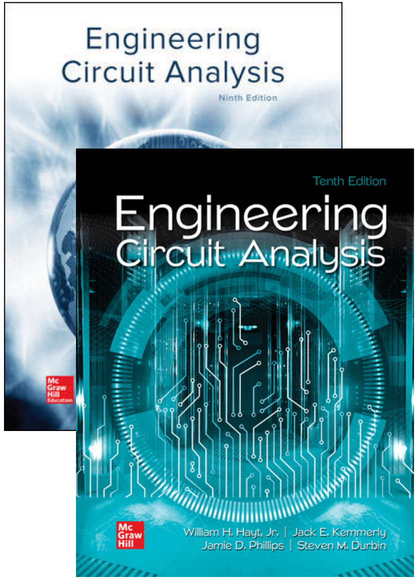
Contact Information

- **Instructor:** Daniel Costinett
  - Office: MK504
  - OH: **W 2:00-3:00 & R 10:00-11:00**, by appointment
  - E-mail: Daniel.Costinett@utk.edu
  - Please use `[ECE 202]` in the subject line
  - Email questions will be answered within 24 hours (excluding weekends)

Textbook and Materials

Textbook

- Hayt, Kemmerly, Phillips, and Durbin, *Engineering Circuit Analysis* 10th Edition
  - ISBN: **1264149913**
  - required
- Course covers Chapters 10-17



