



EEE 203 – Energy Conversion I

PART A: General Information

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| 1. Course Number | EEE 203 |
| Course Title | Energy Conversion I |
| Credit (Contact) Hours | 3.0 (3.0) |
| 2. Level and Term (Section) | Level-2, Term-I |
| Academic Term | July 2022 |
| 3. Type of Course | Core Course |
| Offered to | EEE |
| 4. Pre-requisite Course(s) | None |
| 5. Course Website | Designated Microsoft Teams Group for each section |
| 6. Lecture Schedule | Section A: Mon 08 am, Tues 09 am, Wed 09 am Section B: Sun 11 am, Mon 08 am, Tues 08 am Section C: Sun 12 am, Mon 09 am, Tues 10 am |
| 7. Important Dates | For important dates and examination schedules and latest updates, please follow the Teams Group |
| 8. Course Teacher(s) | Section A: Dr. Hafiz Imtiaz, Associate Professor Dept. of EEE, BUET Email: hafizimtiaz@eee.buet.ac.bd Office: ECE 128, ECE Building Website: https://hafizimtiaz.buet.ac.bd Section B: Dr. Muhammad Abdullah Arafat, Assistant Professor Dept. of EEE, BUET Email: abdullah_arafat@eee.buet.ac.bd Phone: +8801553287666 Office: ECE 226, ECE Building Section C: Same as Section B |

PART B: Course Details

9. Course Content (As approved by the Academic Council)
- *Single-phase Transformer:* principle of operation, construction, no load and excitation current, behaviour during loading, effect of leakage flux, ideal transformer, leakage reactance and equivalent circuit of a transformer, equivalent impedance, voltage regulation, per unit quantities, regulation, losses and efficiency, determination of parameters by tests, polarity of transformer windings, vector group, transformer parallel operation. Harmonics in excitation current, transformer inrush current.
 - *Poly-phase Transformer:* three phase transformers, connections, harmonic suppression in three phase transformer connection.
 - *Autotransformer:* construction, working principle, auto-transformer vs. potential divider, copper saving, advantages/disadvantages, phasor diagrams, equivalent circuits, conversion of a two-winding transformer to an auto-transformer, applications.

- *Instrument transformers*: measurement of high voltages and currents in power system using P.T. and C.T. (respectively). Use of P.T. and C.T. with protective devices.
- *Three-phase Induction Motor*: rotating magnetic field, reversal of rotating magnetic field, synchronous speed, torque in induction motor. Construction - squirrel cage, wound rotor; slip and its effect on rotor frequency and voltage, equivalent circuit of an induction motor, air gap power, mechanical power and developed torque, torque speed characteristic, losses, efficiency & power factor, classification, motor performance as a function of machine parameters, shaping torque speed characteristic and classes of induction motor, per unit values of motor parameters, determination of induction motor parameters by tests, methods of braking, speed control.
- *Induction Generator*: operation, characteristics, voltage build up, applications in wind turbine.

10. Course Objectives

- To understand the construction and operations of various transformers, 3-phase induction motor and induction generator
- To analyse the characteristics of polyphase induction motors, to calculate various machine parameters based on design data and test results
- To demonstrate the parallel operation of polyphase transformers
- Application of induction generator for harvesting renewable energy e.g., wind turbine

11. Background Knowledge required

Fundamental concepts of Electrical Circuits I & II course, and application of Faraday's law

12. Course Outcomes

| CO No. | CO Statement | Corresponding PO(s)* | Domains and Taxonomy level(s)** | Delivery Method(s) and Activity(-ies) | Assessment Tool(s) |
|--------|---|----------------------|---------------------------------|---------------------------------------|------------------------------------|
| 1 | Explain the operations of transformers and 3- ϕ induction motor/generator by applying the knowledge of electrical circuits and electromagnetic induction | PO1 | C2, C3 | Lectures, Discussions | Assignment, Class test, Final exam |
| 2 | Analyse the techniques of parallel operations of transformers (single to single phase, poly to poly phase) | PO2 | C4 | Lectures, Discussions | Assignment, Class test, Final exam |
| 3 | At the end of the course the students will be able to design/develop three-phase transformer using single-phase transformers | PO3 | C6 | Lectures, Discussions | Assignment, Final exam |

***Program Outcomes (PO):** PO1 Engineering Knowledge, PO2 Problem Analysis, PO3 Design/development Solution, PO4 Investigation, PO5 Modern tool usage, PO6 The Engineer and Society, PO7 Environment and sustainability, PO8 Ethics, PO9 Individual work and team work, PO10. Communication, PO11 Project management and finance, PO12 Life-long Learning

****Cognitive Domain Taxonomy Levels:** C1 – Remember, C2 – Explain, C3 – Apply, C4 – Analyse, C5 – Evaluate/Compare, C6 – Create/Design.

Affective Domain Taxonomy Levels: A1: Receive; A2: Respond; A3: Value (demonstrate); A4: Organize; A5: Characterize; **Psychomotor**

Domain Taxonomy Levels: P1: Perception; P2: Set; P3: Guided Response; P4: Mechanism; P5: Complex Overt Response; P6: Adaptation; P7: Organization

13. Assessment Strategy

- Class participation will be judged by in-class evaluation; attendance will be recorded in every class.
- Continuous assessment will be done in the form of quizzes, assignments, in-class evaluations.
- Final Examination: A comprehensive term final examination will be held at the end of the Term following the guideline of academic Council.

14. Distribution of Marks

| | |
|----------------------------------|------|
| Class Participation | 10% |
| Homework, Assignment and Quizzes | 20% |
| Final Examination | 70% |
| Total | 100% |

15. Textbook

- Electric Machinery Fundamentals by Stephen J. Chapman, McGraw-Hill, 2012 (5th edition)

16. Reference books and relevant resources

- Principles of Electric Machines and Power Electronics by P.C. Sen, 2014 (3rd edition)
- Handbook of Renewable Energy Technology edited by A. F. Zobaa, World Scientific Co., 2011
- Alternating Current Machines by A.F. Puchstein and T.C. Lloyd, 1942 (2nd edition)
- Online resources or supplementary materials will be shared with the class on a need basis

N.B. Besides going through relevant topics of the textbook, it is strongly advised that the students follow the class lectures and discussions regularly for a thorough understanding of the topics.

17. Lecture Plan

| Week | Lectures | Topic |
|------|----------|--|
| 1 | 1-3 | <i>Single-phase Transformer</i> : principle of operation, construction, no load and excitation current, behaviour during loading, effect of leakage flux. |
| 2 | 4-6 | Ideal transformer, leakage reactance and equivalent circuit of a transformer, equivalent impedance, voltage regulation. |
| 3 | 7-9 | Per unit quantities, regulation, losses and efficiency, determination of parameters by tests. |
| 4 | 10-12 | Polarity of transformer windings, vector group, transformer parallel operation. Harmonics in excitation current, transformer inrush current. |
| 5 | 13-15 | <i>Poly-phase Transformer</i> : three phase transformers, connections, harmonic suppression in three phase transformer connection. |
| 6 | 16-18 | <i>Autotransformer</i> : construction, working principle, auto-transformer vs. potential divider, copper saving, advantages/disadvantages. |
| 7 | 19-21 | Phasor diagrams, equivalent circuits, conversion of a two-winding transformer to an auto-transformer, applications. |
| 8 | 20-24 | <i>Instrument transformers</i> : measurement of high voltages and currents in power system using P.T. and C.T. (respectively). Use of P.T. and C.T. with protective devices. |
| 9 | 25-27 | <i>Three-phase Induction Motor</i> : rotating magnetic field, reversal of rotating magnetic field, synchronous speed, torque in induction motor. |
| 10 | 28-30 | Construction - squirrel cage, wound rotor; slip and its effect on rotor frequency and voltage, equivalent circuit of an induction motor, air gap power, mechanical power and developed torque. |
| 11 | 31-33 | Torque speed characteristic, losses, efficiency & power factor, classification, motor performance as a function of machine parameters. |
| 12 | 34-36 | Shaping torque speed characteristic and classes of induction motor, per unit values of motor parameters. |
| 13 | 37-39 | Determination of induction motor parameters by tests, methods of braking, speed control. |
| 14 | 40-42 | <i>Induction Generator</i> : operation, characteristics, voltage build up, applications in wind turbine. Summary review. |

18. Mapping of Knowledge Profile (K), Complex Engineering Problem Solving (CP) and Complex Engineering Activities (CA)

| K 1 | K 2 | K 3 | K 4 | K 5 | K 6 | K 7 | K 8 | CP 1 | CP 2 | CP 3 | CP 4 | CP 5 | CP 6 | CP 7 | CA 1 | CA 2 | CA 3 | CA 4 | CA 5 |
|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| √ | √ | √ | | √ | √ | | | √ | | | | | | √ | | | | | |

19. Important University Policies

- Please check the following link for Rules and regulations for the undergraduate programmes:
<https://www.buet.ac.bd/info/Academicinformation/RulesUndergradprogram>