Today: Intro electromechanical devices

- Introduction to electromechanical devices
- AC machine
  - Permanent-magnet synchronous machine, induction machine
  - Operation, losses and efficiency and dynamic model
- 3-phase DC-to-AC inverter
  - Operation, losses and efficiency, dynamic model
- Electric drive: control
Introduction to magnetic devices: $L$

Textbook Sections 13.1-13.3
Terminal characteristics: $L$

- **Faraday’s law**
  - $v(t)$
  - $B(t), \Phi(t)$

- **Ampere’s law**
  - $i(t)$
  - $H(t), \mathcal{F}(t)$

**Terminal characteristics**

**Core characteristics**
Terminal characteristics: $L$

Faraday’s law

$v(t) \leftrightarrow B(t), \Phi(t)$

Terminal characteristics

Ampere’s law

$i(t) \leftrightarrow H(t), \mathcal{F}(t)$

Core characteristics
Physical limits: saturation

Fig. 13.5 $B-H$ characteristics: (a) of free space or air, (b) of a typical magnetic core material.
Physical limits: losses

Copper losses
- DC winding resistance $R_L$
- Skin and proximity effects

Core losses: hysteresis and eddy current losses

$$P_{fe} = K_{fe} (\Delta B)^\beta A_c \ell_m$$  \hspace{1cm} (13.57)

Fig. 13.20 Typical core loss data for a high-frequency power ferrite material. Power loss density is plotted vs. peak ac flux density $\Delta B$, for sinusoidal excitation.
Introduction to electromechanical devices

Reference on electric machines: P.Krause, O.Wasynczuk, S.Pekarek, Electromechanical Motion Devices, 2nd edition, Wiley 2012

Diagram:
- Current $i_a$
- Voltage $v_a$
Permanent magnet on the rotor
Electromechanical induction: “back EMF”
Terminal characteristics and torque
Torque in the single-phase, two-pole permanent magnet synchronous machine
Rotating machine windings
Two-pole, two-phase permanent-magnet synchronous machine
Terminal characteristics
Rotor reference frame
Rotor reference frame
2-pole, 2-phase PMSM characteristics in the rotor reference frame
Physical interpretation: rotating magnetic field