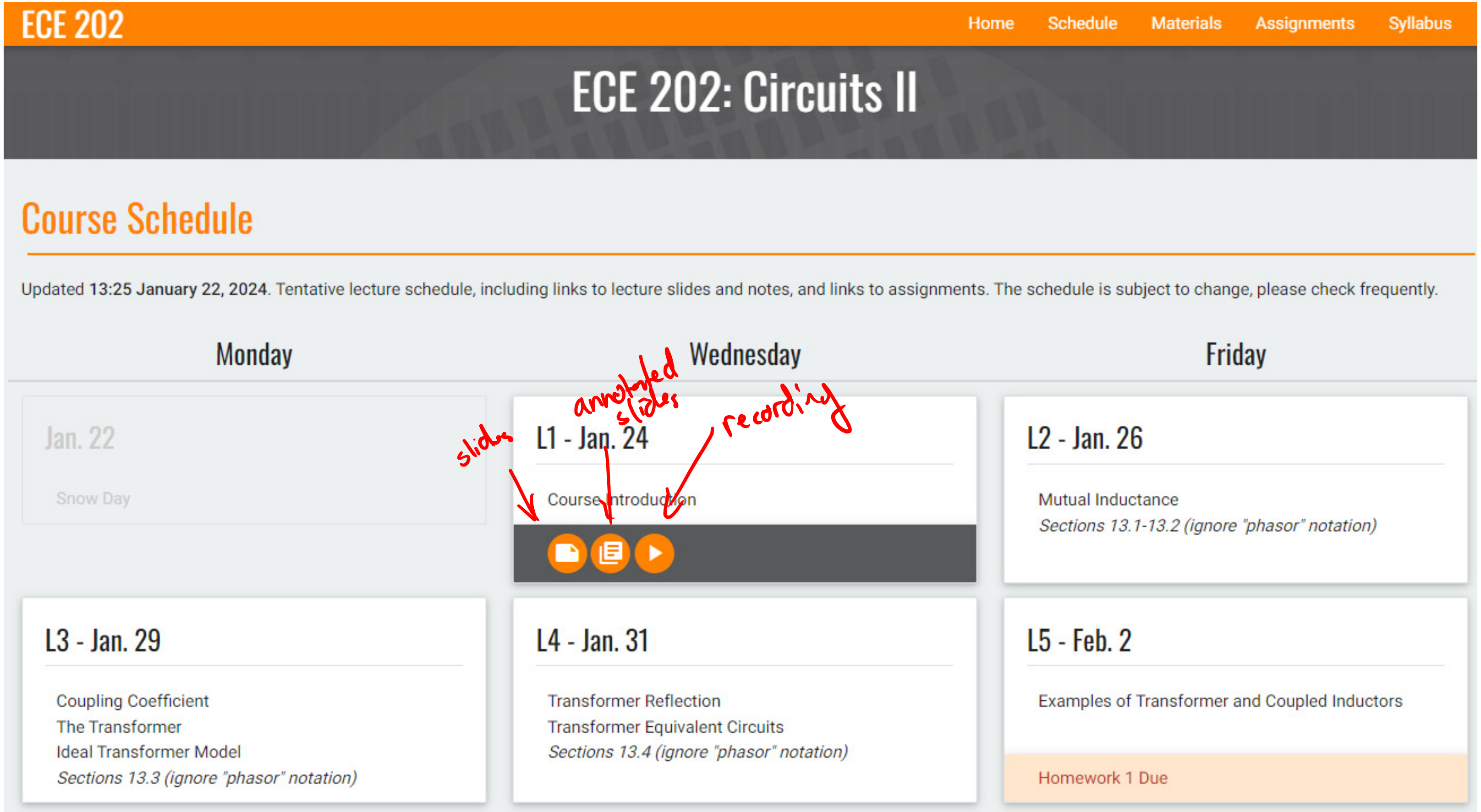
Course Website

- http://web.eecs.utk.edu/~dcostine/ECE202

Software

- MATLAB
- LTSpice

Course Website



Grading

- **Homework: 20%**
  - Weekly, due on Fridays *before* the start of lecture
  - Covers lectures up to and including Monday of the current week
  - The one lowest homework grade will be dropped
- **Quizzes: 10%**
  - In-class, open-book, open-note & calculator
- **Labs: 15%**
  - Completed outside of class
- **Midterms (2): 30%**
- **Final: 25%**
  - All exams open-book, open-note & calculator

Assignments

- Submission
  - Homeworks and Labs should be submitted by uploading a **single pdf** to canvas
    - Physical copy submitted prior to the due date/time loses 5% credit
    - https://www.eecs.utk.edu/resources/it/eecs-it-knowledge-base/using-the-scanner/
    - https://libanswers.utk.edu/faq/103187
    - https://acrobat.adobe.com/us/en/mobile/scanner-app.html : app for Android and iOS

Lab Experiments

- Completed in groups of 2-3
- May be completed using either
  - Analog Discovery Studio
  - Equipment in MK333
- Will require purchase of additional components from parts store

Course Policy

- No late work will be accepted except in cases of documented medical emergency
- Collaboration encouraged on Labs and Homework
  - Must submit your own work on all assignments
  - Adhere to Student Code of Conduct
- Attendance is required in all lectures

How to Succeed in ECE202

- Attend all lectures
- Read associated sections in the book, as listed on the course schedule
- Work collaboratively (in person or virtually) to understand homework assignments
  - Complete your own work
  - Self-assess solution process
  - Review any incorrect answers
- Actively participate in lab sessions
- Review material in advance of quizzes and tests
- Ask questions in lecture / office hours / e-mail after having made an attempt at the material on your own

INTRODUCTION TO ECE202

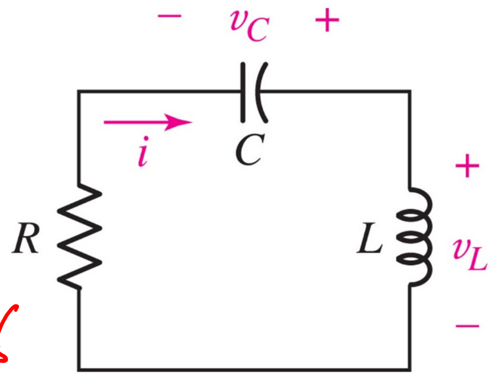
ECE 201 Review

- KCL, KVL, Series/Parallel Circuits (Chapter 3)
- Nodal and Mesh Analysis (Chapter 4)
- Linearity/Superposition, Source Transform (Chapter 5)
- Ideal Op-amps (Chapter 6)
- Capacitors and Inductors (Chapter 7)
- RLC Circuits, Resonance, Damping (Chapter 8-9)
  - Differential Equations approach

End of ECE201

1. Is this circuit useful?

2. What about more complex circuits?



Circuit analysis

DE approach

$$L\frac{d^2 i}{dt^2} + R\frac{di}{dt} + \frac{1}{C} i = 0$$

$$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$$s_1, s_2 = -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

