Introduction to Electrical and Electronic Circuits

LAB. 4

Time and frequency domains

1. Problems

1. How to calculate the damping factor of vibration and pulsation in second-order circuits?
2. WHAT are possible responses in second-order circuits stimulated by a unit jump? What is the circuit impedance in each of these cases ? What are the distinguishing features of the characteristic equation?
3. How is defined the impedance of the capacitor and the coil in the frequency domain? Do these parameters depends on frequency? If so, how ?
4. For what frequency of the sinusoidal signal the impedance of the serial RLC circuit will not have an imaginary part (will be equal to 0)?
5. Write the impedance in the form of operators and transform it into frequency domain for a series RLC circuit.

2. Programme

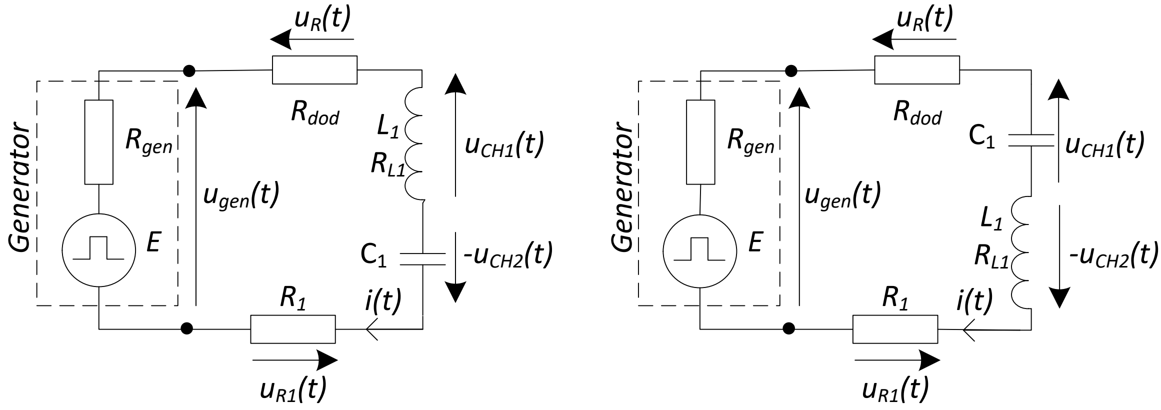
Assemble the series RLC circuit due to the values as in the Table below:

Section 1	**Section 2**	**Section 3**	**Section 4**	**Section 5**	**Section 6**
L_1=133 mH (R_{L1} = 212 Ω) C_1=C_{dod}=400 nF	L_1=130 mH (R_{L1} = 211 Ω) C_1=C_{dod}=400 nF	L_1=34 mH (R_{L1} = 93 Ω) C_1=C_{dod}=450 nF	L_1=L_{dod}=70 mH (R_{L1} = 280 Ω) C_1=150 nF	L_1=L_{dod}=75 mH (R_{L1} = 319 Ω) C_1=157 nF	L_1=L_{dod}=80 mH (R_{L1} = 320 Ω) C_1=149 nF

Section 7	**Section 8**	**Section 9**	**Section 10**	**Section 11**	**Section 12**
L_1=L_{dod}=70 mH (R_{L1} = 280 Ω) C_1=146 nF	L_1=L_{dod}=75 mH (R_{L1} = 319 Ω) C_1=151 nF	L_1=L_{dod}=80 mH (R_{L1} = 320 Ω) C_1=147 nF	L_1=39 mH (R_{L1} = 108 Ω) C_1=C_{dod}=450 nF	L_1=34 mH (R_{L1} = 93 Ω) C_1=C_{dod}=400 nF	L_1=130 mH (R_{L1} = 211 Ω) C_1=C_{dod}=450 nF

Part 1

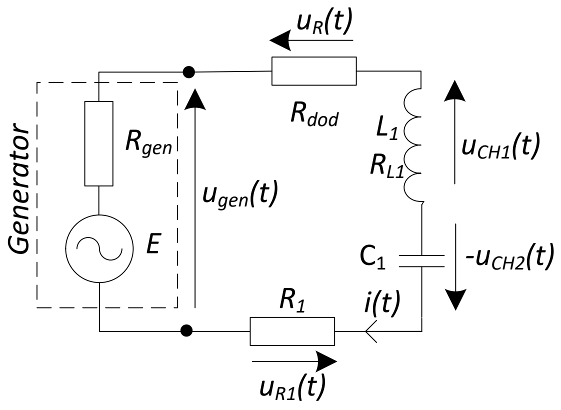
1. Assemble the circuit as in the figure below. Values of each parameters are for a section in accordance with Table above. Additional elements "R_{dod}" will be connected from the outside in the form of decade element.

