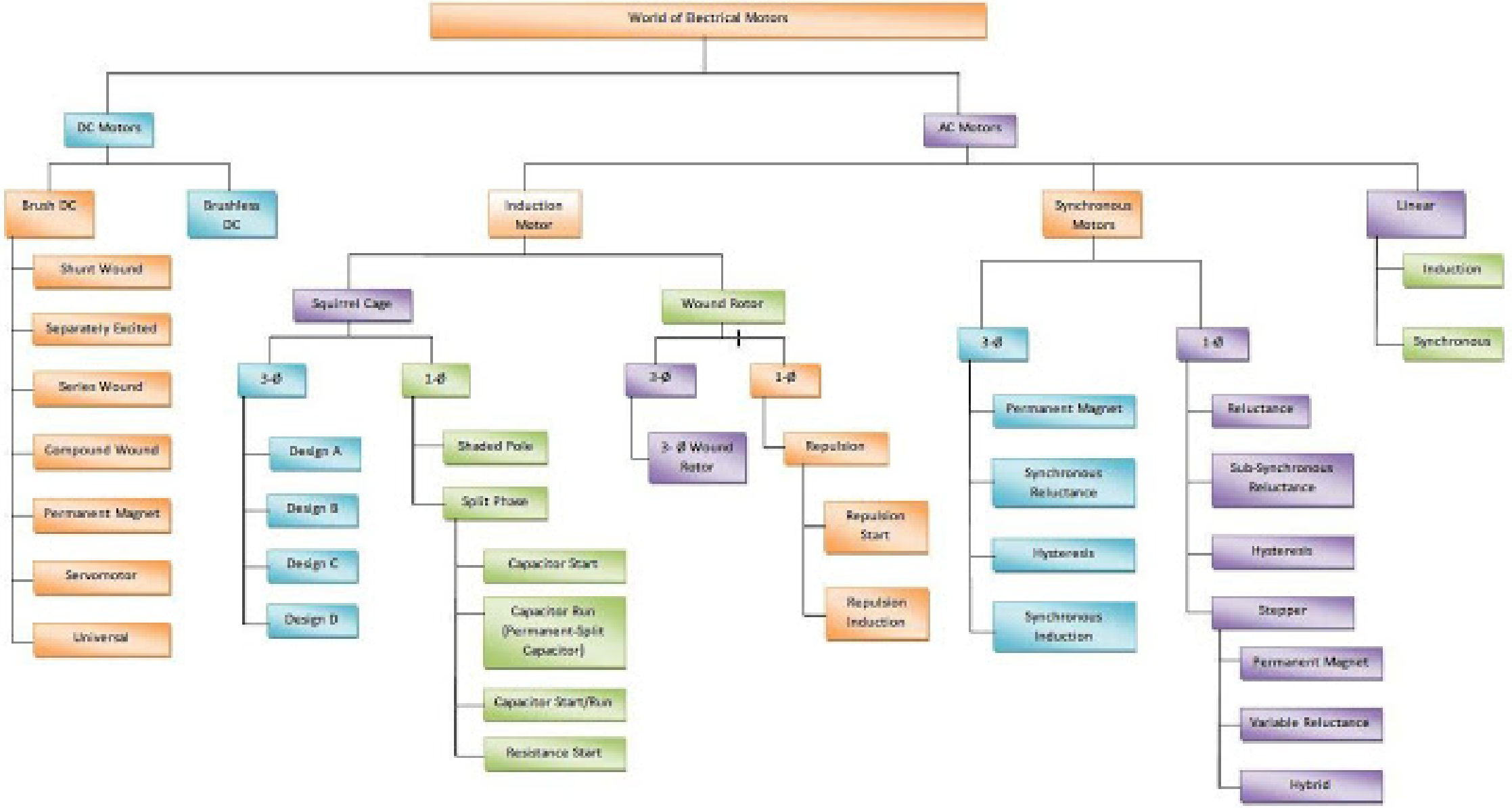
Mathematical Models of DC Motor

Electromechanical System

- Direct current motor (DC Motor)
- Alternating current motor(AC Motor)