resonant frequency f_0^2

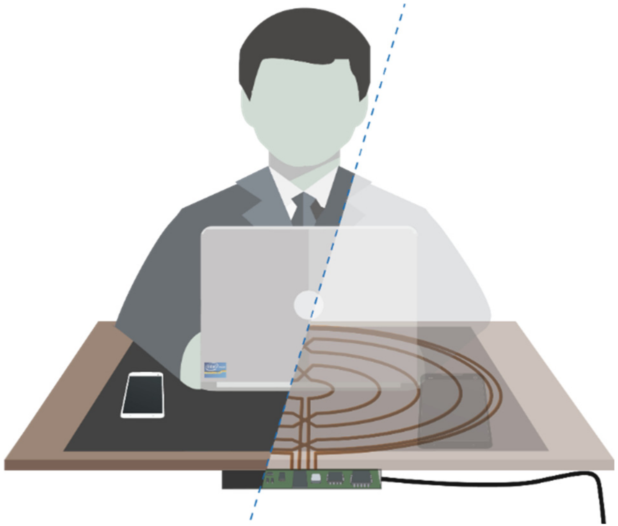
damping

Example Application: Wireless Power Transfer

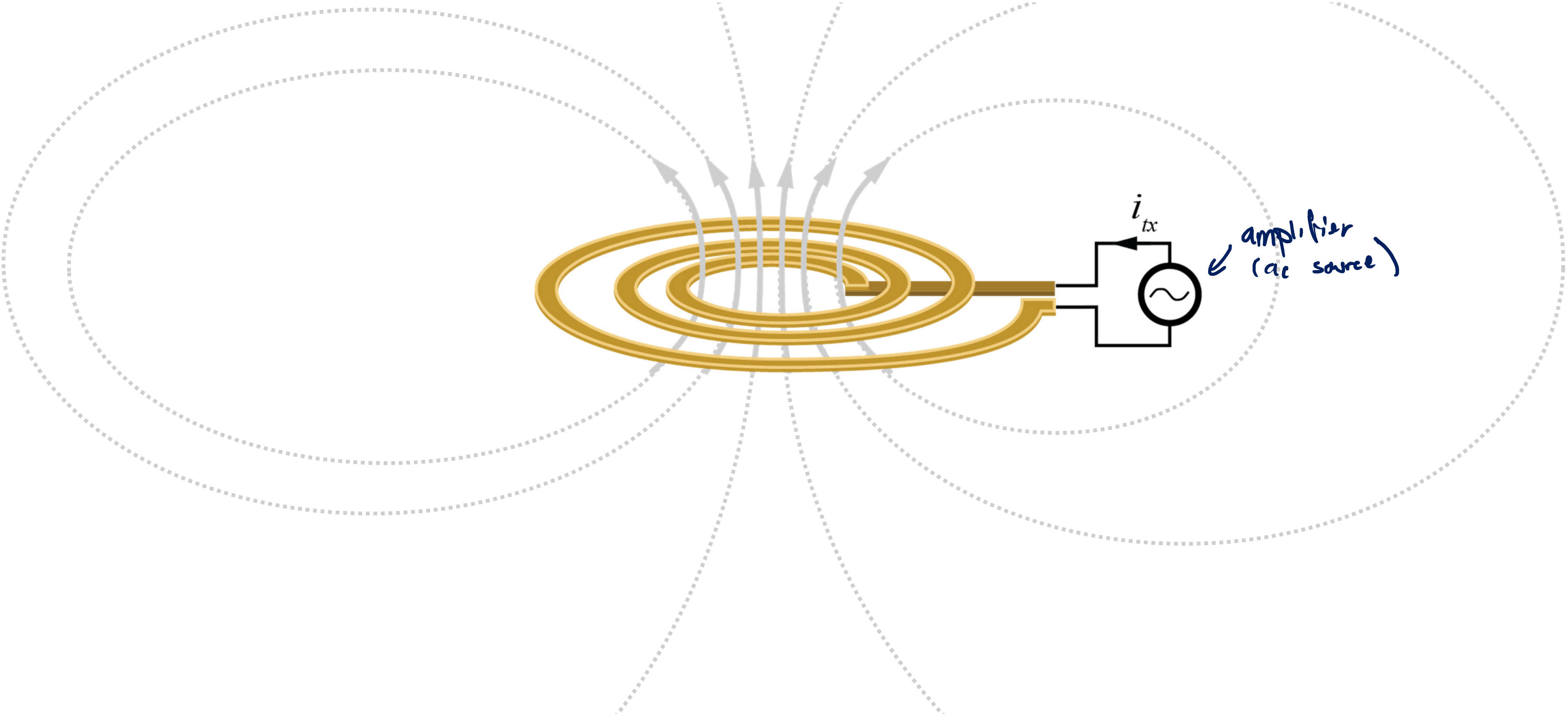
Commercial

Samsung
Fast charging wireless stand 2018
And wireless charger duo

Research



Wireless Power Transfer (WPT)

