The University Of Sheffield.

Electronic & Electrical Engineering.

EEE118 ELECTRONIC DEVICES AND CIRCUITS

Credits: 20

Course Description

The course is intended to provide an introduction to the properties of electronic devices and describe their use in circuits.

1. To understand the details of conduction mechanisms in solids (and vacuum).
2. To appreciate the differences between conductors, semiconductors and insulators and the use of the latter in capacitors.
3. To understand conduction and diffusion and the fundamental origin of Ohm's law.
4. To be able to distinguish between mobile charge and space charge in semiconductors and their respective roles in electronic devices.
5. To develop a thorough understanding of the mechanisms of the p-n junction.
6. To be able to apply the knowledge listed above to relate physical mechanisms in semiconductors to the terminal characteristics of electronic devices, in particular transistors.
7. Introduce the principles of circuit diagrams including active and passive circuit elements to enable students to interpret these and to design their own
8. To describe the characteristics of passive circuit elements such as resistors, capacitors and inductors
9. To describe the behaviour of junction and other types of diode and explore their behaviour in a circuit
10. To introduce the characteristics of transistors such as the BJT, JFET and MOSFET and to describe their roles within electronic circuits.
11. To describe the operation of BJT and MOSFET devices as switches in various circuit environments.
12. To introduce the concept of integrated circuits and describe its application within analogue, digital and storage circuits.
13. To introduce the concept of amplification and explain the role of circuit bias.
14. To introduce the concept of small signal models and develop and apply a simple small signal model for a transistor.
15. To introduce the idealised op-amp and to discuss the possible limitations in practical devices
16. To describe the operation of a number of practical op-amp circuits.
17. To use tools like superposition for the analysis of multiple input op-amp circuits.

Outline Syllabus

Electrons in a Vacuum : force on electron in an electric field, energy, velocity, current and current density. **Electrons in Solids** : transport mechanisms, drift, diffusion. Resistivity of metals and physical origin, temperature coefficient. **Insulators** : breakdown strength, dielectrics and relative permitivity, different types of capacitors and their uses. **Semiconductors** : intrinsic and extrinsic, doping, charge carriers, holes, basic relationships of J for bulk semiconductors.

PN Junctions : structure, junction potential, forward bias behaviour, charge injection, diode equation. Idea of space charge, Poisson's equation, internal fields, reverse breakdown mechanisms. **Basic Diode characteristics** : large and small signal diode models. **Diode Applications** : rectifiers, capacitor input smoothing, ripple, zener diode regulators. Clipping, clamping, voltage doublers, voltage multipliers. Diode characteristics and temperature effects.

Transistors : JFETs and MOSFETs, basic mechanisms and characteristics, transconductance. BJT, transport mechanisms, charge control model, characteristics, BJT, JFET and MOSFET similarities and differences. **Switching Applications** : on-state and off-state behaviour, drive considerations for BJT and MOSFET, inductive loads and back emf, switching AC power, bridge topologies for motor control.

Amplifier Applications : amplification, biasing, designing dc conditions, thermal stability. Small signal model, equivalent circuits, coupling and decoupling, mid-frequency examples. **Operational Amplifiers** : advantages of - ideal performance. Basic circuit shapes, idea of feedback, follower circuits, virtual earth circuits, effect of finite gains. Use of superposition to handle multiple source amplifiers.

Time Allocation

48 lectures and 24 tutorials in semesters 1& 2, 16 hours of laboratories, and 106 hours of independent study.

Recommended Previous Courses

Entry qualifications only

Assessment

One mid term test (January) - 10% each, homeworks – 5%, two labs each worth 7.5%, exam (May/June) answer 4 questions from 6 in 3 hours - 70%

Recommended Books

Streetman and Banerjee "Solid State Electronic Devices" (5^{th} ed) Prentice-Hall
P. Horowitz & W. Hill "The Art of Electronics" (3^{rd} ed). Cambridge Univ. Press. 2015
J. Millman & A. Grable, "Microelectronics", (2^{nd} ed.) McGraw Hill, 1987
A. Sedra & K. Smith "Microelectronics", (6^{th} ed.) Oxford University Press, 2009

Objectives

By the end of the module a successful student should be able to:

1. Determine the differences of electron motion in a vacuum and in solids (drift and diffusion).
2. Outline properties and uses of metals, semiconductors and insulators.
3. Identify the physical processes which are important in semiconductor electronic devices.
4. Understand the p - n junction and the concept of electron and hole current.
5. Appreciate the use of a diode for the emission and detection of light.
6. Identify the physical mechanisms within the JFET and bipolar transistor leading to the output characteristics.
7. Design a simple single transistor amplifying circuit.
8. Identify under what conditions a diode will conduct and what its effect will be on the behaviour of

the circuit as a whole.

9. Design simple capacitor input filtered power supplies, understand the significance of the approximations involved and specify voltage ratings for the components used.
10. Predict the behaviour of circuits containing resistors, capacitors and diodes such as voltage doublers, peak detectors and differentiators
11. Discuss the similarities and differences between the characteristic behaviour of BJTs, JFETs and MOSFETs
12. Determine key operational parameters of a simple switching circuit and design simple circuits - including ones with inductive loads - to achieve specified goals
13. Analyse and synthesise the two practically useful bias circuits used in BJT amplifiers.
14. Apply small signal model ideas by converting a real circuit into a small signal equivalent linear model and make quantitative estimates of a circuit's small signal performance.
15. Calculate circuit gain for inverting and non-inverting operational amplifier circuits for both ideal operational amplifiers and ones with a finite gain.
16. Apply the principle of superposition to determine the output signal from an operational amplifier circuit fed with multiple input signals.