World of Electrical Motors
DC Motors
AC Motors
Brush DC
Brushless DC
Induction Motor
Synchronous Motors
Linear
Shunt Wound
Separately Excited
Series Wound
Compound Wound
Permanent Magnet
Servomotor
Universal
Squirrel Cage
Wound Rotor
3-Ø
1-Ø
3-Ø
1-Ø
Design A
Design B
Design C
Design D
Shaded Pole
Split Phase
3- Ø Wound Rotor
Repulsion
Capacitor Start
Capacitor Run (Permanent-Split Capacitor)
Capacitor Start/Run
Resistance Start
Repulsion Start
Repulsion Induction
3-Ø
1-Ø
Induction
Synchronous
Permanent Magnet
Synchronous Reluctance
Hysteresis
Synchronous Induction
Reluctance
Sub-Synchronous Reluctance
Hysteresis
Stepper
Permanent Magnet
Variable Reluctance
Hybrid

Electromechanical System: DC motor

Electromechanical System: DC motor

Advantages of DC motors:

- It is easy to control their speed in a wide range; their torque–speed characteristic has, historically, been easier to tailor than that of all AC motor categories. This is why most traction and servo motors have been DC machines. For example, motors for driving rail vehicles were, until recently, exclusively DC machines.

- Their reduced overall dimensions permit a considerable space saving which let the manufacturer of the machines or of plants not to be conditioned by the exaggerated dimensions of circular motors