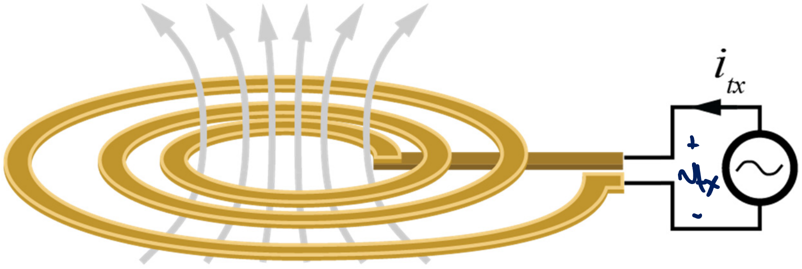


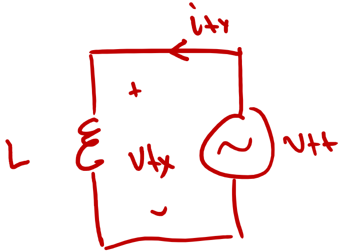
Wireless Power Transfer (WPT)

Ampere's law

flux $\Phi = N \alpha i_{tx}$

N: # of turns; α: geometry & materials coefficient





Faraday's law

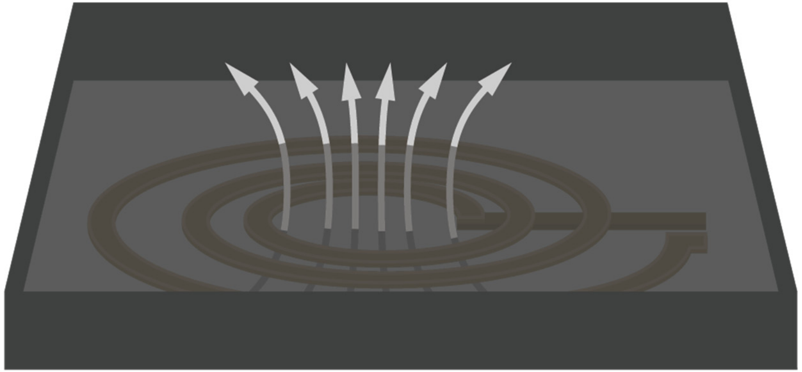
$$v_{tx} = N \frac{d\Phi}{dt}$$

$$v_{tx} = N \frac{d}{dt}\left(N \alpha i_{tx}\right)$$

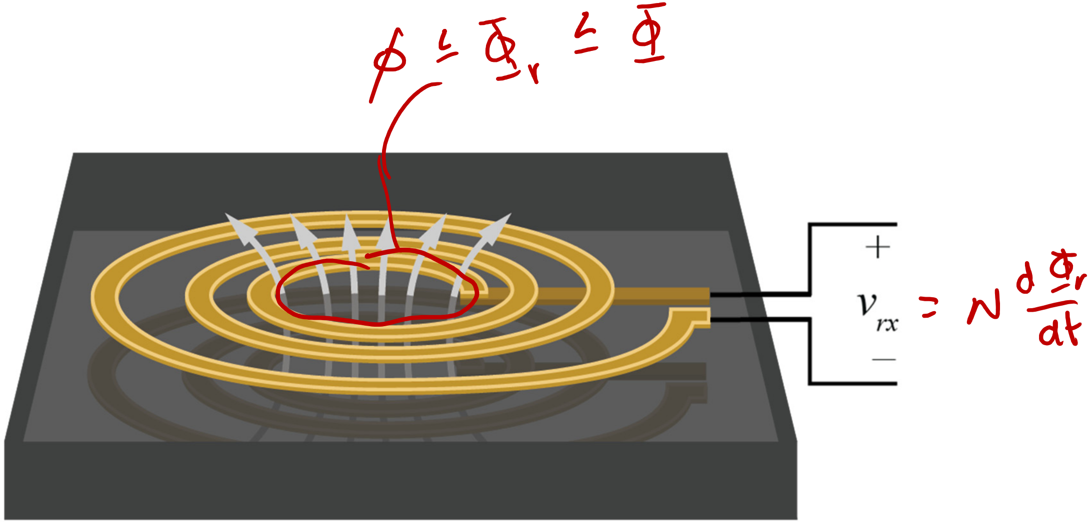
$$\boxed{v_{tx} = N^2 \alpha \frac{di_{tx}}{dt}}$$

