EXPERIMENT 7
Recitation, MATLAB, and Simulink: First-order Transient Circuits

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Objectives of this experiment are to

- Learn to run transient analyses in MultiSim
- Learn the basics of plotting in MATLAB
- Practice calculating solutions to first-order transient circuits

I. Introduction: Transients in MultiSim

In transient analyses, we determine voltages and currents as functions of time. Typically, the time dependence is demonstrated by plotting the waveforms using time as the independent variable. MultiSim can perform this kind of analysis, called a Transient Analysis, in which all voltages and currents are determined over a specified time duration. As an introduction to transient analysis, let us simulate the circuit in Figure 1 and plot the voltage $v_c(t)$.

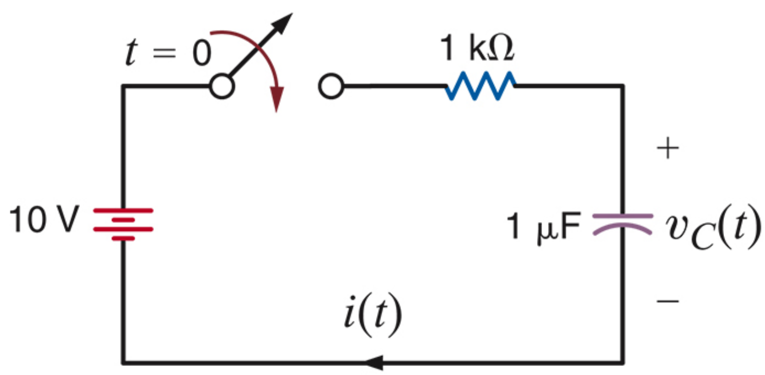

Figure 1: Example Circuit

Inductor and capacitor parts can be found in MultiSim under the Group "Basic". The time-controlled switch, called TD_SW1, is under "SWITCH" in the Group "Basic" (see Figure 2).

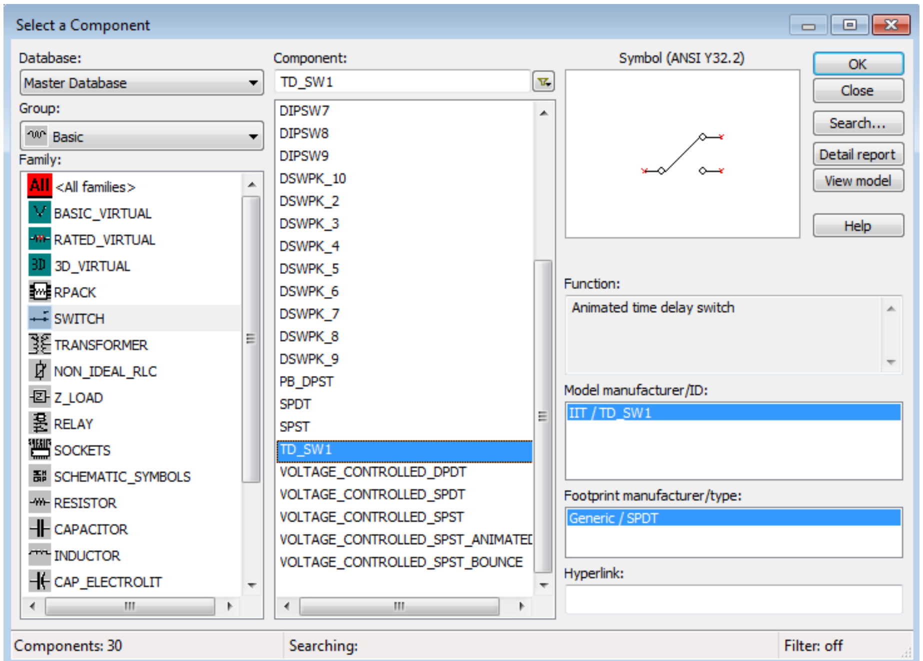

Figure 2: Switch in MultiSim

This switch (Figure 3) has both a connection for both its off-setting (the top connection) and its on-setting (the bottom connection). The two times underneath the part refer to the switching-on time and the switching-off time respectively.

