Basics of electronics

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Semestral Schedule - Lecture 1

- General information.

- Pasive components:

    – Resistors: Resistor Characteristics, Resistor Types.

    – Capacitors

    – Inductors

Lecture 2 - Laplace and Fourier Transforms
- Definitions and Properties

- Laplace Transform Integral

- Properties of Laplace Transform

- Time-Convolution Property

- Time-Correlation Property

- Inverse Laplace Transform

Lecture 3 - Laplace and Fourier Transforms

- Applications

- Differentiation Theorems (Applications to Integrodifferential)

- Equations (Applications to Electric Circuits)

- The Transformed Circuit

- Transfer functions

- Phase and magnitude characteristics

Lecture 4 - Passive Signal Processing

- Laplace Transform - Transfer Functions

- Low-Pass Filters (Low-Pass Filter Functions)

- High-Pass Filters (High-Pass Filter Functions)

- Design: Scaling Laws and a Design Example, Transformation Rules.

Lecture 5 - DC Linear Circuit Analysis

- Voltage and Current Laws Ohm's Law

- Kirchhoff's Current Law (Kirchhoff's Current Law in the Complex Domain)

- Kirchhoff's Voltage Law (Kirchhoff's Voltage Law in the Complex Domain)

- Importance of KVL and KCL.

- Two-Port Parameters and Transformations: Defining Two-Port Networks

- Mathematical Modeling of Two-Port Networsk - Examples

Lecture 6 - AC Linear Circuit Analysis

- Methods of analyzing

- Node Analysis

- Mesh Analysis

- Linearity and Superposition - The Network Theorems of Thévenin and Norton, Tellegen's Theorem

- Maximum Power - Transfer Tellegen's Theorem, Maximum Power Transfer

- Measuring

Lecture 7 - Feedback control theory

- Linear circuit stability,

- Bandwidth and amplification,

- Examples of oscillators (eg. Colpits, Meissner)

- **TEST 1**

Lecture 8 - Semiconductors
- Physical Properties

- Energy Bands

- Electrons and Holes (Transport Properties)

- Electrical Breakdown (Optical Properties and Recombination Processes)

- Diodes: pn -Junction Diode

- diode models

- Diode Reverse Breakdown

- Zener Diodes.

Lecture 9 - Transistors

Junction Field-Effect Transistors **JFET**

- Transfer Characteristics

- JFET Output Resistance

- Source Follower

- Frequency and Time-Domain Response

Lecture 10 - Transistors – basic circuits

- The Emitter-Follower or Common-Collector (CC) Circuit,

- The Common-Emitter Bypass Capacitor,

- System Response,

- Integrated Circuits,

- The Difference Amplifier,

- The Current Mirror.

Lecture 11 - Electrical Equivalent Circuit Models and Device Simulators

- Overview of Equivalent Circuit Models,

- Overview of Semiconductor Device Simulators,

- Electrical Characterization of Semiconductors.

Lecture 12 - Operational amplifiers

- Parameters if ideal OP,

- Feedback loop,

- Examples.

Lecture 13 - Power supplies

- Power Semiconductor Devices and Triac, Power Transistor, Power MOSFET

- Power Conversion: AC-DC Converters, DC-to-AC Converters, DC-DC Converters

- Power Supplies: DC Power Supplies, AC Power Supplies.

Grade components

- *laboratory*: 8 laboratories (5 points each, up to **40 points**). Grade 3 points satisfied laboratory. To pass laboratory - 6 labs must be satisfied and sum must exceed 18,5 points

- project up to **10 points**

- Two tests during lectures (Lecture 7 and 15) - (5 points each, sum **10 points**)

The total number of points is 60.

Grade table

grade	points
5	54,5 - 60
4,5	48,5 - 54
4	42,5 - 48
3,5	36,5 - 42
3	30,5 - 36
2	0 - 30

Electrical Fundamentals

Powers of 10 and prefixes

Quantities greater than 100 or less than 0.01 are usually expressed in the standard form of $A \times 10^n$, where A is a number, called the *mantissa* and n is a whole number called the *exponent*.

Prefix	Abbreviation	Power of ten	Multiplier
Giga	G	9	1 000 000 000
Mega	M	6	1 000 000
kilo	k	3	1000
milli	m	-3	$\frac{1}{1.000}$
micro	m	-6	$\frac{1}{1.000.000}$
nano	n	-9	$\frac{1}{1.000.000.000}$
pico	p	-12	$\frac{1}{1.000.000.000.000}$

Conductors and Insulators

- A voltage applied between two points on a length of a metallic conductor produces the flow of an electric current, and an electric field is established around the *conductor*,

- In some nonmetallic materials, called *insulator*, the free electrons are so tightly bound by forces in the atom that, upon the application of an external voltage, they will not separate from their atom,

- *Semiconductors* are electronic conducting materials wherein the conductivity is dependent primarily upon impurities in the material.

