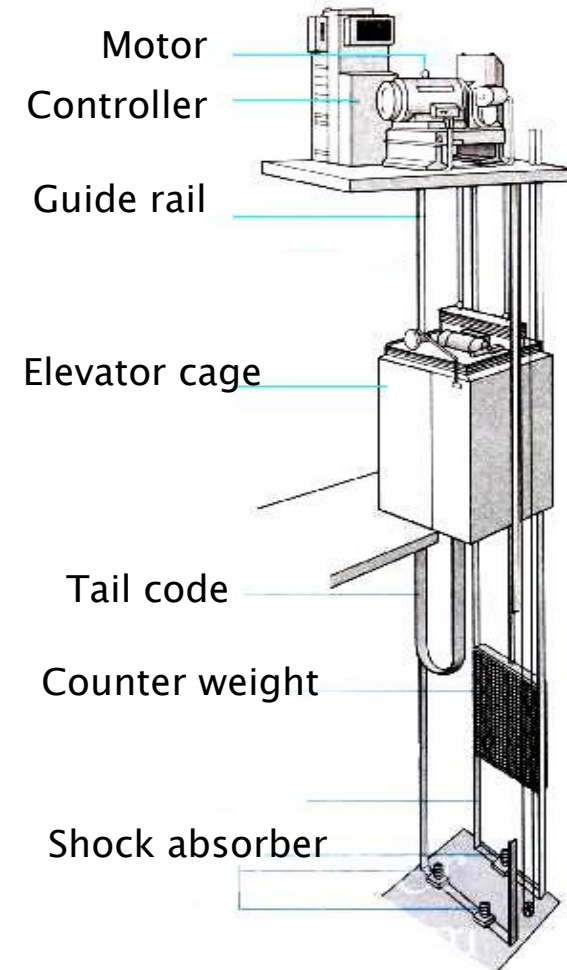
DC servo motor :



Electric Energy → Mechanical energy



ex) Elevator structure :



Armature Control of DC Servomotors

Variables :

R_a : armature resistance, Ω

L_a : armature inductance, H

i_a : armature current, A

i_f : field current, A

e_a : applied armature voltage, V

e_b : back emf, V

θ : angular displacement of the motor shaft, rad

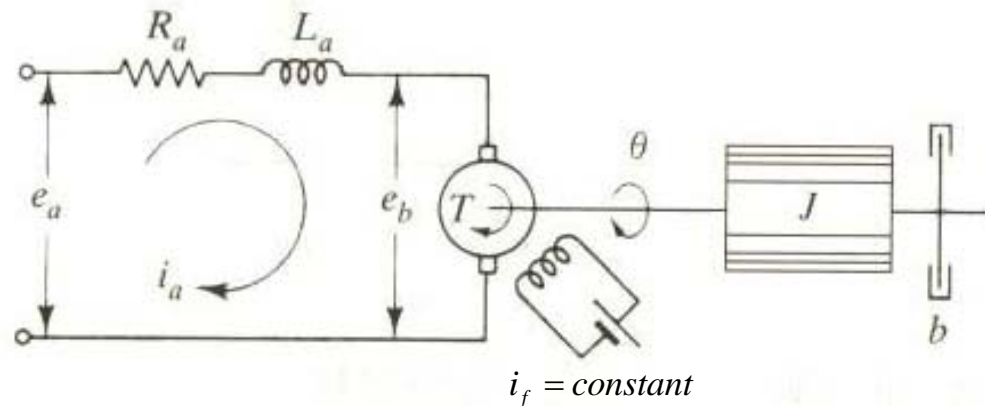
T : torque developed by the motor, N-m

J : equivalent moment of inertia of the motor

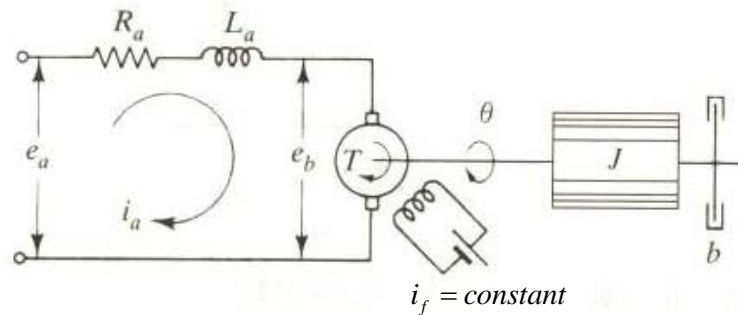
and load referred to the motor shaft, kg-m^2

b : equivalent viscous-friction coefficient of the motor

and load referred to the motor shaft, N-m/rad/s



Armature Control of DC Servomotors



The torque of motor : $T = K i_a$ K : motor – torque constant

For a constant flux, the induced voltage : $e_b = K_b \frac{d\theta}{dt}$ K_b : back emf constant