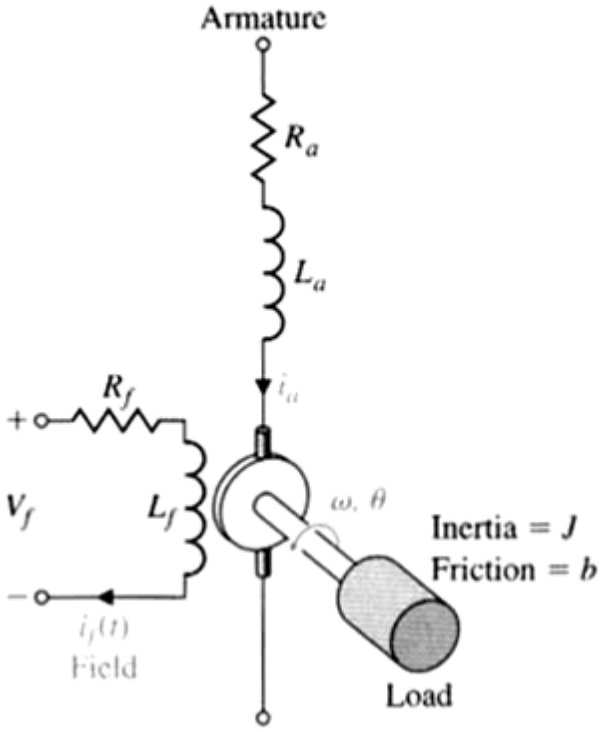
Electromechanical System: DC motor

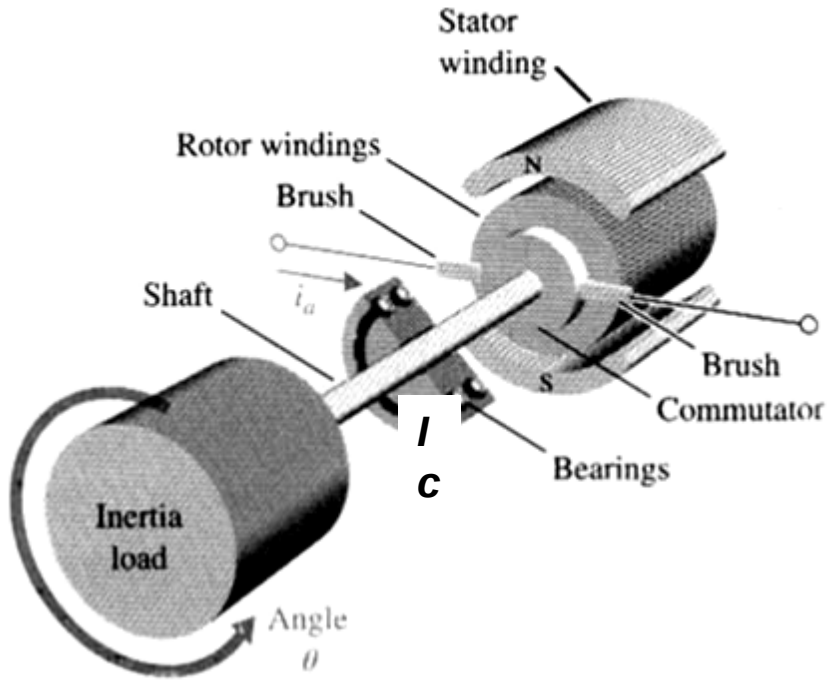
Disadvantages of DC motors

- Since they need brushes to connect the rotor winding. Brush wear occurs, and it increases dramatically in low-pressure environment. So they cannot be used in artificial hearts. If used on aircraft, the brushes would need replacement after one hour of operation.
- Sparks from the brushes may cause explosion if the environment contains explosive materials.
- RF noise from the brushes may interfere with nearby TV sets, or electronic devices, Etc.
- DC motors are also expensive relative to AC motors.

Elements of Electromechanical System

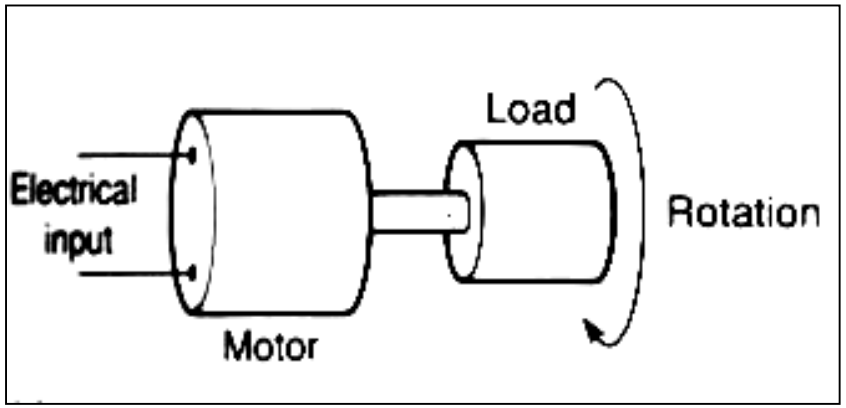
1. Armature-Controlled Motor
2. Field – Controlled Motor

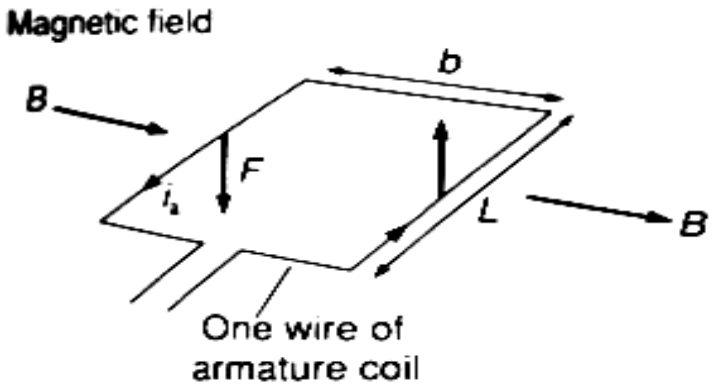




Elements of Electromechanical System

Armature-Controlled Motor





$$F = Bi_a L$$

$$F = NBi_a L$$

i_a – armature current (A)

B – magnetic field (T)

L – length of wire (m)

N – number of wire loop

Elements of Electromechanical System

Armature-Controlled Motor

Kirchoff's voltage law states that the sum of all voltages around a loop must equal zero

$$v_a - v_{R_a} - v_{L_a} - v_b = 0$$

$$v_a - v_b = L_a \frac{di_a}{dt} + R_a i_a \quad \Rightarrow \quad v_a - k_3\omega = L_a \frac{di_a}{dt} + R_a i_a$$