DC and AC current

- Direct current **DC** is defined as a unidirectional current in which there are no significant changes in the current flow,

- Alternating current **AC** is defined as a current that reverses direction at a periodic rate. The average value of alternating current over a period of one cycle is equal to zero.

Passive and active components

- *Passive components* are those that need no power supply for their operation

- No purely passive component can have an output that supplies more power than is available at the input.

- *Active components* make use of a power supply, usually DC, so that the signal power output of an active component can be higher than the signal power at the input.

Resistors

- The resistance of a sample of material, measured in units of ohms (W), is defined as the ratio of voltage (in units of volts) across the sample of material to the current (in units of amperes) through the material.

$$R = \frac{U}{I}$$
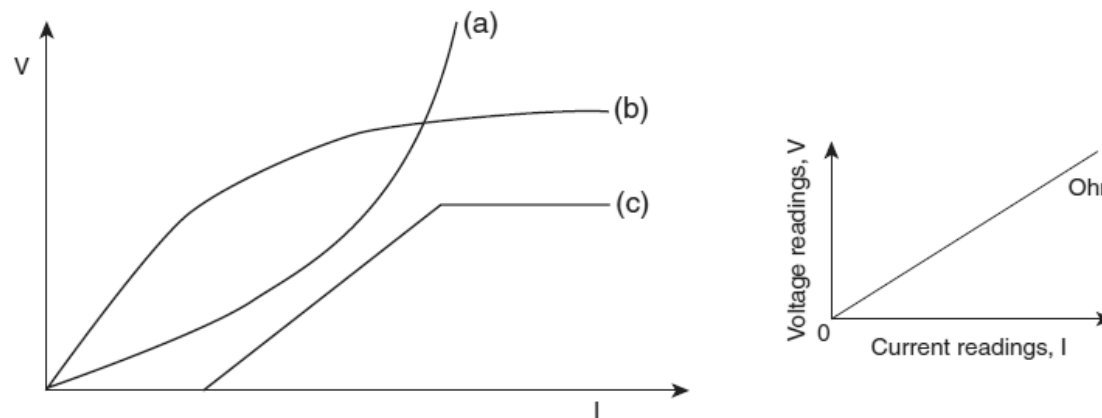
Characteristic is indicated by graph, curves or lines: (a) light bulb, (b) ntc thermistor, (c) diode

Resistivity and resistance

- The resistance of any sample of a material is determined by its dimensions and by the value of resistivity of the material,
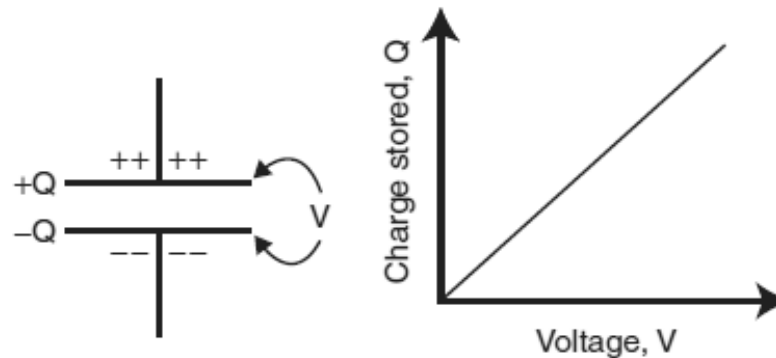
- *Resistance* R can be calculated as follow:

$$R = \frac{\rho L}{A}$$

where ρ is *resistivity*, A area of cross-section and L length.

Resistors overview

Capacitors

- Two conductors that are not connected and are separated by an insulator constitute a *capacitor*,

- When electrical charge Q (measured in units of coulombs) has been transferred, the voltage across the plates equals the voltage V across the voltage source *capacity* C (measured in units of farads) is equal

$$C = \frac{Q}{V}$$

Capacitor and capacity

- The parallel-plate *capacitor* is the simplest (theoretical) arrangement and its capacity value C is, for ideal conditions, easy to calculate. For a pair of parallel plates of equal area A, separation d, the *capacity* is given by
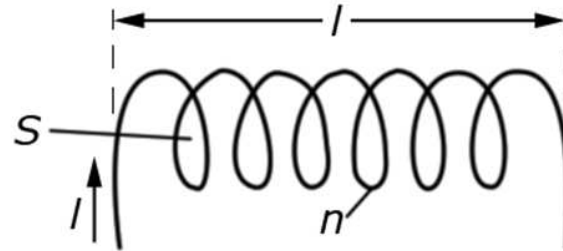
$$C = \frac{\xi_r \xi_0 A}{d}$$

where the quantity ξ_0 is a universal constant called the *permittivity of free space*, and it has the fixed value of 8.84×10^{-12} farads per metre.

