Electric Machines 2

1. **Course number and name:** 020ME2ES4 Electric Machines 2

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours per week

3. **Instructor's or course coordinator's name:** Flavia KHATOUNIAN RAJJI (EL) and Ragi GHOSN

4. **Instructional materials:**
   a. **Textbook**
      a. R. P. BOUCHARD et G. OLIVIER, "*Electrotechnique : 2° éd*.", Presses internationales, Polytechnique, 1999.
      b. P. VAS, "*Parameter Estimation, Condition Monitoring, and Diagnosis of Electrical Machines*", Clarendon Press-Oxford, 1993.
      c. D. BAREILLE et J. P. DAUNIS, "*Electrotechnique – Transformateurs et machines tournantes*", Dunod, 2006.
      d. J. CHATELAIN, "*Les machines électriques, Tome 1&2*", Dunod, 1993&1984.
   b. **Other supplemental materials:** PowerPoint presentation, Exercises, instructions, Lab experiments instructions.

5. **Specific course information**
   a. **Catalog description:**
      This course aims to extend the concepts of electrical engineering according to four axes: I) Transformers: Special transformers – Transformers in unbalanced mode – Transformers in transient mode – Parallel operation of transformers. II) DC machines: DC machines in transient mode - Application in unsaturated transient conditions. III) Induction Machines (IM): Generator and brake operation of a three-phase IM - Special types of IM: Deep-Bar Squirrel-Cage, Double-Cage rotors and Single-Phase IM – Modeling of the induction machine in transient mode and applications. IV) Synchronous machines: Rotating fields theory – Transient modeling of synchronous machines: with smooth poles, with salient poles, with or without damper bars – Applications.

   b. **Prerequisites:** Electric Machines 1 **(**020ME1ES2)

   c. **Required** for EE students.

6. **Educational objectives for the course:**
   a. **Specific outcomes of instruction:**
      - Explain the operation of special transformers (three-windings transformers, autotransformers, current and voltage transformers) and the operation and drawbacks of parallel transformers.
      - Understand the operation of transformers in unbalanced mode and apply the right models to calculate unbalanced components.

- Simulate and understand the operation of transformers in transient mode.
- Determine DC machines models in transient mode and apply results in unsaturated transient conditions.
- Describe the requirements for generator operation of an IM and calculate the minimum capacity value required for an independent generator operation with an inductive load.
- Describe the requirements for braking operation of an induction machine and calculate the resistance value required for this operation.
- Describe the operation of Deep-Bar Squirrel-Cage IM and Double-Cage rotors IM
- Calculate an approximate value of the capacity required to start a single-phase induction motor.
- Explain the transient models of an IM. Recommend the most appropriate one in a specific case.
- Calculate, where applicable, the values of the transient model parameters of an induction machine, using the manufacturer datasheet.
- Perform simulations of an induction machine operation in both transient and steady-states, using MATLAB/Simulink software.
- Understand synchronous machines models in transient mode, describe the evolution of short-circuit currents in generator mode and calculate corresponding transient parameters from experimental results.

b. PIs addressed by the course:

PI	1.1	1.3	6.1	6.2	6.3	6.4
Covered	x	x	x	x	x	x
Assessed		x	x	x	x	x

7. Brief list of topics to be covered:

- Course introduction (1.25 hours)
- Special transformers: three windings transformers, autotransformers, current and voltage transformers (3.75 hours)
- Transformers in unbalanced mode, transformers in transient mode, parallel operation of transformers (2.5 hours)
- DC machines in transient mode, application in unsaturated transient conditions (2.5 hours)
- Reminder on three-phase induction machine operating in steady-state (1.25 hours)
- Generator and braking operation of a three-phase IM. Special types of IM (2.5 hours)
- Transient models of a three-phase IM (Clarke, Concordia, Park transforms). Determination of the parameters of an IM model using the manufacturer datasheet (3.75 hours)
- Simulation of an induction machine operation in both transient and steady-states using MATLAB/Simulink software (1.25 hours)
- Reminder on rotating fields theory and synchronous machines in steady-state (1.25 hours)

- Synchronous machines with salient poles model and synchronous machines characteristics in steady-state (1.25 hours)
- Transient modeling of a generalized synchronous machine (3.75 hours)
- Application on generators under short-circuit operation, transient parameters determination from short-circuit experimental results (2.5 hours)
- Lab experiments (12 lab hours)