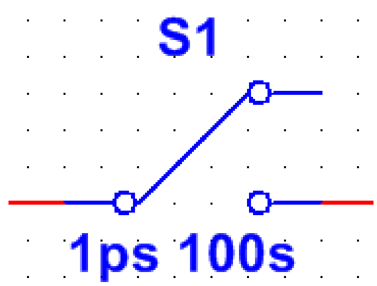

Figure 3: MultiSim part TD_SW1

After placing the switch, you may double click on it to modify some of its attributes (Figure 4). For our purposes, we want the switch to turn on at effectively t=0 and stay on throughout the duration of our simulation, so let us set “Time on (TON)” to 1ps and “Time off (TOFF)” to 100s. We also want the switch to be ideal; i.e., we want the switch to have no resistance when on and to have infinite resistance when off. For some versions of MultiSim, this is default, and there are no additional TD_SWI attributes. For other versions of MultiSim, this part includes the “On resistance (Ron)” and “Off resistance (Roff)” attributes. If you have these settings, adjust the former to something very small, like 10 pΩ, and the later to something very large, like 1 TΩ.

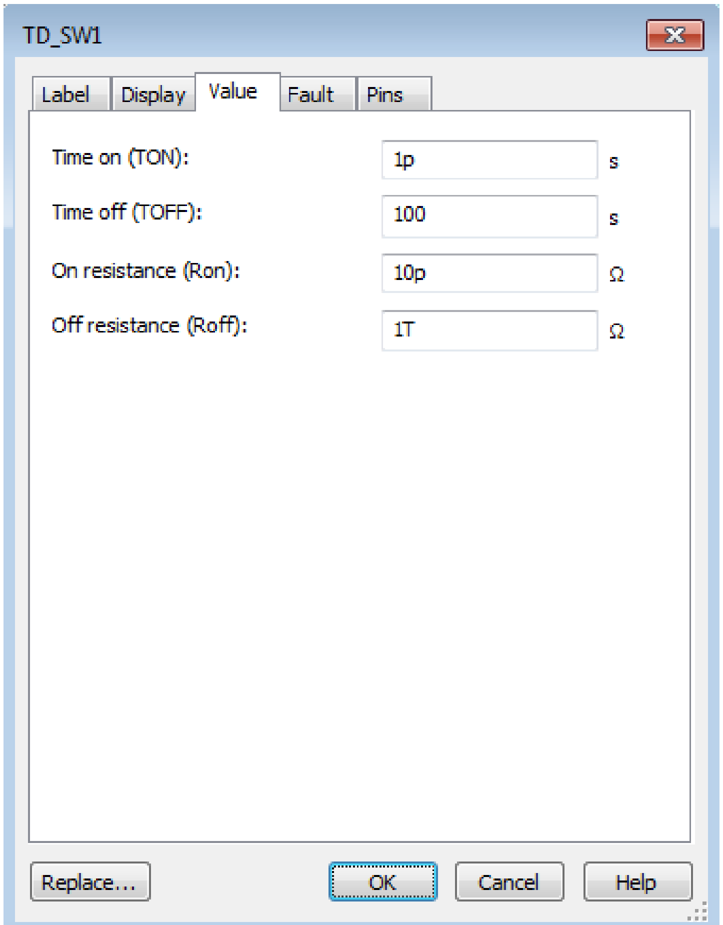

Figure 4: Switch Attributes in MultiSim

After placing and wiring the switch along with the other parts, the MultiSim schematic should look something like the circuit in Figure 5.

