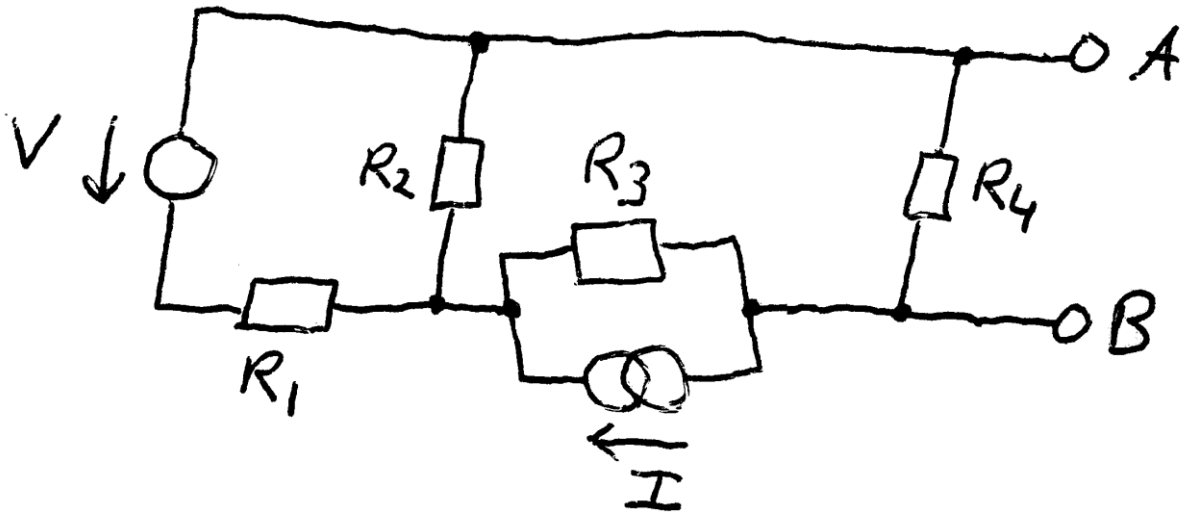


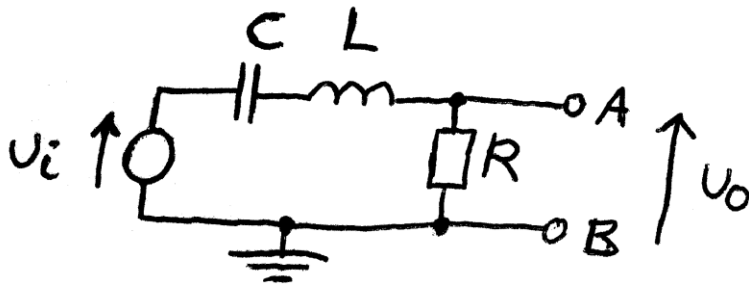
Problem 1



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

- Explain in words if in this circuit the equivalent resistance is going to be larger or smaller than R_4 ;
- Derive the Thévenin equivalent resistance R_{Th} ;
- Use mesh analysis to derive the Thévenin voltage V_{Th} .

Problem 2



Consider the circuit above. The reactances at some specific frequency are $X_C = 1 \text{ k}\Omega$, $X_L = 600 \Omega$ and take for the resistor $R = 100 \Omega$. The voltage source delivers a current of magnitude $|i_{in}| = 0.01 \text{ A}$.

- Draw all voltage phasors to scale, with respect to the input current. Also indicate the input voltage magnitude $|v_i|$ in this diagram;
- We connect an AC voltmeter across terminals A and B. Our voltmeter has an internal resistance of $10 \text{ k}\Omega$. 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 .

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

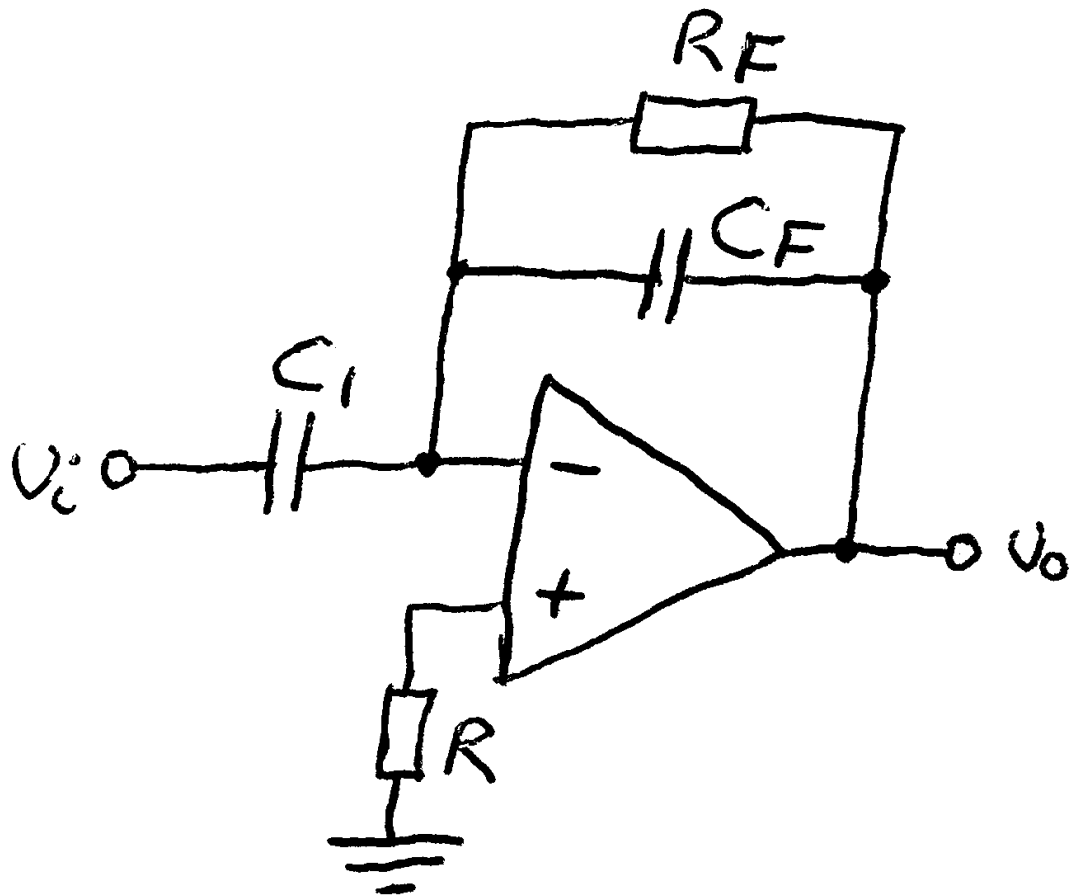
A general expression for transfer functions of LRC circuits in terms of the angular frequency ω is:

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

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

- 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.
- 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.

- Explain in words why we can treat v_+ as connected to earth, that is, we can consider R shorted out;
- Derive the transfer function v_o/v_i ;
- Argue why for a non-ideal op-amp R could be useful to incorporate.

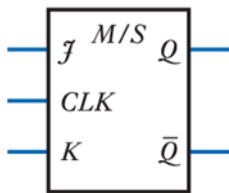
Problem 4

Problem 4.1

		CD			
		00	01	11	10
V	00	X	1	0	X
AB	01	1	X	1	0
	11	0	X	0	X
	10	1	0	0	X

- 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, 1, 4, 3, 5, 2
 As usual, represent the decimal numbers by their binary equivalent, using the outputs Q_1, Q_2, \dots 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.