

Portland State University

Electrical & Computer Engineering

-EE 347 Power Systems I Lecture-

Prerequisites: ECE 223, or permission of the instructor

Co-requisite: EE 347L, Power Systems I Lab

Instructors: Robert Bass, Ph.D.

Office Hours: Tuesday, 2:00pm-2:50pm. Discord.

Description: Fundamentals of electrical power systems, particularly non-rotating three-phase power systems. Phasor representation. Complex impedance. Real, reactive, apparent power. Power factor. Non-sinusoidal representation: power quality, THD. Power factor, resonance, PF correction. Power Transformers. ABCD representation of two-port transmission networks. Power systems representation: single-line diagrams, per-unit representation. Power flow analysis.

Textbook: Chapman, S.J., "Electric Machinery and Power System Fundamentals," McGraw-Hill, 2002, ISBN 0-07-229135-4 (required)

References: "FE Reference Handbook," National Council of Examiners for Engineering and Surveying (NCEES), <http://ncees.org/exams/study-materials/download-fe-supplied-reference-handbook/>

"Draft of Proposed NFPA 70," 2014 Edition, National Fire Protection Association, (NEC: National Electric Code)
www.nfpa.org/Assets/files/AboutTheCodes/70/70-A2013-ROPDraft.pdf

Instruction: The class will meet twice per week for 100 minutes of lecture. Homework will be assigned roughly every week. Select homework problems will be graded. A mid-term exam will be administered around halfway through the term. A final exam will be administered at the end of the term.

Students shall abide by the course Homework Expectations, the Late Homework Policy, the Assignment Dispute Policy, the Lab Badge Access Policy, the Lab Lock-out-Tag-out Policy, and the Student Codes of Conduct.

Meeting Times: Tuesdays, Thursdays, 12:00pm to 1:50pm

Grading and Scale:

Lecture (65%): Home Work - 30%, Mid-Term - 15%, Final - 20%

A	B	C	D
> 90%	> 80%	> 70%	> 60%

Instructor discretion may be applied to the boundaries between letter grades.

If you have a dispute regarding the grading of an assignment, follow the instructions listed in the Grade Dispute Form, which is posted in Canvas. Do not ask the instructor or TA to review a dispute unless you use this process.

Course Objectives:

Upon completion of EE 347, a student should be able to:

1. Design and analyze three-phase power circuits, including unbalanced three-phase circuits.
2. Perform power calculations, including power factor correction.
3. Model transformers using the ideal transformer model and transformer equivalent circuits.
4. Represent power systems using professional tools and standards: single-line diagrams, per-unit representation, etc.
5. Apply various classifications of transformers to convert AC voltages and currents
6. Understand the phenomena of harmonics, power quality, notching and three-phase voltage variation.
7. Apply power-flow analysis techniques to model symmetric and asymmetric faults.
8. Interpret and create industry-standard drawings of power systems using computers.
9. Use computer-based applications to solve power analysis problems.

Course Content:

Fundamentals of Power

Basic power circuits; single-phase and three-phase, including both balanced and unbalanced three-phase circuits. DC, single- and three-phase power. Phase sequencing. Power expressions; real (average), reactive, apparent (complex), instantaneous and RMS. Power factor, both leading and lagging, and power factor correction. Magnetizing VARs. Maximum power transfer. Power transfer efficiency.

Transformers, Magnetic Circuits and Materials

Flux and flux density, MMF and magnetic field intensity, permeance and reluctance. Ohm's Law, KVL and KCL for magnetic circuits. B-H curves for linear and ferromagnetic (non-linear) materials. Linear transformers. Dot convention. Single- and three-phase transformers. The ideal transformer model. Transformer equivalent circuits. Autotransformers, voltage regulation with distribution transformers, residential transformers.

Distribution and Transmission

Resistance, capacitance and inductance in transmission lines. Line loss, phase shifting and voltage regulation. Transmission line models; short-, medium- and long-length t-line models; ABCD linear network models. Design of transmission lines; conductor spacing, cross-sectional area and bundling. Distribution transformers. Building electrical systems. Grounding. Ground faults. Circuit protection. Neutral line currents due to unbalanced loads. Harmonics, power quality, total harmonic distortion (THD), triplen currents and triplens in the neutral line.

Power Systems Analysis

Power system representation; single-line diagrams, per-unit representation. Fault analysis: three-phase faults (symmetric faults); asymmetric faults, including line to line, line to ground, double line to ground. Sequence impedances for asymmetric fault analysis. Power flow studies.