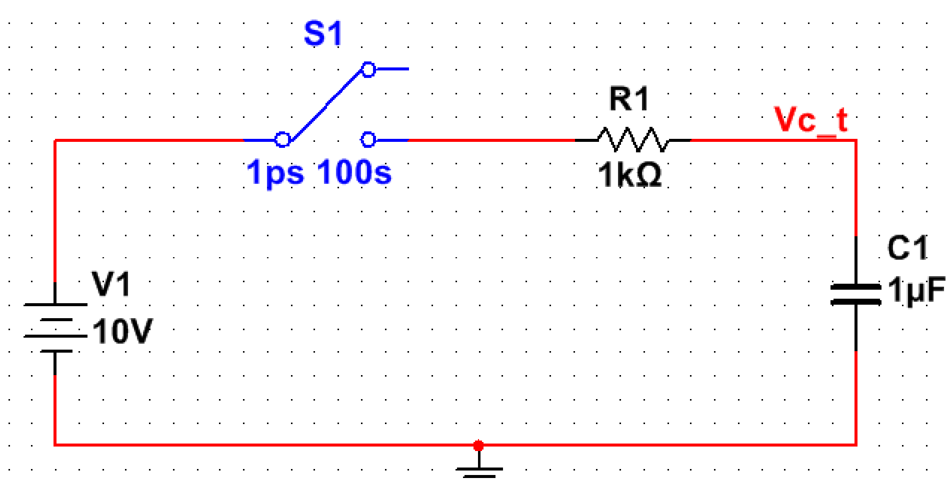

Figure 5: MultiSim Schematic

Know that, if desired, one may double-click a capacitor or inductor and set its initial condition. By default, MultiSim's "Transient" analysis will determine the initial condition for the circuit it is connected to, which is what we want for this lab. Only manually insert an initial condition for a capacitor or inductor if your specific application requires it.

The appropriate analysis can be chosen in MultiSim's dropdown menus by selecting "Simulate" → "Analyses and simulation" (Figure 6). Then select "Transient" and the window in Figure 7 will show. You may want to take time to browse the various settings that are available, but the parameters "Start time (TSTART)" and "End Time (TSTOP)" are especially important to take note of. These always have to be set and adjusted depending upon your specific application. For our purposes (the simulation of first-order transients), we will be plotting a value for t>0, so we will set TSTART=0s. TSTOP will vary from circuit to circuit. Since the example circuit's time constant (Tau) is 1ms (1kΩ*1μF), a stop time of around 6ms (6*Tau) would be appropriate. Choosing the voltage across the capacitor (Vc_t) as the output and running the simulation will generate the plot in Figure 8.