Armature circuit D.E : $L_a \frac{di_a}{dt} + R_a i_a + e_b = e_a$

Inertia and friction : $J \frac{d^2\theta}{dt^2} + b \frac{d\theta}{dt} = T = K i_a$

Armature Control of DC Servomotors

Laplace transforms of equations :

$$e_b = K_b \frac{d\theta}{dt}$$

$$K_b s \Theta(s) = E_b(s)$$

$$L_a \frac{di_a}{dt} + R_a i_a + e_b = e_a$$

→

$$(L_a s + R_a) I_a(s) + E_b(s) = E_a(s)$$

$$J \frac{d^2\theta}{dt^2} + b \frac{d\theta}{dt} = T = K i_a$$

$$(J s^2 + b s) \Theta(s) = T(s) = K I_a(s)$$

$$T.F = \frac{\Theta(s)}{E_a(s)} = \frac{K}{s(R_a J s + R_a b + K K_b)} = \frac{\frac{K}{R_a J}}{s \left(s + \frac{R_a b + K K_b}{R_a J} \right)}$$

$$= \frac{K_m}{s(T_m s + 1)}$$

$$K_m = K / (R_a b + K K_b) = \text{motor gain constant}$$

$$T_m = R_a J / (R_a b + K K_b) = \text{motor time constant}$$

Example of a DC Servomotor System

ex) servo-motor system

R_a : armature resistance, Ω

i_a : armature current, A

i_f : field current, A

e_a : applied armature voltage, V

e_b : back emf, V

θ_1 : angular displacement of the motor shaft, rad

θ_2 : angular displacement of the load shaft, rad

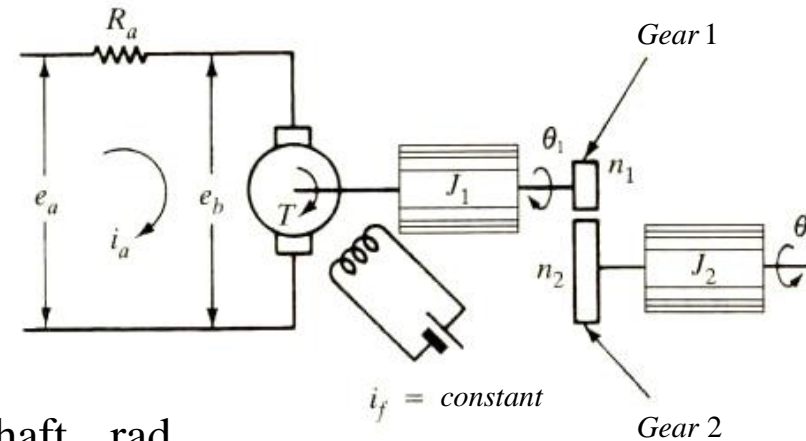
T : torque developed by the motor, N-m

J_1 : equivalent moment of inertia of the motor, kg-m^2

J_2 : equivalent moment of inertia of the load, kg-m^2

The torque of motor : $T = K i_a$

For a constant flux, the induced voltage : $e_b = K_b \frac{d\theta}{dt}$ K_b : back emf constant



Example of a DC Servomotor System

Armature circuit D.E : $R_a i_a + e_b = e_a$ Inertia and friction : $J_{1eq} = J_1 + \left(\frac{n_1}{n_2}\right)^2 J_2$

Laplace transforms of these equations :

$$K_b s \Theta(s) = E_b(s), \quad (L_a s + R_a) I_a(s) + E_b(s) = E_a(s), \quad (J s^2 + b s) \Theta(s) = T(s) = K I_a(s)$$