$L = N^2 \alpha$

Wireless Power Transfer (WPT)

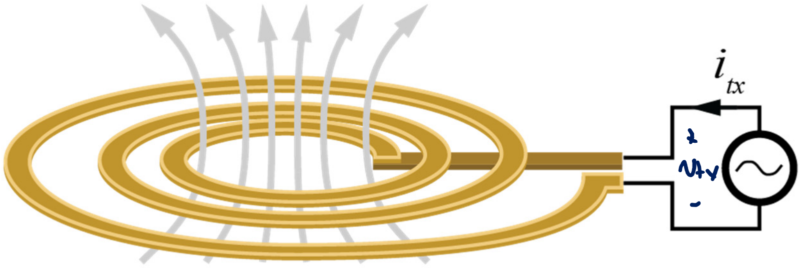


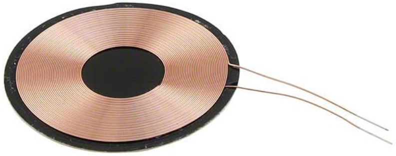
Wireless Power Transfer (WPT)



WPT System Design

USB charging of phone
USB: 5V & 5A (in this example)
P = 25W





<u>Example Coil</u>
TDK Part Number: WR282840-37K2-LR3
3 x 3 cm, 37 turns, L = 46 µH, f_s = 250 kHz

Let's say $i_{tx} = I_A \sin(\omega t)$, $\omega = 2\pi(250\text{ kHz})$, $I_A = 5A$

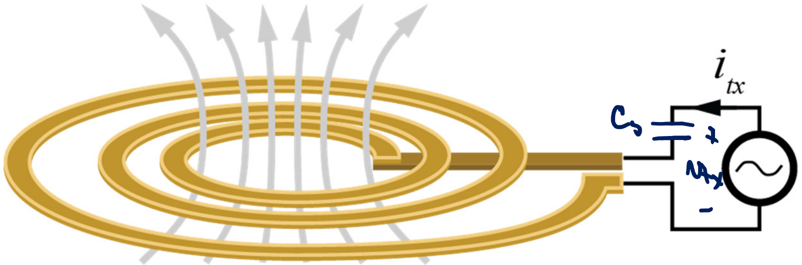
$$v_{tx} = L\frac{di_{tx}}{dt} = L\frac{d}{dt}\left(I_A \sin(\omega t)\right) = \left[L I_A \omega\right]\cos(\omega t)$$

361 V !!

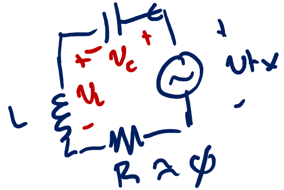
way too high!

WPT Compensation

again $i_{tx} = I_A \sin(\omega t)$



equiv circuit



$v_{tx} = v_L + v_C$

$$= L\frac{di_{tx}}{dt} + \frac{1}{C}\int_0^t i_{tx}\,dt$$

$$= L I_A \omega \cos(\omega t) + \frac{1}{C}\frac{1}{\omega} I_A \left(-\cos(\omega t)\right)$$

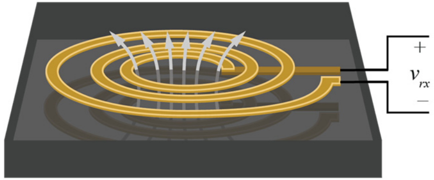
$$v_{tx} = \left(L I_A \omega - \frac{1}{\omega C} I_A\right)\cos(\omega t)$$

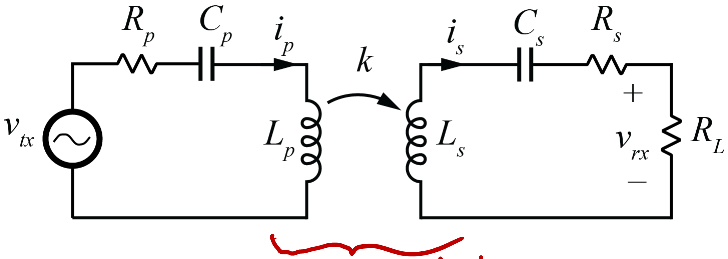
can arbitrarily reduce voltage from amplifier