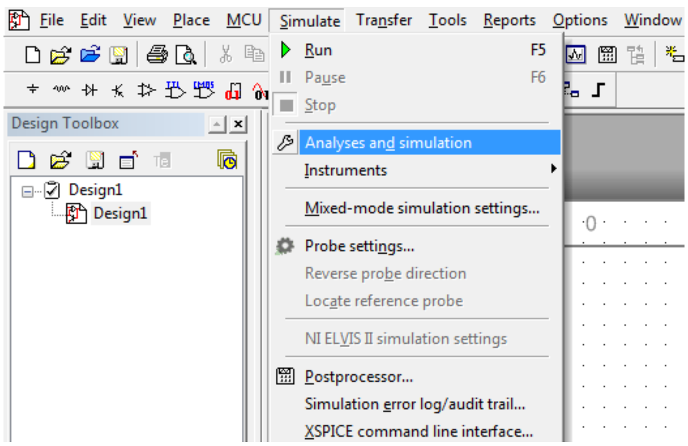

Figure 6: Simulation & Analyses Selection

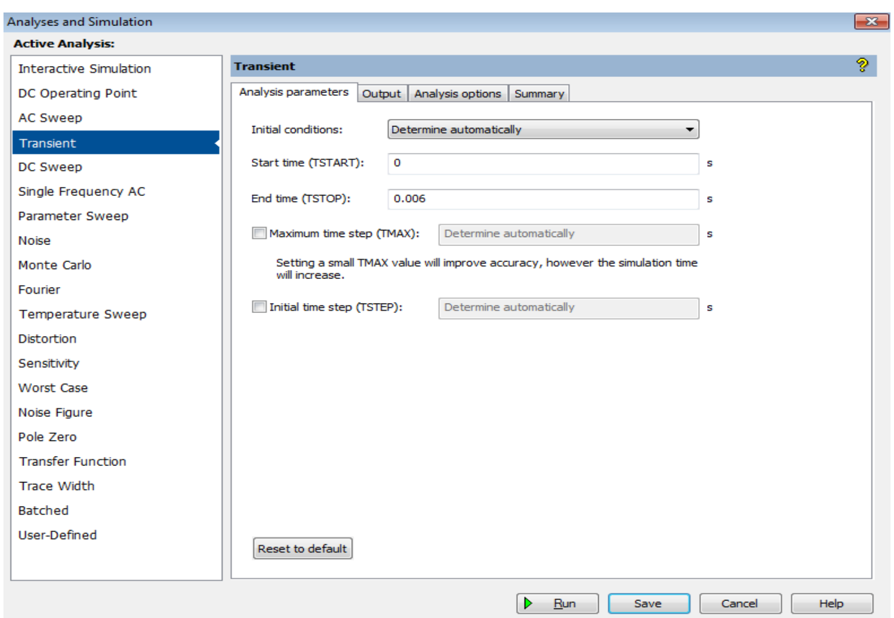

Figure 7: Transient Analysis Window

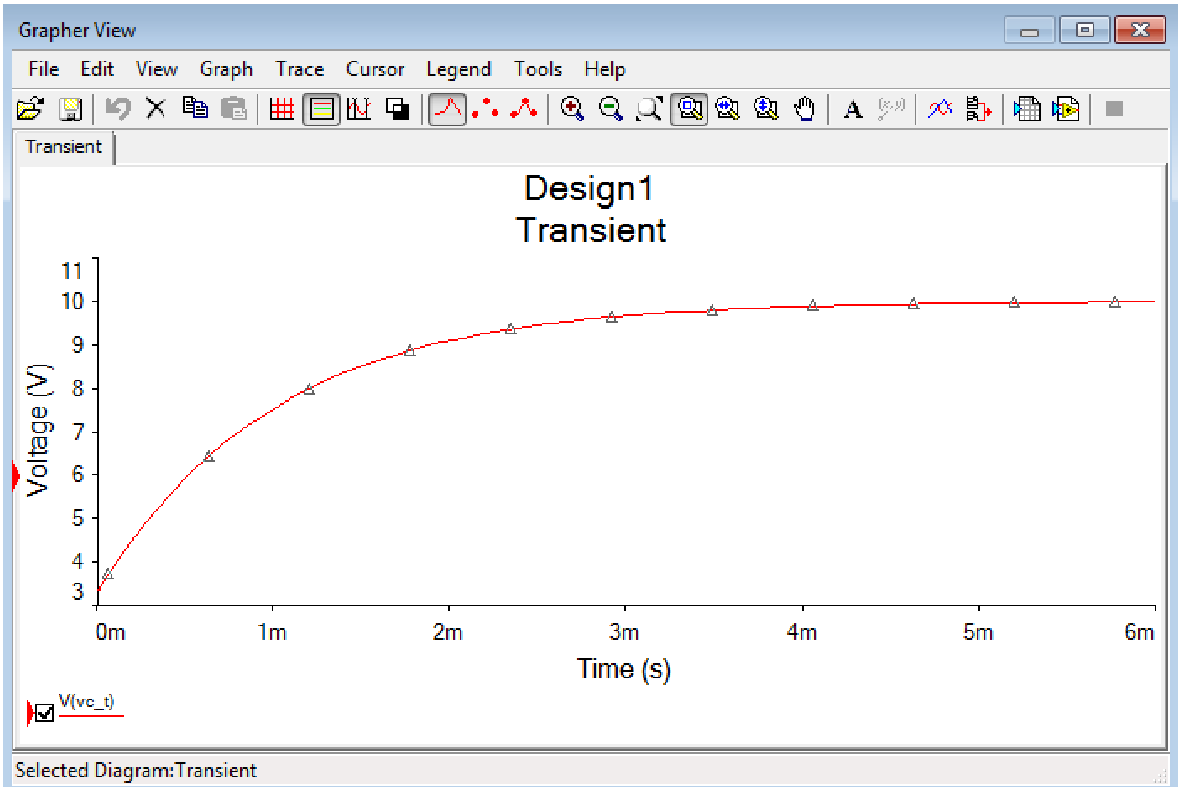

Figure 8: $V_C(t)$ plotted for Circuit in Figure 1

Don't panic if your schematic now displays the switch in a different position than before you ran the simulation. Because we set the switch to open again at 100s, but the simulation only ran for 6ms, it never actually reopened—the schematic shows that is the case. If you run the same simulation again, MultiSim knows to open-up the switch before resimulating.

