E E 559 A Wi 25: Special Topics In Electrical Energy Systems

Wireless Power Transfer

This course surveys wireless power transfer technology, with a focus on electromagnetic methods, both far field [long range, low power] and near field [short range, high power]. The course is organized around descriptions of wireless power transfer systems, presenting the relevant electromagnetic concepts as they are needed for each application.

For near field systems, we will describe conventional inductive and resonant wireless power transfer systems. We will discuss multi-hop wireless power transfer, and automatic tuning (both frequency and impedance tuning). We will discuss transmit amplifier designs.

In far field systems, we will describe rectification, power optimized waveforms, and approaches to beam forming.

Throughout the course, we will review the relevant electromagnetic concepts as they arise in the context of various wireless power applications. We expect to touch on (1) lumped circuit quantities (resistance, capacitance, inductance, mutual inductance, impedance) as quasi-static limiting cases of Maxwell's equations (2) resonance (3) quality factor (4) normal modes (5) transformers (6) impedance matching (7) antennas, including far field and near field behavior (8) electromagnetic materials, in particular lossy media, and the use of high permeability low conductivity materials (ferrite) in wireless power transfer. We will also discuss diodes, rectifiers, voltage multiplier circuits, and rectennas.

The course will include several Lab activities, and a final project involving design or analysis of a wireless power transfer system or an RF energy harvesting system.

Prerequisite Knowledge: Undergraduate electromagnetism or circuits

Winter 2025 is the second time the course has been offered.

Staff

Lecture: Joshua Smith, jrs@cs.washington.edu

Office hours: TBD

TA: Zane Chalich,

Office hours: Before Class, outside of lecture room (Wednesdays 5pm-6pm, at hallway tables/whiteboard outside of lecture room ECE045)

Grading

The labs / assignments count for 60%, and the final project 40%. Of the final project, 10% of that is the proposal, 40% is the presentation, and 50% is the written report. (So of the final final grade, 0.4 * 10% = 4% is the proposal, 0.4*40% = 16% is the presentation, and 0.4*50% = 20% is the written report.) To convert to the 4.0 scale, we divide the final percentage by 25, add a small fudge factor (-0.05 this year), and round.

Week	Date	Topic
1	Jan 8	History of Wireless Power; Review of AC Circuits; Oscilloscope demo
2	Jan 15	Complex arithmetic, impedance, voltage dividers; Resonance, Quality factor
3	Jan 22	Intro to impedance matching, transformers, Mutual inductance, coupling coefficient
4	Jan 29	Resonant wireless power systems
5	Feb 05	VNA, Smith chart, Impedance matching
6	Feb 12	Multihop WPT, normal modes, empirical formulas for L,C,M,k,R,Q
7	Feb 19	Rectification, Voltage Boosting, energy harvesting
8	Feb 26	EM modeling (Maxwell 3D & HFSS); Circuit simulation (Simplorer)
9	Mar 05	DC-DC converters; Switched cap circuits; applications & advanced topics

10	Mar 12	RF exposure & heating; Regulatory; Capacitive, Acoustic, RF beamforming, & Optical WPT; Space-based Solar Power
Finals week	Mar 19	Final presentations
Final Report due	Mar 23	