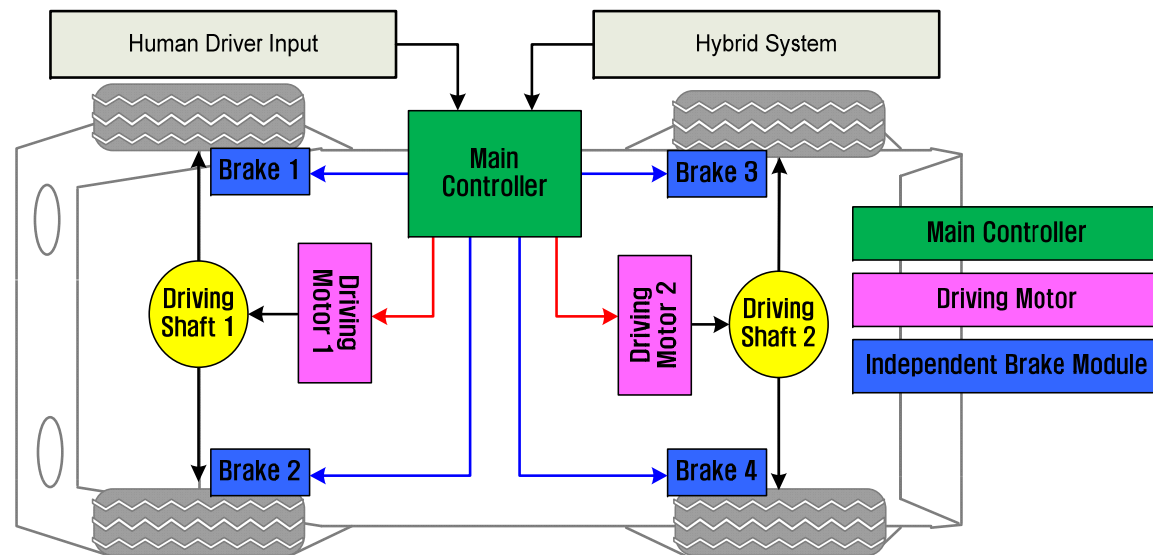
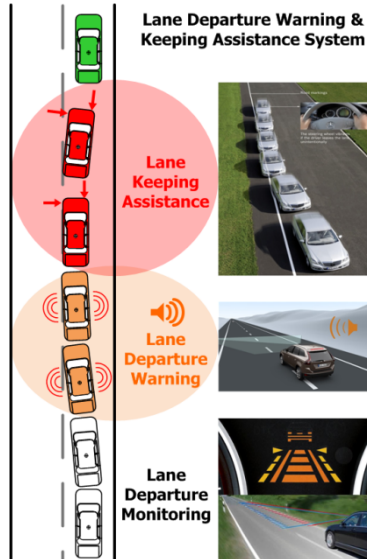
$$\begin{aligned} T.F = \frac{\Theta(s)}{E_a(s)} &= \frac{K}{s(R_a J s + R_a b + K K_b)} = \frac{\frac{K}{R_a J}}{s \left(s + \frac{R_a b + K K_b}{R_a J} \right)} \\ &= \frac{K_m}{s(T_m s + 1)} \end{aligned}$$

Electric Vehicle

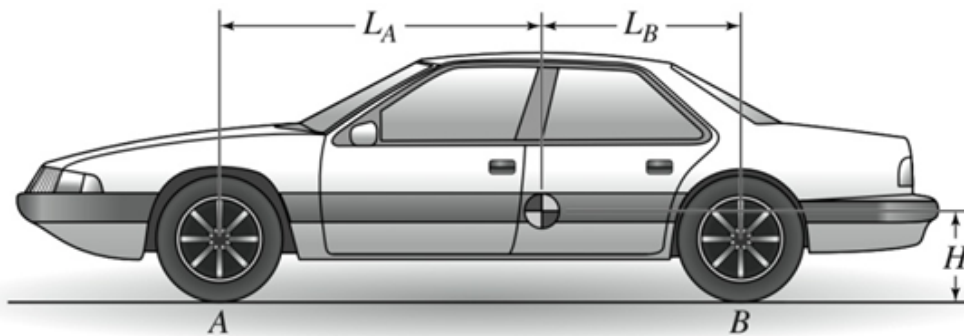
Safety and Maneuverability Control Allocation for 4WD Electric Vehicle

- System Configuration

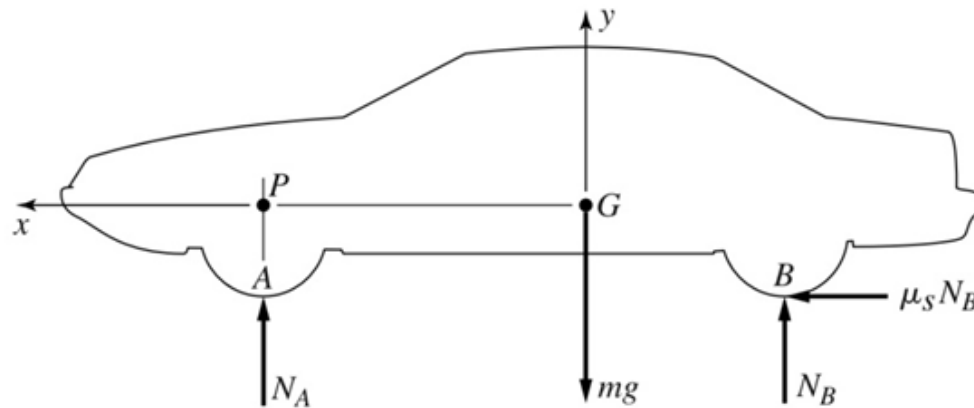
- Objective: **Driving Control Algorithm** for Maneuverability, Lateral Stability and Rollover Prevention
- Main Controller Input: Human Driver Input, Measured Vehicle Signal
- Actuator: Front and Rear Driving Shaft Motors, Independent Brake Module



Rear wheel drive electric vehicle: DC Motor



(a)



(b)

Motor selection

1. Max speed : 120 kph
2. Max accelerations: $>0.6G$
3. 0-100 kph : 8seconds

