EIT Circuits Review

Basics

Electric force: $\vec{F} = q\vec{E}$
Coulomb's law: $\vec{E} = \dfrac{q}{4\pi\epsilon_0 r^2}$
Voltage: $V_{ab} = \displaystyle\int_a^b \vec{E}\cdot \mathrm{d}\vec{l} = \vec{E}\cdot\vec{L},\ \text{if const } \vec{E}$

Components

Resistors

Ohm's law: $I = V/R$
voltage change across a resistor: $V = IR$
power dissipated in a resistor: $P = I^2R$
addition in series: $R_{eq} = R_1 + R_2$
addition in parallel: $1/R_{eq} = 1/R_1 + 1/R_2$

Capacitors

Definition of capacitance: $C = Q/V$
voltage change across a capacitor: $V = Q/C$
current through a capacitor: $I = \mathrm{d}Q/\mathrm{d}t$
energy stored in a capacitor: $E = Q^2/2C$
addition in series: $1/C_{eq} = 1/C_1 + 1/C_2$
addition in parallel: $C_{eq} = C_1 + C_2$

Inductors

Definition of (self) inductance: $L = V/(dI/dt)$
voltage change across an inductor: $V = L(dI/dt)$
energy stored in an inductor: $E = LI^2/2$
addition in series: $L_{eq} = L_1 + L_2$
addition in parallel: $1/L_{eq} = 1/L_1 + 1/L_2$

Kirchhoff's rules

Junction rule:

Sum of currents into a junction is equal to sum of the currents out of the junction (conservation of charge).

Loop rule:

Voltage change around a closed loop is zero (conservation of energy).

Hints:

- get as many equations as the unknowns
- use the junction rule first for (N-1) equations (N = number of junctions)
- then use loop rule with smallest possible loops with least overlap until you have enough equations

AC Circuits

with an alternating-current (AC) voltage or current source, operating at a definite frequency

Impedances

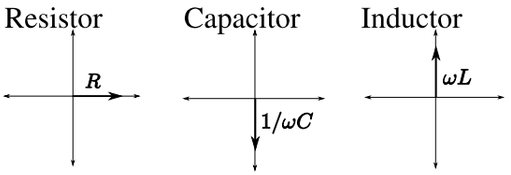
Replacement for Ohm's law in AC circuits:

$$I_{rms} = V_{rms}/|Z|$$

|Z| = absolute value of impedance

Method 1: Phasors

Impedances as vectors:



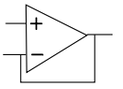
- components in series = vector additions
- |Z| = length of vector sum
- power dissipation: $P_{\mathrm{rms}} = I_{\mathrm{rms}}^2 \mathrm{Re}(Z)$
  only horizontal component dissipates power

Method 2: Complex Impedances

Impedances as complex numbers
Resistor: $Z_R = R$
Capacitor: $Z_C = 1/j\omega C$
Inductor: $Z_L = j\omega L$

- components in series = complex number addition
- |Z| = $\sqrt{Z^* Z}$
- power dissipation: $P_{\mathrm{rms}} = I_{\mathrm{rms}}^2 \mathrm{Re}(Z)$
  only real component dissipates power

Semiconductor Circuits



Op-amps:

- a differential amplifier with a huge gain factor
- almost always used with negative feedback;
- golden rules apply only with negative feedback

Op-amp golden rules:

1. Voltages at the inverting input and the noninverting input are the same.
2. Input draws no current.

Topics not covered here:
magnetic fields, electric and magnetic fields with extended bodies, mutual and self inductance, nonlinear circuit elements (diodes), active circuit elements (transistors)