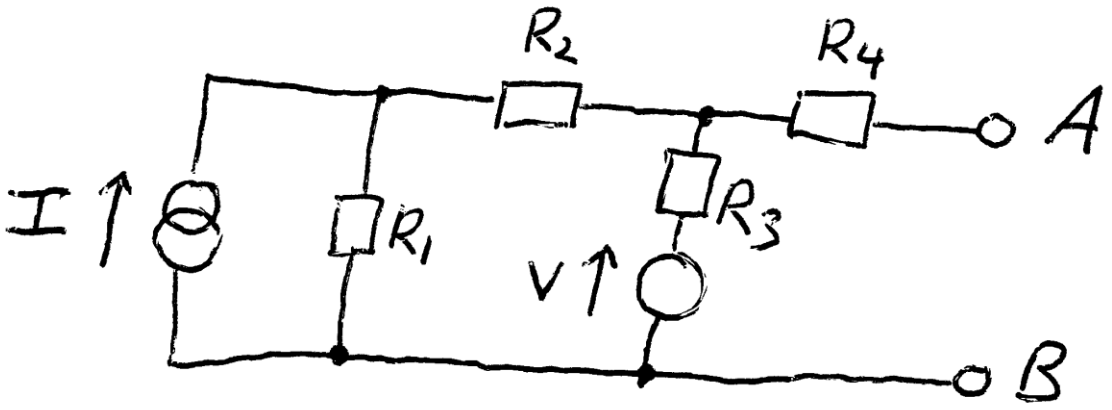
Problem 1



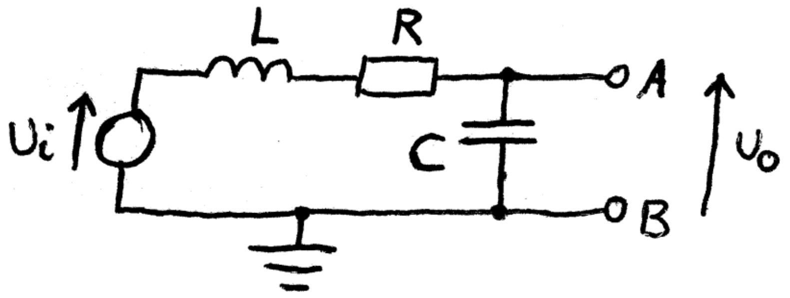
In this problem we are considering the circuit above through terminals A and B.

a) Explain in words if in this circuit the equivalent resistance is going to be larger or smaller than R_4;

b) Derive the Thévenin equivalent resistance R_{Th};

c) <u>Use mesh analysis</u> to derive the Thévenin voltage V_{Th}.

Problem 2



Consider the circuit above. The reactances at some specific frequency are $X_C = 1\ \Omega$, $X_L = 90\ \Omega$ and take for the resistor $R = 45\ \Omega$. The voltage source delivers a current of magnitude $|i_{in}| = 0.1$ A.

a) Draw all voltage phasors to scale, with respect to the input current. Also indicate the input voltage magnitude $|v_i|$ in this diagram;

b) We connect an AC voltmeter across terminals A and B. Our voltmeter has an internal resistance of 100 Ω. Explain in words if the voltmeter will give an accurate reading of the voltage over the element;

Now consider the voltage from terminal A to B, denoted v_o. Work with the general circuit elements, with resistance R, inductance L and capacitance C.

c) Explain in words whether this circuit, across terminals A and B, acts as a low-pass, high-pass, acceptor or rejector filter;

A general expression for transfer functions of LRC circuits in terms of the angular frequency ω is:

