# Introduction to Electrical and Electronic Circuits
# LAB. 3
## Transient in circuits with non-zero initial conditions

## Problems

1. What are equivalent circuits in s-domain for an inductor and a capacitor with non-zero initial conditions?
2. What are equivalent circuits for an inductor and a capacitor with non-zero initial conditions for t=0?
3. Sketch waveforms of a voltage across the inductor $u_L(t)$ in the circuit shown in Fig. 1 for closing and then for opening the switch. Assume the switch opens not sooner than steady-state is reached. Draw the appropriate waveforms for three inductor models:
   - a full model involving both residual resistance of the inductor as well as its shunt capacitance (please note the shunt capacitance is very small)
   - a simplified model neglecting shunt capacitance i.e. assuming the inductor is represented by its inductance and internal resistance only
   - a fully simplified model neglecting both shunt capacitance and internal resistance i.e. assuming the inductor is represented by its inductance only

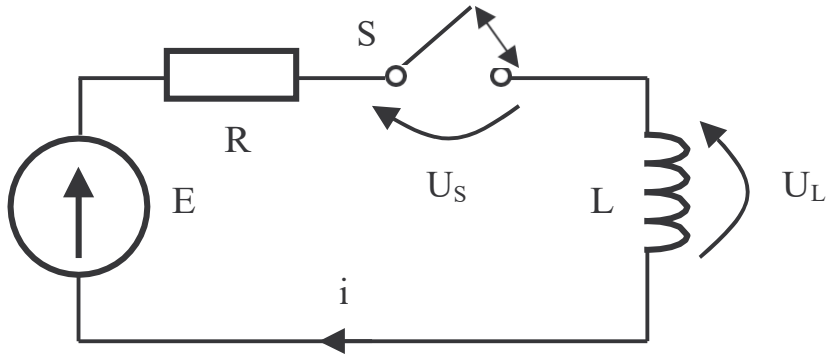


Fig.1.

4. Repeat the above for a voltage across the switch $u_s(t)$ and a circuit current i(t).
5. Explain the overvoltage occuring at opening the switch. How can it be decreased?

## Programme

1. Assemble a circuit shown in Fig. 2. Set generator mode to pulse and its frequency to 40 Hz app. Increase generator amplitude until you can clearly hear the contactron works.
2. Observe voltage across the inductor $u_L(t)$, voltage across the switch $u_s(t)$ and a circuit current i(t) for opening and closing the switch. For the voltage across the inductor $u_L(t)$ measure its maximum value and frequency.
   Caution: Because of the fact that both channels of the oscilloscope have the common ground, voltage across the coil can be observed only in one-channel (the second channel must not be connected !). The current i(t) and the voltage $u_s(t)$ across the switch can be observed simultaneously in two-channel mode of the oscilloscope, but you have to remember that zero (ground) node (of both channels) should be connected to the point

between the switch and the resistance $R_p$ and the second channel (that is connected to this resistance) should work in the inversion mode (otherwise we will observe –i(t)).

3. Connect to the circuit the elements that reduce the overvoltage occuring at opening the switch.
   - a capacitor in parallel with the inductor
   - a capacitor in parallel with the switch
   - a diode in parallel with the inductor.

   In each case note influence of the connected element on the voltage across the inductor $u_L(t)$ and measure its maximum value. Change the time base in order to expand period of oscillations after opening the switch phase Note the period for all combinations.
4. To reduce the current through the switch we have to connect the resistance in series with the capacitor. Select the right value of this resistance in order to limit the maximum value of the current to 30 mA.

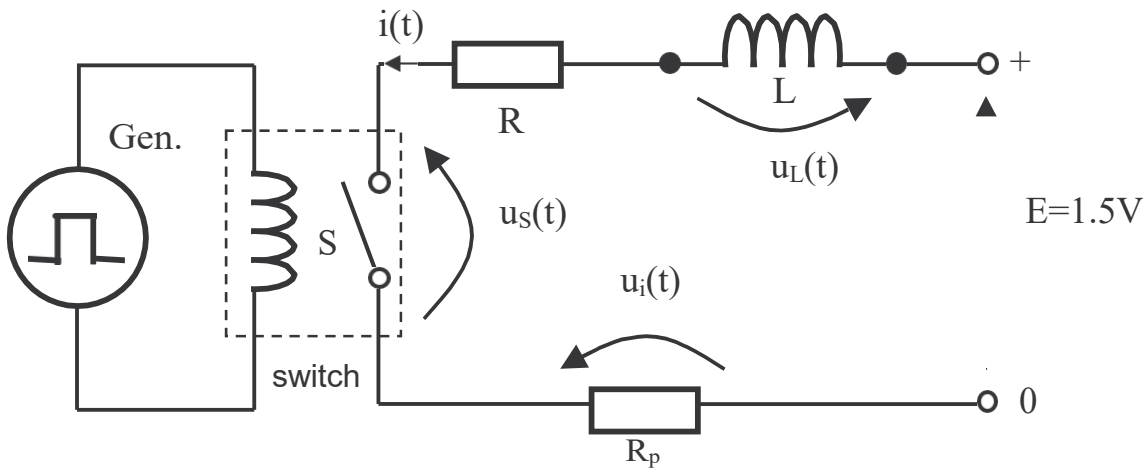


Fig.2.

## Report

1. Draw a diagram of the circuit assembled.
2. Draw the observed waveforms of $u_L(t)$, $u_s(t)$ and i(t). Explain these waveforms. Hint: For a particular combination draw closing and then opening waveform of $u_L(t)$, below $u_s(t)$, then below i(t). Remember, the voltage Kirchhoff's law must hold true.
3. For the voltage across the inductor $u_L(t)$ note its overvoltage ratio (i.e. ratio of the maximum value to the supply voltage) for all assembled circuits
4. Describe briefly what changes in $u_L(t)$ if a capacitor or a diode is connected. How many times is the overvoltage ratio reduced?
5. Draw the waveforms of the current through the switch (from the point 4 and 5).
6. Calculate shunt capacitance of the coil, assume that L = 120 mH.