Capacitors overview
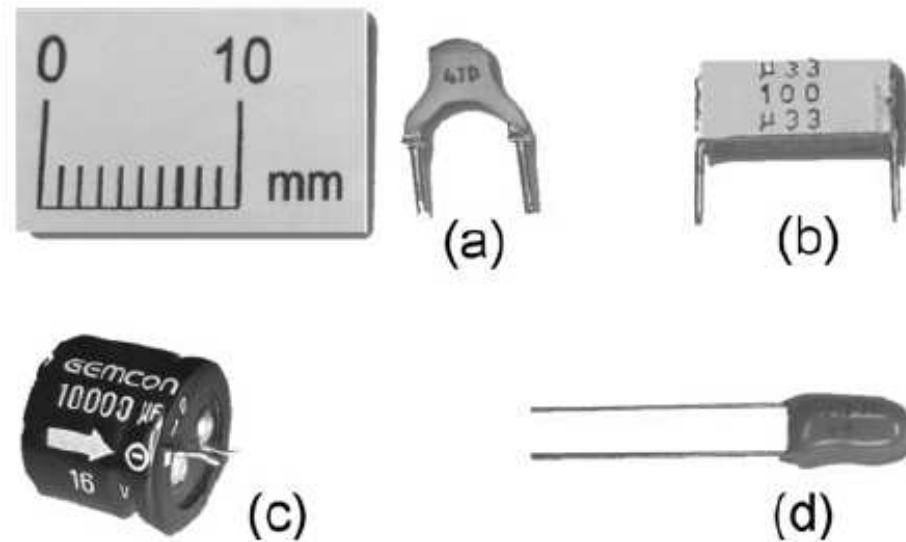
Capacitor selection: (a) ceramic, (b) polyester stacked film, (c) electrolytic, (d) tantalum electrolytic.
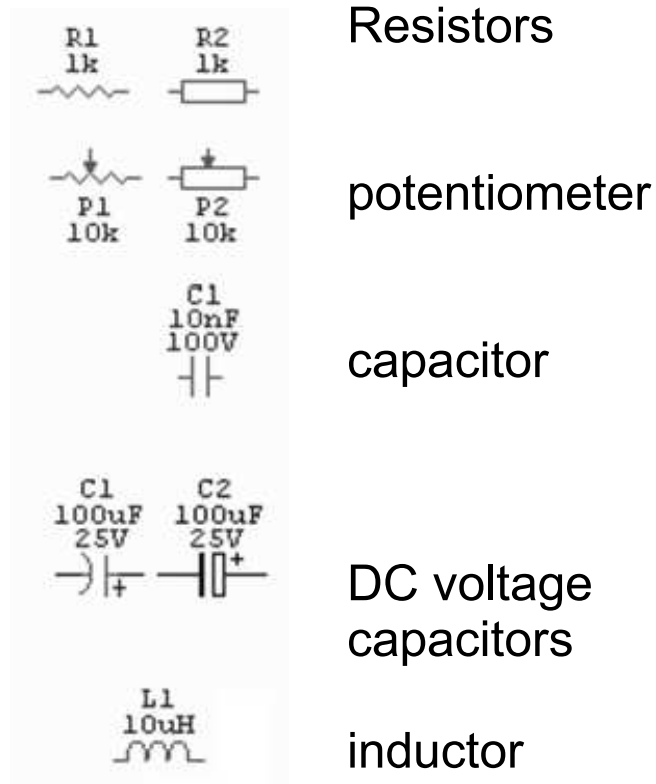
Inductor

- An *Inductor* is a component whose action depends on the magnetic field that exists around any conductor when a current flows through that conductor.

- *Inductance* is proportional to the square of turns n^2, area of cross-section A, *magnetic permeability* μ and reverse proportional to the length of coil L:

$$L = \frac{\mu \cdot n^2 \cdot A}{L}$$

- When the strength of such a magnetic field (or magnetic flux Φ) changes, a voltage E is induced between the ends of the conductor. This voltage is termed *electromotive force*

$$E = -\frac{d\Phi}{dt} = -L\frac{dI}{dt}$$

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Electrical symbols of resistor, capacitor and inductor

R1   R2
1k   1k

Resistors

P1   P2
10k   10k

potentiometer

C1
10nF
100V

capacitor

C1   C2
100uF 100uF
25V   25V

DC voltage
capacitors

L1
10uH

inductor