The back emf can be written as $v_b = k_3\omega$

Elements of Electromechanical System

Armature-Controlled Motor

Rotational system of DC motor is

$$T_m - T_d = I\frac{d\omega}{dt}$$

where

$$T_m = k_4 i_a - \text{ torque motor } (\text{N}\cdot\text{m})$$

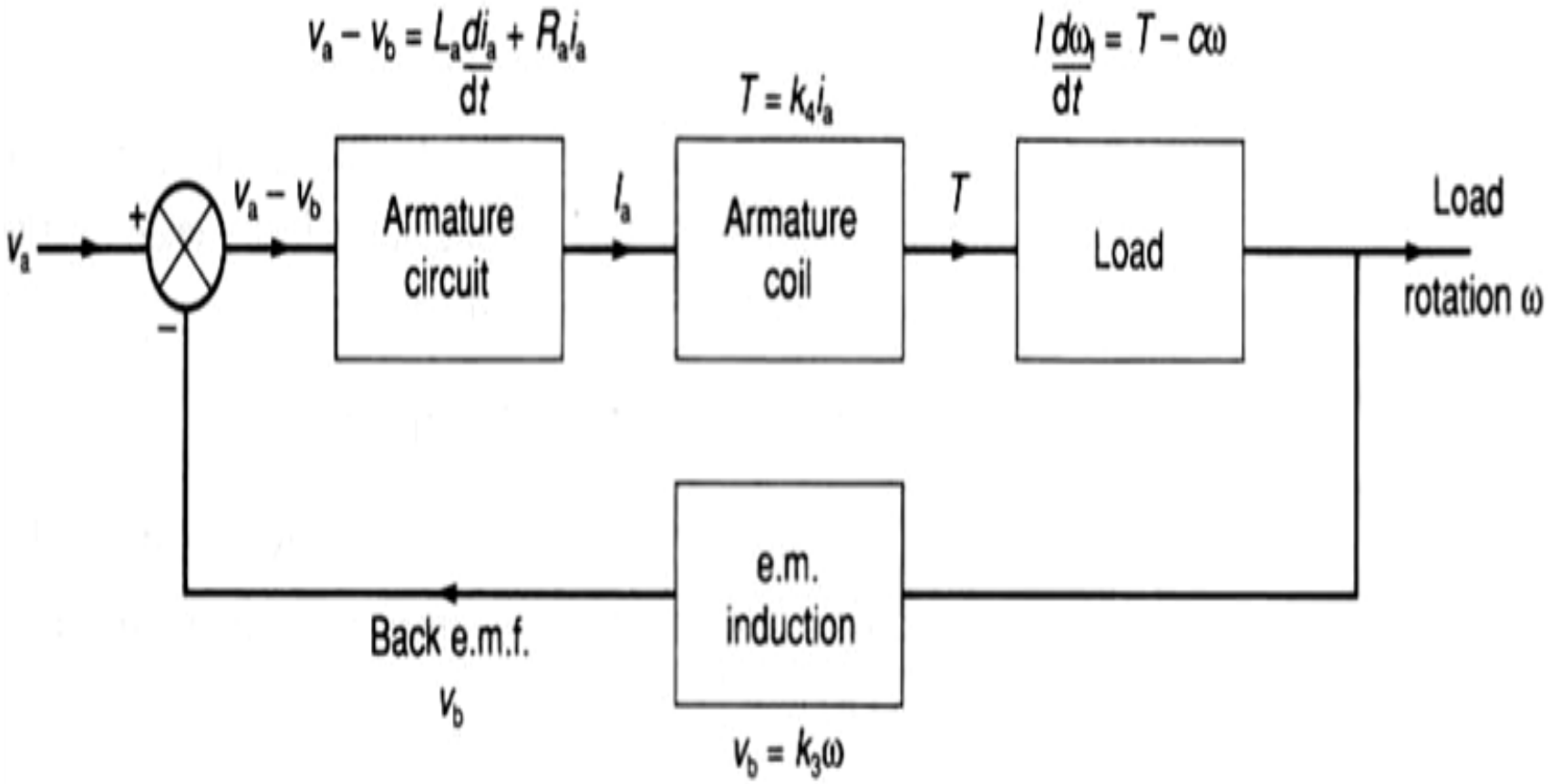
$$T_d = c\omega - \text{ damping torque} (\text{N}\cdot\text{m})$$