if $L\omega = \frac{1}{\omega C}$, $v_{tx} = \phi$ V

$\omega = \frac{1}{\sqrt{LC}}$ → resonant frequency

Receiver Side

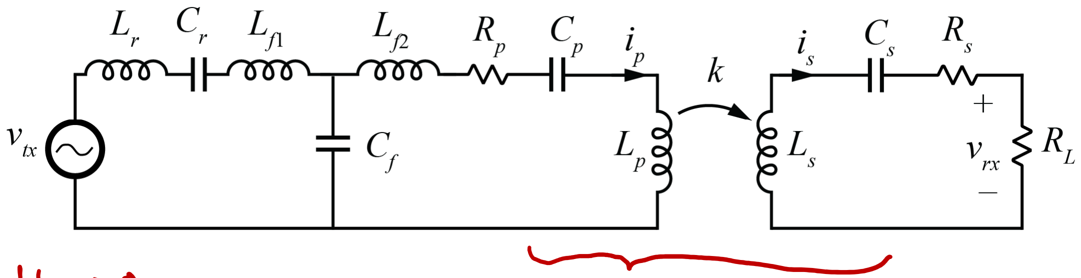




2 L's & 2 C's

4th order diff EQ.

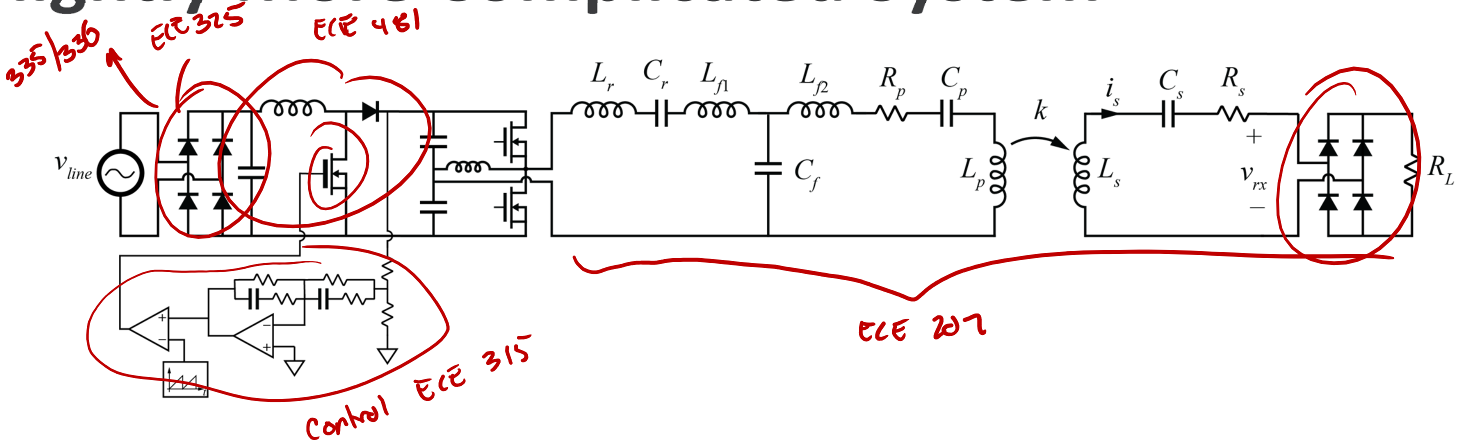
A Slightly More Complicated System



9th order Diff EQ

L. Jiang, F. Tamjid, C. Zhao, D. Costinett, A. Fathy and S. Yang, "A GaN-based 100 W two-stage wireless power transmitter with inherent current source output," *2016 IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW)*, Knoxville, TN, 2016, pp. 65-72.

A Slightly More Complicated System



Course Content

- Magnetically Coupled Circuits (Ch 13)
- Sinusoidal Steady-State Analysis (Ch 10)
- AC Circuit Power Analysis (Ch 11)
- Fourier Circuit Analysis (Ch 17)
- Circuit Analysis in the s-Domain (Ch 14)
- Frequency Response (Ch 15)
- Two-Port Networks (Ch 16)
- ~~Polyphase Circuits (Ch 12)~~ [ECE 325]

ECE 202 Core Concepts

- Continued development of fluency with circuit analysis
  - Solving circuits *without* resulting to Nodal/Mesh Analysis
- Linear, Time Invariant (LTI) systems
  - Superposition and shift independence
  - Transformation-based solutions to complex circuits
- Frequency-domain analysis

Transform-Based Solutions