II. Introduction: Plotting in MATLAB

The need to create a plot or graph of something is common amongst engineers. Often a mathematical equation is not feasible to describe some set of data, so another option for analyzing the data is in graphical form. Additionally, even if an equation is available, a plot can give an engineer a different way to look at the same phenomena, providing additional insight.

Let us use MATLAB to plot the solution to the first-order transient circuit shown in Figure 1. For t>0, $v_c(t)$ = 10 - 10e^(-1000t) V. An m-file that could plot this function is given in Figure 9. Figure 10 shows the resulting plot.

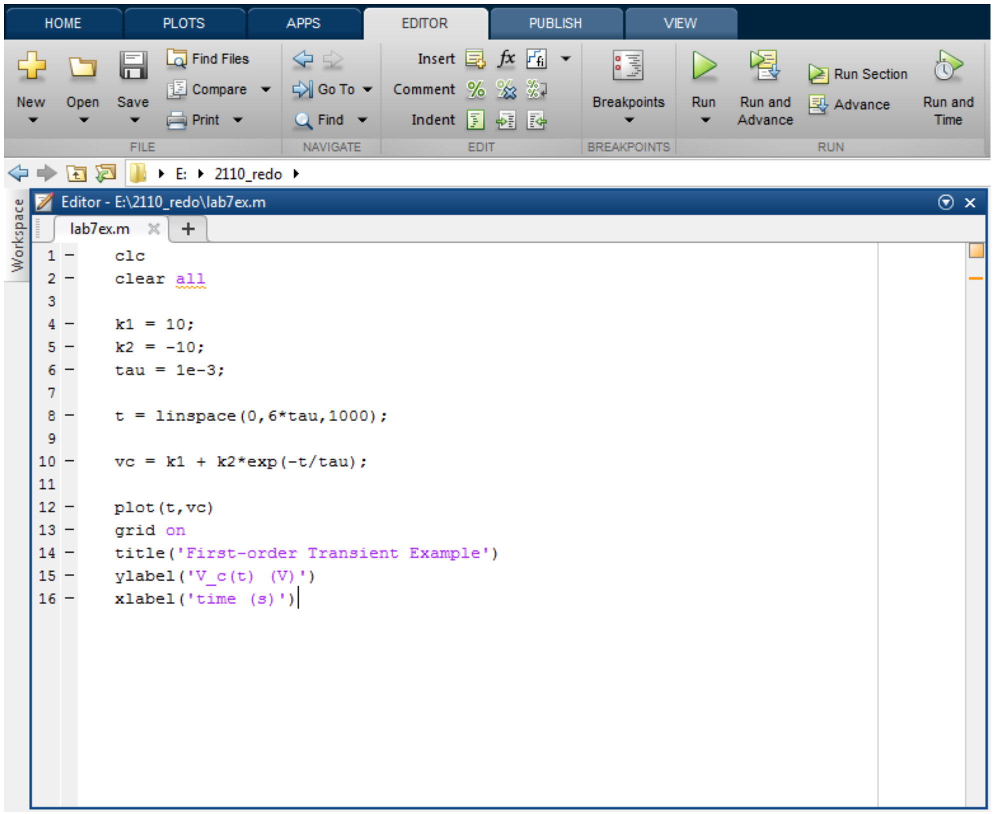

Figure 9: MATLAB m-file

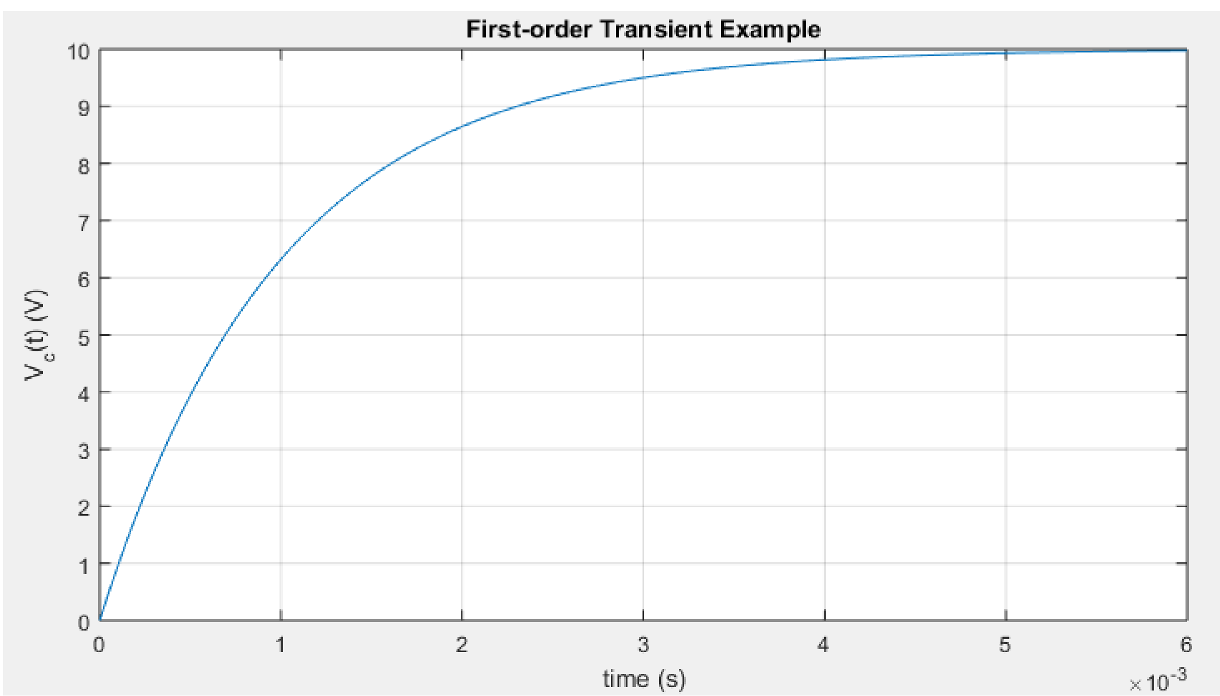

Figure 10: VC(t) plot - MATLAB

Be sure to type “help linspace” and “help plot” into MATLAB’s command window before moving on. MATLAB’s help provides clear explanations as to how to use these commands and what other options are available.

III. Exercises