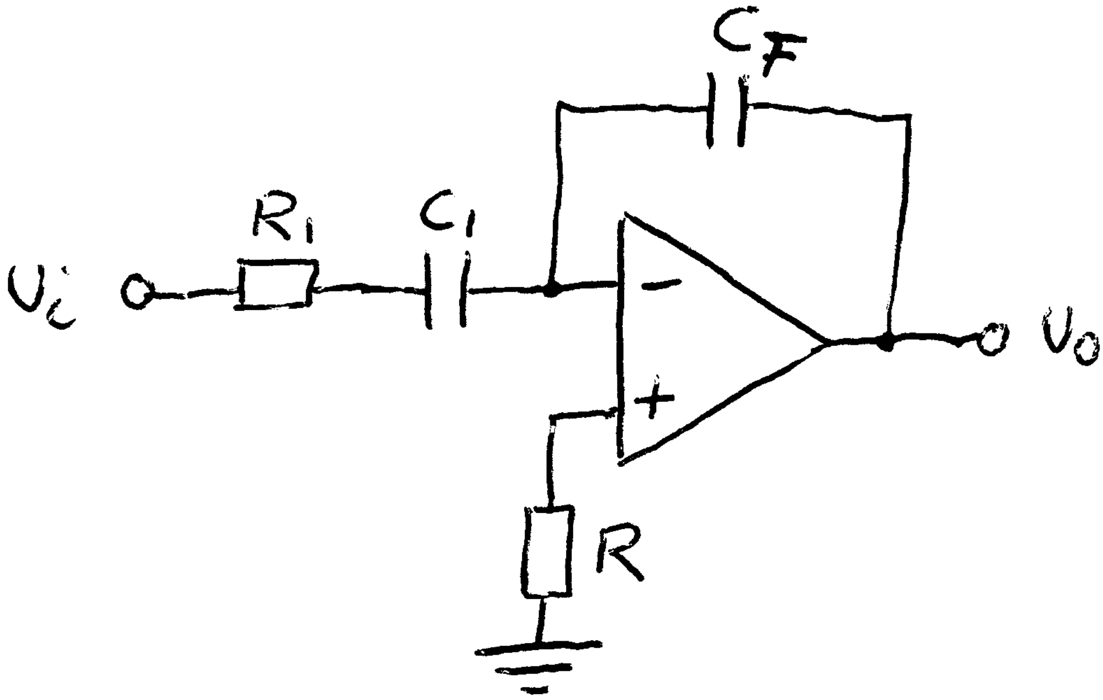
$$\frac{v_o}{v_i} = \frac{1}{1 + D\omega^2 + jE\omega + jF\omega^{-1} + G\omega^{-2}} \qquad \text{(Eq. 2.1)}$$

where D, E, F and G are real (so not complex-valued) constants.

d) In the low frequency limit for this generalized transfer function, what is the relation between the gain and frequency? State your answer in decibels per frequency decade.

e) Derive the transfer function for the circuit at the top and show that it has the form as in equation 2.1. Also give the expression for the constants D, E, F and G in terms of R, L and C. Note that some of the constants D, E, F and G are zero.

Problem 3



Consider the circuit above incorporating an ideal opamp.

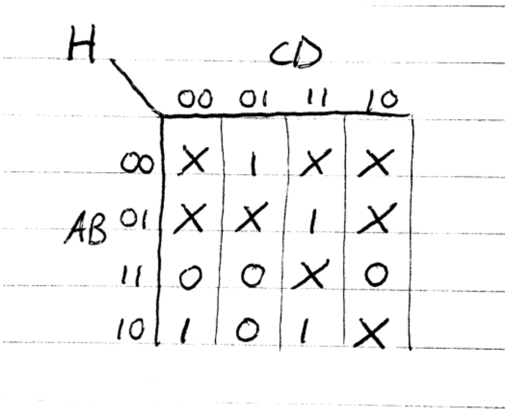
a) Explain in words why we can treat v_+ as connected to earth, that is, we can consider R shorted out;

b) Derive the transfer function v_o/v_i;

c) Argue why for a non-ideal op-amp R could be useful to incorporate.

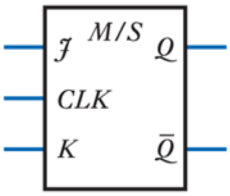
Problem 4

Problem 4.1



a) Find the simplified sum-of-products expression for the Karnaugh map above;

Problem 4.2



b) Design a synchronous counter that goes through the decimal states:
0, 3, 5, 4, 2, 1
As usual, represent the decimal numbers by their binary equivalent, using the ouputs Q_1, Q_2, … of your flip-flops. Use the M/S J-K flip-flops as shown above: no asynchronous inputs. Also draw the final circuit that you designed.