

Syllabus - PH412 Analog and Digital Electronics

Concepts

Being the second part of a three quarter sequence, this course presents deeper analyses of more complex circuits and discrete solid state devices used for experimental physics and engineering applications. The development of experimental skills and analytical approaches to analyses of physical systems is integrated into the course. Students gain experience working with common laboratory instrumentation, learn how turn theory and diagrams into a functioning circuit and learn how to present experimental work and analysis in a concise report. Concepts from introductory physics courses and the paradigms courses are reinforced in the context of experimentation and analysis. Specific concepts include: time-dependent electromagnetic phenomena; material responses to electromagnetic fields; time-domain and frequency-domain analyses of physical systems; Fourier series and Fourier transforms; complex numbers - amplitude and phase; resonance in physical systems; positive feedback and oscillators; physics and applications of signal diodes, LEDs and photodiodes; physics and applications of bipolar transistors and field effect transistors; concepts of digital logic; rudimentary logic gates and applications.

Texts

- Required books:

Introductory Electronics for Scientists and Engineers, by R. E .Simpson, ISBN 0205083773.

- Useful books:

The Art of Electronics and *Student Manual for the Art of Electronics* both by Horowitz and Hill.

Meeting Times

The lectures and laboratory sessions are organized coherently. Some lectures will discuss laboratory procedures and results, and some laboratory sessions will involve discussion of theoretical issues.

- Lectures: Monday and Wednesday at 9:00 in 275 Weniger
- Laboratory sessions: Tuesday and Thursday 9:00 - 10:20 in 302 Weniger, but the labs will be open 8:30 - 12:00.

Instructors

- Tomasz M. Giebultowicz, Associate Professor of Physics
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- Rodney Snyder, Teaching Assitant, Rodney_snyder34@yahoo.com

Grading

- Laboratory reports and problems = 70%, midterm examination = 10%, final examination = 20%. Class participation will also be taken into account for borderline grade decisions.

- Since the lectures and laboratory experiments assume understanding of all previous material, it is important that reports and problem sets be submitted on time. The policy concerning penalties for late reports will be discussed in class.

Topics

Operational Amplifier Filters

- Time-domain and frequency domain analysis of the integrating or low-pass amplifier
- Time-domain and frequency domain analysis of the differentiating or high-pass amplifier

Operational Amplifier Comparators

- Comparator concepts
- Schmidt trigger comparator and an application to temperature control

Monostable and astable multivibrators

- Common timing devices

Operational Amplifier Oscillators

- Phase-shift oscillator
- Voltage-controlled oscillator (VCO)

Diodes and Applications

- Basic physics of diodes: small signal silicon diodes, Schottky barrier diodes, tunnel diodes, Zener diodes
- LEDs
- PIN photodiodes
- Applications: nonlinear electronics, rectified power source, RF detector, optical communication, thermoelectric effect

Bipolar Junction Transistors and Simple Amplifiers

- Basic physics of bipolar junction (BJT) transistors

- Common collector or emitter follower amplifier
- Common emitter inverting amplifier

Field Effect Transistors and Simple Amplifiers

- Junction field-effect transistor (JFET) physics
- JFET amplifier
- Metal oxide semiconductor field-effect transistor (MOSFET) physics
- MOSFET switches and complementary MOSFET (CMOS) switches

Transistor Applications: Differential Amplifiers, Oscillators

- Current mirror as a constant current source
- JFET differential amplifier
- JFET Colpitts oscillator
- Crystal oscillators

Concepts of Digital Logic

- Logical operations and tables, complex logical operations
- Binary arithmetic as a set of logical operations

Logic Gates and Simple Applications

- Analog properties of digital logic integrated circuits (ICs)
- Behavior of simple logic gates
- Decoder circuit
- D-type flip-flop and applications: data latch, binary counter, DAC driver with a counter circuit
- Retriggerable monostable multivibrator and applications