EE3125: BASIC POWER ELECTRONICS

Effective Term

Semester B 2025/26

Part I Course Overview

Course Title

Basic Power Electronics

Subject Code

EE - Electrical Engineering

Course Number

3125

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

Nil

Exclusive Courses

Nil

Part II Course Details

Abstract

The DC-DC converter is the most basic type of power electronics. This device is used to convert a direct current (DC) voltage level to another DC voltage level, either stepping it up (boost converter) or stepping it down (buck converter). DC-DC converters are fundamental in various applications, including battery management systems, power supplies, and renewable energy systems, as they enable efficient voltage regulation and power management. Their simplicity and effectiveness make them a foundational element in the field of power electronics.

This course "Basic Power Electronics" is an introductory course dedicated to the principles and applications of DC-DC converters, with a particular focus on both isolated and non-isolated topologies. Students will explore various converter types, including buck, boost, buck-boost, Cuk, and isolated converters such as flyback and forward converters, gaining a comprehensive understanding of their operational principles and knowledge of basic power devices such as power transistor, power MOSFET, and IGBT. The course emphasizes modeling techniques for analyzing converter performance and the design of control strategies to enhance stability and efficiency. Key topics include switching techniques, modulation methods, and the impact of converter design on applications in renewable energy systems, battery management, and electric vehicles. Through a combination of theoretical lectures and laboratory (simulation) experiences, participants will develop the skills necessary to analyze, design, and implement DC-DC converters, preparing them for advanced studies and careers in electrical engineering and related fields.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Identify different DC-DC converter topologies and explain their operational principles.		x	x	
2	Analyze DC-DC converters and their control		x	x	
3	Design systems for real-life applications		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 basic DC-DC 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	#Assignments (min.: 2)	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.

may include homework, exercise, project/mini-project, presentation

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

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

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.

State-Space Modeling and Linearization

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

Voltage-Mode Switching Regulator Transfer Functions

General control-law considerations. Source-to-state transfer functions. Source-ot-output transfer functions. Classic stability considerations.

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. Dual loop control. Current sharing control.

Feedback Control Design

Pole placement design. Loop gain. Stability criterion. Compensation techniques. Converter dynamics. Implementation consideration and practical issues.

Applications

Examples of DC-DC converters for different applications: battery management systems, power supplies, 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.