Thus

$$k_4 i_a - c\omega = I\frac{d\omega}{dt}$$

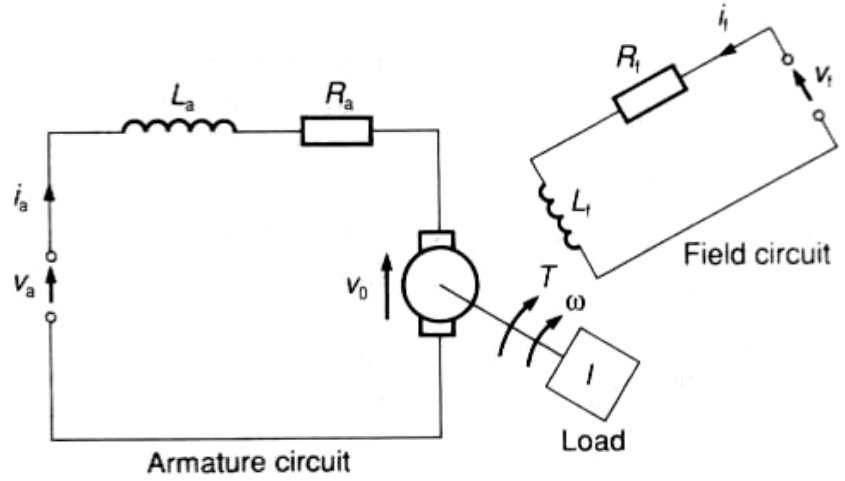
Elements of Electromechanical System

Armature-Controlled Motor



Elements of Electromechanical System
Field-Controlled DC Motor

Kirchoff's voltage law states that the sum of all voltages around a loop must equal zero



$$v_f = R_f i_f + L_f \frac{di_f}{dt}$$

The armature current(i_a) is constant

Elements of Electromechanical System
Field-Controlled DC Motor

Rotational system of DC motor is

$$T_m - T_d = I\frac{d\omega}{dt}$$

where

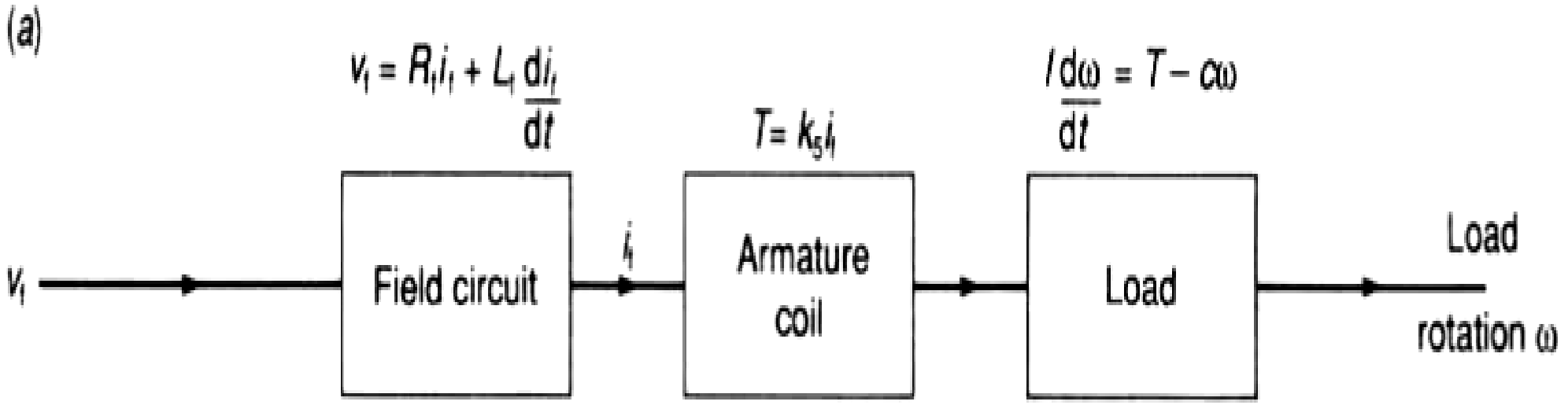
$$T_m = k_5 i_f$$

$$T_d = c\omega$$

Thus

$$k_5 i_f - c\omega = I\frac{d\omega}{dt}$$

Elements of Electromechanical System
Field-Controlled DC Motor



Elements of Electromechanical System