EE4148: ADVANCED POWER SYSTEMS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Power Systems

Subject Code
EE - Electrical Engineering

Course Number
4148

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
EE3123 Introduction to Electric Power Systems

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract
This course is designed to introduce advanced technologies for power system dynamic analysis. The course focuses on low-carbon transmission networks dominated by inverter-based resources (IBR), to align with the ongoing transformation of

the power systems. It begins with a review of the key challenges in low-carbon power systems, followed by an in-depth discussion of system dynamics and stability issues, including voltage stability, angle and frequency stability, small-signal stability, and transient stability. Conventional and innovative solutions to these issues will be introduced, as well as the system protection principles. Additional relevant topics, such as grid-forming inverters, system strength assessment, load modelling, and professional software, will also be covered to provide a comprehensive understanding. The course aims to let students master the necessary technologies and skills for power system analysis and develop insights into future advancements.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the stability issues in low-carbon power systems		x	x	
2	Analyze different stability problems with corresponding methods		x	x	
3	Explain the control principle of grid-forming inverter and system protection principles		x	x	
4	Apply simulation tools to analyze the system stability		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	Lecture	Students will engage in formal lecturers to gain the knowledge about concepts, principles, and measures to stability problems in low-carbon power systems.	1, 2, 3, 4	2 hrs/week
2	Tutorial	Students will apply the analysis methods to address real-world problems through practical exercises and case studies.	1, 2, 3, 4	1 hr/week

3	Laboratory	Students will use professional software to analyze the system stability through hands-on activities and guided instruction. .	1, 2, 3, 4	3 hrs/week for 4 weeks

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Tests (min.: 2)	1, 2, 3, 4	20	-	No
2	#Assignments (min.: 3)	1, 2, 3, 4	10	-	Yes
3	Lab Exercises/ Reports	1, 2, 3, 4	20	-	Yes

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 Low-Carbon Power Systems

Basic concepts of low-carbon power systems. Concepts of inverter-based resources (IBR).

Stability Issues in Power Systems

Stability definitions. New stability issues in IBR-dominated systems. Real-world stability events. Stability in different time scales.

Voltage Stability

V-Q sensitivity. Short-circuit ratio (SCR). Jacobian matrix. Voltage collapse. STATCOM

Angle Stability and Frequency Stability

Swing equations. Power-angle relationship. Phase-locked loop. Duality in synchronization. Inertia and frequency stability. Primary and secondary frequency response. ROCOF.

Small-Signal Stability

Concept of small-signal and linearization. Sub-synchronous oscillations. Small-signal stability criteria. State-space modeling. Eigenvalues and modal analysis. Impedance-based methods.

Transient Stability

Concepts of nonlinear systems. Phase plane and trajectory. Lyapunov function. Transient energy functions. Direct method. SEP, UEP, and Limit cycle. Fault clearing time. Single SG transient stability. Introduction to IBR transient stability. Introduction to transient stability in multi-machine systems.

Grid-Forming Inverter

Grid following and grid forming inverters. The role of grid-forming inverter in power systems. Virtual synchronous generator (VSG) control. Droop control. Fast fault current injection. Recent developments.

System Fault Protections

Protection principles. Fault types. Sequence current. Relays. Distance protection. Differential protection. Travelling wave protection.

Load Modeling

Static and dynamic load model, Composite load model, Constant impedance load. Constant current load. Constant power load, and induction motor load.

Other Advanced Techniques

Software. Explorations of AI-supported stability analysis. Comprehensive system strength assessment. Real-Time simulations. Digital twin. Hardware-in-the-loop (HIL). Emerging research topics and future trends.

Reading List

Compulsory Readings

	Title
1	P. Kundur and O. Malik, Power System Stability and Control, 2nd ed. New York, NY, USA: McGraw-Hill, 2022.

Additional Readings

	Title
1	G. Turan, Modern Power System Analysis. Boca Raton, FL, USA: CRC Press, 2016.
2	J. Machowski, et al., Power System Dynamics: Stability and Control. Hoboken, NJ, USA: John Wiley & Sons, 2020.
3	J. Fang, et al., Grid-Forming Converters: Principles, Control, and Applications in Modern Power Systems, 1st ed. Cambridge, MA, USA: Academic Press, 2024.