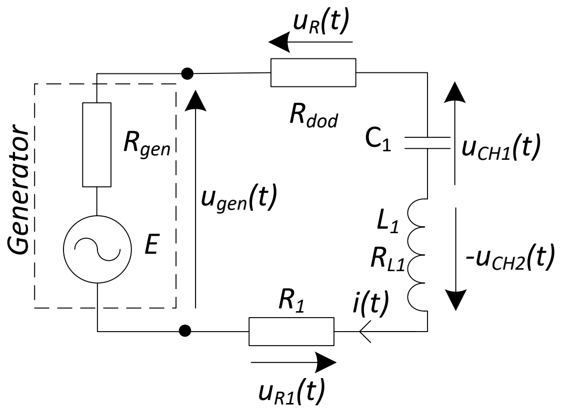


2. Connect the input (**rectangular** signal) to the input of the circuit (internal resistance of the generator R_{gen} = 50 Ω). Determine the frequency of the rectangular wave so that at $R_{add} = 0$ was the steady state of the signal. Channels 1 ($U_L(t)$ = CH1) and 2 ($U_C(t)$ = CH2) connect the oscilloscope to the inertial elements . Remember the common mass of channels (between elements L and C) and the use of inversion on channel 2! Redraw both responses to the protocol.
3. Try to increase the resistance value of the R_{dod} to the minimum value for which oscillations will disappear. Note the value of this resistance and redraw waveforms visible on both channels.
4. For the R_{dod} resistance, 50% larger than the one found in the previous point, redraw the waveforms from both channels of the oscilloscope.
5. Disconnect the channel 2, and modify the first channel to measure the current waveform i(t) (the voltage $U_{R1}(t)$ at R_1). Set the value of $R_{dod} = 0$. Measure the circuit oscillation period.
   Tip: extend the time base so that about 1 response period is visible on the screen. In addition, note the peak values of the first two oscillations and the steady state.
6. Note the current waveforms i(t) for the resistance R_{dod} set at 3 and 4.

Part 2

1. Change the input signal: sinusoidal signal , internal resistance of the generator R_{gen} = 50 Ω). Set the generator frequency to approx. 1 kHz.





2. Channels 1 [$u_C(t)$ = CH1] and 2 [$u_L(t)$ = CH2] connect to the C_1 and L_1. Remember of the common mass of channels (between elements L and C) and the use of inversion on channel 2! Measure the relationship between waveforms on both channels, i.e. what is the shift (or delay) time of CH1 to CH2.
3. Connect the CH1 to $u_C(t)$ and CH2 to $u_{R1}(t)$ (inversion on channel 2) - the mass of both channels between elements. Measure the relationship between waveforms on both channels, i.e. what is the shift (or delay) time of CH1 to CH2.
4. Connect the CH1 to $u_R(t)$ and CH2 to $u_L(t)$ (inversion on channel 2) - mass of both channels between elements. Measure the relationship between waveforms on both channels, i.e. what is the shift (or delay) time of CH1 to CH2.
5. Using a voltmeter, measure an effective voltage value on L, C, R_{dod}=50Ω and generator (NOTE resistor R_1 should be short with an additional wire). Perform measurements for five frequency values according to the table below.

***f* [Hz]**	**Section 1**	**Section 2**	**Section 3**	**Section 4**	**Section 5**	**Section 6**
f_1	400	400	700	500	500	500
f_2	700	700	1300	1500	1500	1500
f_3	1100	1100	2500	4500	4500	4500

***f* [Hz]**	**Section 7**	**Section 8**	**Section 9**	**Section 10**	**Section 11**	**Section 12**
f_1	500	500	500	700	700	400
f_2	1500	1500	1500	1300	1300	700
f_3	4500	4500	4500	2500	2500	1100

3. Report

Part 1

1. Draw voltage waveforms on all three elements in the RLC circuit (one below the other). Do the voltage values sum up (in shape) to *E* ? Note that the voltage waveform at R_{gen} will have the same shape as the voltage at R_{dod}. Justify the answer.
2. Calculate the fading oscillation frequency on the basis of laboratory measurement, and compare to the calculation results. Calculate the relative and absolute error of the measurement . Comment on the differences.
3. Calculate the value of critical resistance R_{crit} for your circuit and compare with the value set in the lab. Calculate the relative and absolute error of the measurement . Comment on the differences.
4. Make the simulation (eg. In the *PSpice)* of the second- order circuit for three values of R_{dod}= {0; R_{crit}; 1, 5R_{crit} } Put the draw in the report.

Part 2

1. Determine the phase shifts (calculate the delay into stages knowing what the period of the sinus signal is) between the voltage on the capacitor C_1 and the resistor R_1. Do the same for voltage on R_{dod} and L_1 and elements L_1 and C_1. Why in some cases, the shift does not agree with the theoretical values? Tip: coil resistance.
2. List the effective values of the measured voltages in the table . Why is the sum of the effective values of voltages in the current eyelet not equal to 0 ?
3. Perform the appropriate simulation (eg. In the *PSpice)* to obtain effective values of voltages and phase shifts of these voltages to the set frequency f_1, f_2, f_3.
4. Draw voltage vectors (vector diagram) in all cases, ie. f_1, f_2, f_3. Is the vector sum of the voltages equal 0 ?
5. For what frequency the capacitor impedance is greater than the coil impedance? What will be the voltage on the elements when the frequency will be equal to 0 (const. signal), and what if the frequency will be very high?