Some Prerequisites in Electrical Engineering and Information Technology

- Analogue Circuit Analysis
- Electronic Devices and Circuits
- Solid State Electronics
- Electromechanics Fields and Waves

Analogue Circuit Analysis

**Prerequisites:** Linear algebra, vector analysis, matrix analysis and complex calculus.

**Course objectives:**
The student will gain an insight in the analysis and evaluation of DC as well as AC circuit analysis. The course will discuss linear analogue networks, ideal operational amplifier networks, bridge networks, one and two–port networks, RLC networks, transformers and polyphase circuits. Power considerations will be made as well as frequency response of sinusoidal signals. Frequency plots and Bode plots are introduced. At the end of the course, the student is supposed to recite, paraphrase and apply the concepts in problem solving of all topics covered. Also, the student is supposed to be able to analyse, design, evaluate and optimise a circuit with respect to a certain parameter such as power or frequency response.

**Contents in key words:**

1. **Introduction to circuit analysis**
   - Definitions, Kirchhoff’s Laws, Physical Resistors, Simple networks with resistances, Current and voltage sources, Power, power transfer and optimisation of the power factor in DC

2. **DC circuit analysis**
   - Mesh and Nodal analysis, Graph of a network, trees and cotrees, Superposition, $\otimes$ – $\otimes$ Transform, $Y$ – $\otimes$ Transform, Thévenin’s Theorem and Norton’s Theorem

3. **Operational amplifier circuits**
   - Input and output parameters, Amplifier circuits

4. **AC circuit analysis**

5. **Power**
   - Average Power, apparent power, reactive power, Effective values, Complex Power, Power Measurement, Power transmission in AC (source to load)
6. Bridge networks

7. Frequency response plot of impedance and admittance
   Frequency response plot of simple R, L, C networks, $Z \leftrightarrow Y$ conversion

8. RLC networks
   Series RLC networks, Parallel RLC network, General form of the quality factor $Q$

9. One–port networks
   Linear one–port networks with passive elements, Linear one–port networks including dependent sources, Source transformation, One–port networks including independent sources

10. Two-port networks
    Definition of two-port networks, Parameters, Calculus of two-port matrices, Series, parallel and cascaded connection of two-port networks, Impedance transformation and transmission lines

11. Frequency response plots of $U_2/U_1$
    First order filter, Second order filter

12. Bode-plots
    Logarithm and Decibel, Bode plots

13. The Transformer
    Transformer equations, Equivalent circuits of transformers, Frequency response of transmitters, Power transformer

14. Polyphase Circuits
    Three-phase circuits

**Literature:**


**Electronic Devices and Circuits**

**Prerequisites:** Analog Circuit Analysis

**Course objectives:**
This course provides substantial knowledge of the function pn junctions, pn- and zener diodes, bipolar and field-effect devices, basic analog and digital circuits. The course will discuss the device parameters of diodes, BJT’s, field effect transistors,
single stage amplifiers using common emitter, common base and common collector configurations as well as all configurations of FET amplifiers including CMOS and multi stage amplifiers, differential amplifier and output stages. In the next step a basic operational amplifier circuit and the use of these amplifiers at different applications are discussed. Furthermore all basic digital circuits (inverter, NAND, NOR, tri state inverter and transmission gates) at transistor level are introduced. Sequential logic circuits RS-, D- and JK- flip flops including truth tables and timing diagrams are shown for use at different type of counters, frequency dividers and shift registers. Finally principles of digital-to-analogue and analogue-to-digital converters are shown. At the end of the course, the student is supposed to recite, paraphrase and apply the concepts in problem solving of all topics covered. Also, the student is supposed to be able to analyse, design, evaluate and calculate parameters at analogue and digital electronic circuits e.g. dc biasing of single stage amplifiers, combined operational amplifier stages, drawings of digital circuits, timing diagrams of flip flops and counters and so on.