Your report must include **ALL** circuit diagrams, with all variables clearly labeled, and **ALL** calculations must be clearly shown. In addition, you will need to include in your lab report screenshots of simulation schematics, simulation results, MATLAB code, and MATLAB results. Make sure individual parts of an exercise are not separated from the other parts of that same exercise.

1) The switch in Figure 11 has been opened for a long time and is closed at t = 0. Calculate $i_0(t)$ for t > 0. Plot $i_0(t)$ versus time using MATLAB and include the plot in your report. Now simulate this circuit using MultiSim and plot $i_0(t)$ versus time. Include this plot in your report as well.

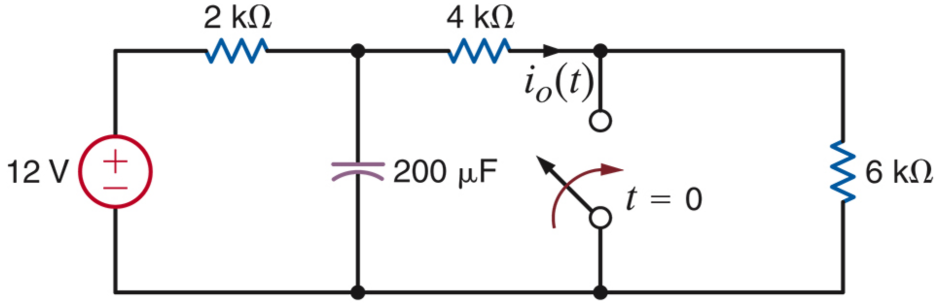

Figure 11: Circuit for Exercise 1

2) The switch in Figure 12 has been closed for a long time and is opened at t = 0. Calculate $i_0(t)$ for t > 0. Plot $i_0(t)$ versus time using MATLAB and include the plot in your report. Now simulate this circuit using MultiSim and plot $i_0(t)$ versus time. Include this plot in your report as well.

