

Recent Changes to the Junior-Level Electrical Engineering Design Course at Western Kentucky University

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Abstract

The topic of electric circuits is foundational in electrical engineering. In the electrical engineering program at Western Kentucky University, a seven-hour Circuits course sequence, emphasizing more on circuit analysis (and little on circuit design), is required for majors in the program. A three-hour Digital course, without a lab, is also required. Hence, there is an opportunity to enhance circuit design and implementations. In order to provide electrical engineering students with more circuit design experience after taking these courses, changes to the program's junior design course have been made. Until very recently, team projects from various areas of electrical engineering have been assigned in this course; however, it was decided that team projects emphasizing circuit design would be assigned moving forward. In the most recent course offering, the circuits projects were chosen such that students were required to explore more advanced topics. Working in teams of three or four, they were tasked with designing the circuits from first principles, then simulating the designs using software. During the final weeks of class, each student individually breadboarded their team's circuit design. These changes to the design course provided the students with more real design experience in an essential and foundational program topic and reinforced their simulation, breadboarding, testing, and validation skills. Additional benefits to the curriculum are also expected and will be discussed.

WKU EE Program Summary

- Total credit hour requirement: 124
- Breakdown of course hours:
 - EE and ENGR: 52
 - MATH (incl. STAT): 21
 - PHYS: 9
 - ENG: 9
 - Engineering/Science: 6
 - CS: 3
 - Science elective: 3
 - Additional general education: 21

EE and ENGR courses

Lecture/Lab courses (43 hours):

- EE 180 – Digital Circuits (3)
- EE 210 – Circuits & Networks I (3.5)
- EE 211 – Circuits & Networks II (3.5)
- EE 345 – Electronics (4)
- EE 380 – Microprocessors (4)
- EE 420 – Signals & Linear Systems (3)
- EE 431 – Intro. to Power Systems (3.5)
- EE 460 – Continuous Controls Systems (3.5)
- EE 473 – Electromagnetics I (3)
- EE tech electives (12)

} 10 hours (of 52) allocated to circuits,
primarily fundamentals and analysis

Project courses (9 hours):

- EE 101 – Electrical Engineering Design I (1)
- EE 200 – Electrical Engineering Design II (2)
- EE 300 – Electrical Engineering Design III (1) → First design course taken *after* Circuits
- ENGR 490 (2) and ENGR 491 (3) – Senior Project I & II

Circuits course descriptions

EE 180 – Digital Circuits

An introductory course in digital circuit **fundamentals**. Topics include number systems, Boolean algebra, binary codes, logic gates, flip-flops, counters, and registers.

EE 210 – Circuits & Networks I

An introductory course in circuit **analysis** including Kirchhoff's Laws, independent and dependent sources, power and energy, lumped linear fixed networks, power factor, phasors, and three phase networks. Laboratory included.

EE 211 – Circuits & Networks II

A second course in circuit **analysis** with an emphasis on frequency response techniques. Topics include impedance, transformed networks, Laplace transforms, resonance, two-port parameters, mutual inductance, forced and natural responses, transformers, transient response, and sinusoidal steady-state response. Laboratory included.

Considerable time in analysis and fundamentals, but little design.

Summary of junior design course (EE 300) changes

- Assign electric circuits projects only
 - A wide range of project types assigned in prior years
- Projects to emphasize more advanced concepts than those encountered in lecture/lab courses – independent learning required
- Emphasize three ‘phases’ of design: calculation, simulation, testing

EE 300 Spring 2021 Projects

- 1) Design of a band-pass electric filter
- 2) Design of a band-stop electric filter

Electric filter designs vary considerably in complexity based on the requirements.

EE 300 Spring 2021 Projects (continued)

3) Design of a simple analog computer

Required function: solve second-order differential equation of the form

$$y''(t) + ay'(t) + by(t) = x(t)$$

given certain constraints and initial conditions.

EE 300 Spring 2021 Projects (continued)

- The complexity of each project can be easily adjusted
- Only three projects assigned, but two separate teams worked on each project
- Students organized into two 'companies', ABC Company and XYZ Company
- Each company subdivided into three teams
- Instructor met regularly with each Company separately via Zoom breakout rooms
- Team meetings were also held via Zoom breakout rooms

EE 300 Spring 2021 Projects (continued)

- Each team required to perform ‘pen-and-paper’ calculations beginning with first principles
- Simulation via mathematical software packages and circuit simulation software performed next
- Last two weeks of class were allocated to solderless breadboarding of preliminary designs in a laboratory

Benefits of the changes

- Considerable investment is made in providing a background in electric circuits – this work enhances that background by providing real design experience
- Increased proficiency in mathematical and circuit simulation software for each EE student
- Practice in independent learning – circuits assigned were more complex than those covered in the lecture courses
- Enhanced circuit testing skills for each EE student

Additional Curricular Benefits

- Simplification of prerequisite requirements
- Ideally, design courses will be taken one after the other, one per year, but this is not always possible
 - While taking EE junior design prior to senior design is preferable, it is not essential with these changes
- Changes still allow for the treatment of non-technical professional topics (like ethics)

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