NATIONAL UNIVERSITY OF ENGINEERING

COLLEGE OF ELECTRICAL AND ELECTRONICS ENGINEERING

ELECTRICAL ENGINEERING PROGRAM

EE214 – ELECTRICAL MACHINES II

I. GENERAL INFORMATION

CODE	**:**	EE214 – Electrical Machines II
SEMESTER	**:**	7
CREDITS	**:**	05
HOURS PER WEEK	**:**	07 (Theory – Practice)
PREREQUISITES	**:**	EE211 – Electrical Machines I
CONDITION	**:**	Mandatory

II. COURSE DESCRIPTION

It is a subject of a theoretical – practical nature and belongs to the area of professional training. Its purpose is to provide the student with the necessary knowledge related to: constructive aspects, principles of operation, fields of application and operation in steady state of the electric machines of direct and alternating current. In the case of alternating current machines, emphasize their operation as part of a power system.

III. COURSE OUTCOMES

At the end of the course the student will:

- Identify, design and understand the functions of synchronous and asynchronous machines.
- Know the concepts necessary to calculate the operating parameters of the different motors.
- Be able to model all types of electric machines by formulating the electrical and mechanical equations with the corresponding binding equations to analyze the particular case of operation of the electric machine.

IV. LEARNING UNITS

1. SYNCHRONOUS MACHINES

Characteristics and constructive aspects of cylindrical rotor machines and protruding poles. Scope. Excitation systems. Electromagnetic processes in the synchronous vacuum generator, waveform of the magnetic field of excitation and induced voltage. Electromagnetic processes in the synchronous generator under symmetrical load, armature reaction. Magnetic force diagrams. Short circuit electromotive force diagram. Practical plot of the Pothier diagram. Characteristics of a synchronous alternator, in vacuum, in symmetrical short circuit and in load, external characteristics and regulation. Electromechanical transformation of energy, losses and performance. Power and electromagnetic torque. Parallel operation of synchronous machines, synchronization of a synchronous generator with a high-power system, active power. Reactive power, and its regulation. Stability conditions of stationary operation, typical and characteristic V-regime. Synchronous machine operation as an energy transformation motor, phasor diagram of electromotive force in vacuum or under load. The

synchronous compensator. Synchronous motor starting methods. Synchronous machine tests: in vacuum, symmetric short circuit and inductive zero power factor. The slip tests.

2. ASYNCHRONOUS MACHINES

Characteristics and construction aspects of asynchronous machines (winding rotor and squirrel cage), field of application and selection criteria. Electromagnetic processes in the three-phase asynchronous voltage equation machine for the vacuum and under load regime. Equivalent circuits. Use of the equivalent "T" circuit for the study of operating regimes: brake, motor, generator, phasor diagrams. Determination of the parameters of the equivalent circuit "T" from tests. Determination of the parameters of the equivalent circuit "T" from tests. Determination of the inverted "L" circuit parameters. Electromechanical transformation in the asynchronous motor, losses and efficiency, power and electromagnetic torque, maximum torque and starting. Mechanical power. Analytical determination of the electromechanical and operating characteristics of the asynchronous motor through equivalent circuits. Start of squirrel cage and winding rotor motors, cage motors with improved starting properties, (high slip), double cage motors. Determination of the stability conditions in stationary operation and operation characteristics of the three-phase asynchronous motor. Asynchronous motor speed regulation, methods.

3. CONTINUOUS CURRENT MACHINES

Characteristics and constructive aspects, field of application. Reaction of reinforcement in the machine under load, transverse and longitudinal components. Armature reaction in the generator and motor, ways to improve switching. Compensating windings. Classification of the generators by the excitation method, electromechanical transformation of the energy in the generator, independent excitation generator, vacuum and load excitation characteristics, exterior and regulation characteristics. Shunt generator. Conditions of self-excitation, characteristics of excitation in empty and in load, external characteristic and of regulation. Serial generator and composite generator. DC motors, reciprocity principle of electric machines, electromechanical energy transformation. Start-up, start-up characteristics, operating characteristics of Shunt, series, compound motors (speed, torque, versus load). Speed regulation, methods.

4. SINGLE PHASE MOTORS

Classification, construction aspects and field of application. Principle of operation and operation characteristics of single-phase asynchronous motors, split phase, start by capacitor, with permanent condenser and double condenser. Principle of operation of single-phase switch motors, operating characteristics of the universal series motor.

V. METHODOLOGY

The course is developed in theory and practice sessions. In the theory sessions the teacher presents the concepts, principles of electrical machines selection their applications in electrical circuits. In the practical sessions different problems and their various applications are presented and solved. In all classes the active participation of the student is promoted both in the analysis and in the solution of problems.

VI. EVALUATION FORMULA

The learning will be evaluated through the "G" system.

- Partial Exam (PE): Weight 1
- Final Exam (FE): Weight 1
- Average of Practices (P): Weight 1.

$$FA = \frac{PE + FE + P}{3}$$

VII. BIBLIOGRAPHY

- “Induction Motors”, Bahram Amin. Springer Science & Business Media, 2001.
- “Analysis of Synchronous Machines”, T. A. Lipo. CRC Press, 2017.
- “Design of Rotating Electrical Machines”, Juha Pyrhonen, Tapani Jokinen. John Wilesy & Sons, 2013.