Contents in key words:

1. Introduction
   Definitions and Symbols, Basic Elements and Circuits, Kirchhoff's Laws

2. Passive Circuits
   Decarations, Properties and Labeling of Circuits, Resistors, Capacitors and Inductors

3. Semiconductor Circuits
   Diode, Bipolar Junction Transistors, JFET devices, MOSFET Devices, CMOS Devices

4. Amplifier Circuits
   Amplifiers, Current Sources and Current Mirrors, Differential Amplifier, Class AB Amplifier, Feedback Amplifiers

5. Operational Amplifiers
   Structure, Basic Amplifiers, Offset Voltage and Offset Current, Input and Output Impedance, Frequency Characteristics, Op Amp Applications

6. Multivibrators
   Multivibrator with Transistors, OPA Schmitt-Triggers, OPA free running Multivibrator

7. Digital Circuits
   Declarations, Timing Declarations, Power Dissipation, Fan Out, Positive and negative Logic, Logical Symbols

8. Logic Circuits
   Bipolar Circuits, MOS Circuits

9. Sequential Logic
   Flipflops, Counters, Shift Registers

10. Decoders, Multiplexers
    Decoders, BCD-to-7 Segment Decoders, Priority Encoder, Multiplexers, Demultiplexers

11. Digital-to-Analog and Analog-to-Digital Converters
Digital-to-Analog Converters, Analog-to-Digital Converters

**Literature:**


**Solid State Electronics**

**Prerequisites:** Analysis, complex calculus, statistics, differential equations, Fourier transformation, basics of mechanics and electrodynamics.

**Course objectives:**
In the first part of the course the student will gain insight into the basic quantum mechanical and solid state physics principles of semiconductor devices. The second part of the course aims at an understanding of the basic processes and equations being necessary for semiconductor device modelling. Intrinsic and doped semiconductors are discussed and the pn-diode is introduced as the prototype semiconductor device. At the end of the course, the student is supposed to recite, paraphrase and apply the concepts of quantum mechanics and band electrons in semiconductors and he/she should be in problem solving of all topics covered.

**Contents in key words:**

1. **Fundamentals of Quantum Mechanics (QM)**
   - History, The Schroedinger equation (SE), The infinite quantum well, The measurement process in QM, The finite quantum well, Potential barriers, The harmonic oscillator

2. **Structure of Matter**
   - The hydrogen atom, The periodic table of the elements, From atoms to the solid state

3. **Electrons in Crystals**
   - From molecules to the solid state, Crystal lattices, Fabrication of crystals, Bloch electrons, Band structure

4. **Electrons in Semiconductors**
   - Acceleration of Bloch-electrons, Electron mobility, Currents in semiconductors, Metals, semiconductors and isolators

5. **Quantum Statistics for Electrons and Holes**
   - Density of states (DOS), Fermi-Dirac distribution, Occupation of bands
6. **Doped semiconductors**  
Donors and acceptors, Doping Technologies, Carrier statistics in doped semiconductors, Temperature dependence of the resistivity

7. **Fundamental equations of semiconductors**  
Currents in semiconductors, Generation and recombination, Continuity equations, Poisson equation

8. **The pn-junction**  
The electrochemical potential, Band diagram of a pn-junction, Einstein relation, The Schottky model

**Literature:**

(1) Semiconductor Fundamentals by Robert F. Pierret, G. W. Neudeck, Addison-Wesley
[http://www.lti.uni-karlsruhe.de/seite_1818.php](http://www.lti.uni-karlsruhe.de/seite_1818.php)

---

**Electromechanic Fields and Waves**

**Prerequisites:** advanced mathematics

**Course objectives:**
Electromagnetic Fields and Waves are based on Maxwell’s theory. The complete Maxwell electric and magnetic fields are introduced including material equations, continuity equation and boundary conditions. Mathematical properties are discussed and different kinds of fields are classified with respect to their energies: static, stationary, low frequency harmonic and full wave fields. Dynamic harmonic fields and their approximations for capacitive and inductive problems, e.g. skin effect are analysed and calculated in detail. Super conductivity is introduced as an example of non classical material behaviour. Full-wave analysis of harmonic fields is given on waveguides (TE-, TM-waves). Plane waves are examined referring to reflection, energy and losses. Furthermore the radiation of Hertzian dipoles is introduced. Electrodynamic potentials and Poynting vector concepts are covered.

**Contents in key words:**

1. **The Electromagnetic Model.**  
The Electromagnetic Model. Si Units and Universal Constants.

2. **Vector Analysis.**  

3. **Static Electric Fields.**

4. Solution of Electrostatic Problems.

5. Steady Electric Currents.


10. Antennas and Radiating Systems.

Literature:


continative: