# EE4149: POWER ELECTRONICS

**Effective Term**

Semester A 2026/27

## Part I Course Overview

**Course Title**

Power Electronics

**Subject Code**

EE - Electrical Engineering

**Course Number**

4149

**Academic Unit**

Electrical Engineering (EE)

**College/School**

College of Engineering (EG)

**Course Duration**

One Semester

**Credit Units**

3

**Level**

B1, B2, B3, B4 - Bachelor's Degree

**Medium of Instruction**

English

**Medium of Assessment**

English

**Prerequisites**

EE3110 Analogue Electronic circuits or
EE3122 Analogue Circuit Fundamentals

**Precursors**

Nil

**Equivalent Courses**

EE3125 Basic Power Electronics

**Exclusive Courses**

Nil

## Part II Course Details

**Abstract**

Electrical energy is essential to modern society and must be efficiently converted and processed to meet the requirements of diverse electrical loads. For example, modern microprocessors require low-voltage, high-current DC supplies, while electric machines typically operate using high-voltage, variable-frequency AC power. Power electronics is the enabling technology that facilitates these energy conversions with high efficiency, playing a critical role in energy conservation, carbon-emission reduction, and sustainable development. The field applies electronic, electrical, and control engineering principles to the analysis, design, and control of power conversion systems.

This course provides students with a solid foundation in power electronics through the study of power semiconductor devices and their application in power electronic converters. Core power conversion topologies for AC–DC, DC–DC, and DC–AC energy conversion are introduced and analyzed. Emphasis is placed on developing students' ability to understand operating principles, perform circuit analysis, and carry out basic converter design with due consideration of efficiency, performance, and practical constraints. Applications of power converters in electrical and electronic engineering systems are also discussed to reinforce engineering relevance.

Through a combination of lectures and laboratory (simulation) experiences, students will develop the analytical and practical skills necessary to analyze, design, and implement power converters. The course strengthens fundamental engineering knowledge, problem-solving capability, and design competence, and prepares students for advanced studies and professional practice in electrical engineering and related fields.

### Course Intended Learning Outcomes (CILOs)

| | CILOs | Weighting (if app.) | DEC-A1 | DEC-A2 | DEC-A3 |
|---|---|---|---|---|---|
| 1 | Explain the principles of switched-mode power conversion and the role of semiconductor power devices in electrical energy conversion | | x | x | |
| 2 | Analyze different power converter topologies and explain their operating principles and control methods | | x | x | |
| 3 | Apply appropriate design techniques to calculate component values and key parameters for practical power converters, taking into account performance requirements and engineering constraints | | x | x | |

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

### Learning and Teaching Activities (LTAs)

| | LTAs | Brief Description | CILO No. | Hours/week (if applicable) |
|---|---|---|---|---|
| 1 | Lectures | Students will engage in formal lectures to gain knowledge in key concepts in power electronics technologies and develop the ability to analyze the operation and control of power converters through instructor-led explanations, examples, and discussions. | 1, 2, 3 | 2 hrs/wk |
| 2 | Tutorials | Students will apply key concepts from power electronics to analyze and solve problems in various applications. | 1, 2, 3 | 1 hr/wk |
| 3 | Lab | Students will perform simulation studies of power converters that they have learned in classroom using simulation software Plexim. | 1, 2, 3 | 3 hrs (once only) |

**Assessment Tasks / Activities (ATs)**

| | ATs | CILO No. | Weighting (%) | Remarks ("-" for nil entry) | Allow Use of GenAI? |
|---|---|---|---|---|---|
| 1 | Tests (min.: 2) | 1, 2, 3 | 30 | - | No |
| 2 | Assignment (min.: 1) | 1, 2, 3 | 10 | - | Yes |
| 3 | Lab | 1, 2, 3 | 10 | - | No |

**Continuous Assessment (%)**

50

**Examination (%)**

50

**Examination Duration (Hours)**

2

**Minimum Continuous Assessment Passing Requirement (%)**

30

**Minimum Examination Passing Requirement (%)**

30

**Additional Information for ATs**

Remark:

To pass the course, students are required to achieve at least 30% in course work and 30% in the examination. Also, 100% laboratory attendance rate must be obtained.

**Assessment Rubrics (AR)**

**Assessment Task**
Examination

**Criterion**
Achieving all CILOs

**Excellent** (A+, A, A-)
High

**Good** (B+, B, B-)
Significant

**Fair** (C+, C, C-)
Moderate

**Marginal** (D)
Margin

**Failure** (F)
Not even reaching marginal

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**Assessment Task**
Coursework

**Criterion**
Achieving all CILOs

**Excellent** (A+, A, A-)
High

**Good** (B+, B, B-)
Significant

**Fair** (C+, C, C-)
Moderate

**Marginal** (D)
Margin

**Failure** (F)
Not even reaching marginal

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# Part III Other Information

**Keyword Syllabus**

Introduction to Power Electronics

Power electronics and applications. Power semiconductor switches. Classification of power converters. Review of circuit analysis fundamentals, and power efficiency calculations.

Inductors & Converter Principles

Understanding behavior of inductors. Switching mechanisms. Switching inductor cells. Voltage Converter. Duty Cycle and operation modes (continuous conduction mode and discontinuous conduction mode)

DC-DC converters

Buck converter. Boost converter. Buck-boost converter. Cuk Converter. Their variants. Operating principles and mechanism. Waveforms, calculations and design considerations.

Isolated DC-DC converters

Forward converter. Flyback converter. Half-bridge converter. Full-bridge converter. Operating principles and mechanisms. Waveforms, calculations and design considerations.

Lower Frequency Models

State-space averaging approximation for continuity. Discontinuous conduction mode. Small-signal approximation for linearity. Application of approximation techniques.

Voltage Mode and Current Mode Control Schemes

Hysteretic control. Pulse-width modulation (PWM) control. Fixed-frequency control. Slope Compensation. Voltage loop control. Current loop control. Current sharing control.

AC-DC Converters

Inverters. Rectifiers. Operating principles and mechanisms. Waveforms, calculations and design considerations.

Power Factor and Harmonics

Definition. Standards for power quality. Improvement and harmonic elimination techniques. Pulse width modulation.

Applications

Examples of power converters for different applications: battery management systems, power supplies, electric vehicles, and renewable energy systems

## Reading List

### Compulsory Readings

| | **Title** |
|---|---|
| 1 | Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics: Converters, Applications and Design,” 3rd Edition, John Wiley, 2003. |
| 2 | Daniel M. Mitchell, "Dc-Dc Switching Regulator Analysis", 1st Edition, McGraw Hill, 1988. |
| 3 | Dragan Maksimovic and Robert Erickson, "Fundamentals of Power Electronics, 3rd Edition, Springer, 2020. |

### Additional Readings

| | **Title** |
|---|---|
| 1 | Rashid M H, “Power Electronics: Circuits, Devices & Applications,” 3rd Edition, Pearson/Prentice Hall, 2004. |
| 2 | P.T. Krein “Elements of Power Electronics”, 1st Edition, Oxford University Press, 1997. |