Lecture Schedule:

	Meeting Day	Topics	Reading	Due
Week 1	Tuesday	3- φ Power, Single-Line Diagram Basics	pp 56-81	
	Thursday	Power Factor and PF Correction	pp 44, 243	
Week 2	Tuesday	Power Quality, ITI Curve	ITI Notes	HW#1
	Thursday	IEEE 519, THD, Harmonics in Power Systems	IEEE 519 pp 9-11,63,78	
Week 3	Tuesday	Transformers: Ideal Model, Ratings	pp 82-102	
	Thursday	Transformers: Operation, Equivalent Circuits	pp 102-110	HW#2
Week 4	Tuesday	Transformers: Voltage Regulation, Efficiency	pp 116-126	
	Thursday	Transformers: Autotrans., 3- φ , CTs & PT	pp 126-153	
Week 5	Tuesday	Midterm Exam		HW#3
	Thursday	Transmission Lines: Equ. Ckts Models	pp 446-467	
Week 6	Tuesday	Transmission Lines: ABCD Models	pp 467-482	
	Thursday	Transmission Lines: ABCD Models, HVDC		
Week 7	Tuesday	Per-unit, Single-Line Diagrams	pp 110-115 pp 492-500	
	Thursday	Power Systems Representation: \mathbf{Y}_{Bus} Modeling	pp 501-508	HW#4
Week 8	Tuesday	Jacobi and Gauss-Seidel Methods	pp 512-549	
	Thursday	Symmetric Faults	pp 530-549	
Week 9	Tuesday	Sequence Components	pp 555-585	
	Thursday	Unsymmetrical Faults	pp 591-597	HW#5
Week 10	Tuesday	Unsymmetrical Faults – Open Circuits	pp 597-641	
	Thursday	Course review		
Week 11	Thursday	Final Exam (10:15am-12:05pm, 3/17)		

Academic Integrity:

Students shall demonstrate their knowledge with honesty and integrity. PSU considers academic dishonesty to be an unacceptable practice. The complete PSU Student Academic Integrity Policy is available on the PSU web site.

Safe Campus Obligation:

As an instructor, one of my responsibilities is to help create a safe learning environment for my students and for the campus as a whole. Please be aware that as a faculty member, I have the responsibility to report any instances of sexual harassment, sexual violence and/or other forms of prohibited discrimination. If you would rather share information about sexual harassment, sexual violence or discrimination to a confidential employee who does not have this reporting responsibility, you can find a list of those individuals. For more information about Title IX please complete the required student module Creating a Safe Campus in your Canvas.

Classroom Requirements for All Students and Faculty Due to Covid-19

The University has established rules and policies to make the return to the classroom as safe as possible. It is required for everyone to follow all the Return to Campus rules and policies. To participate in this class, PSU requires students to comply with the following.

Masks Required at all Times in Classroom

- [Students shall wear a mask or face covering](#) indoors at all times. Masks or face coverings must be properly worn (fully covering nose and mouth and tight fitting). Mesh masks, face shields, or face covering that incorporates a valve designed to facilitate easy exhalation are not acceptable. Because a mask must be worn in the classroom, there should be no eating or drinking in the classroom. If a student has a medical condition or a disability that prevents them from wearing a mask or cloth face covering, the student must obtain an accommodation from the [Disability Resource Center \(DRC\)](#) to be exempt from this requirement.
- CDC, State, and County guidance does not limit class size for in-person instruction or require physical distancing.

Vaccination

- Students shall be vaccinated against COVID-19 and complete the COVID-19 vaccination attestation form. Those students with medical or nonmedical exemptions or who will not be on campus at all must complete the process described on “COVID-19 Vaccine Exemption Request Form” to establish those exemptions.

Health Check, Illness, Exposure or Positive Test for COVID-19

- Complete the required self-check for COVID-19 symptoms before coming to campus each day.
- If you are feeling sick or have been exposed to COVID-19, do not come to campus. Call SHAC to discuss your symptoms and situation (503.725.2800). They will advise you on testing, quarantine, and when you can return to campus.
- If you test positive for COVID-19, [report your result to SHAC](#) and do not come to campus. SHAC will advise you on quarantine, notification of close contacts and when you can return to campus.
- Please notify your instructor should you need to miss a class period for any of these reasons so that we can discuss strategies to support your learning during this time.
- If I become ill or need to quarantine during the term, either I or the department chair will notify students via PSU email about my absence and how course instruction will continue.

Failure to Comply with Any of these Rules

As the instructor of this course, the University has given me the authority to require student compliance with these policies. If a student does not comply with these requirements, I may ask the student to leave the classroom or I may need to cancel the class session entirely.

In addition, failure to comply with these requirements may result in a referral to the Office of the Dean of Student Life to consider charges under [PSU's Code of Conduct](#). A student found to have violated a university rule (or rules) through the due process of student conduct might face disciplinary and educational sanctions (or consequences). For a complete list of sanctions, see Section 14 of the Student Code of Conduct & Responsibility.

Guidance May Change

Please note that the University rules, policies, and guidance may change at any time at the direction of the CDC, State, or County requirements. Please review the University's main [COVID-19 Response webpage](#) and look for emails from the University on these topics.