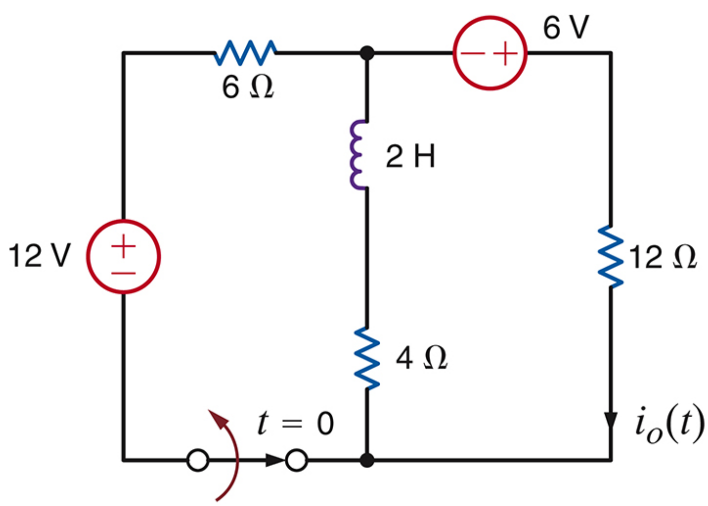

Figure 12: Circuit for Exercise 2

3) The switch in Figure 13 has been closed for a long time and is opened at t = 0. Calculate $v_0(t)$ for $t > 0$. Plot $v_0(t)$ versus time using MATLAB and include the plot in your report. Now simulate this circuit using MultiSim and plot $v_0(t)$ versus time. Include this plot in your report as well.

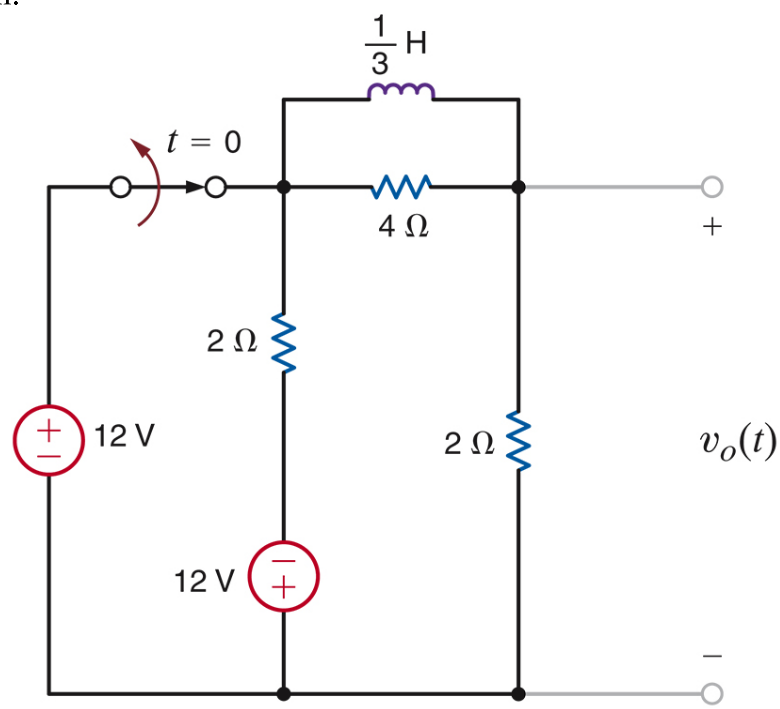

Figure 13: Circuit for Exercise 3

4) The switch in Figure 14 has been opened for a long time and is closed at t = 0. Calculate $v_C(t)$ for $t > 0$. Plot $v_C(t)$ versus time using MATLAB and include the plot in your report. Now simulate this circuit using MultiSim and plot $v_C(t)$ versus time. Include this plot in your report as well.

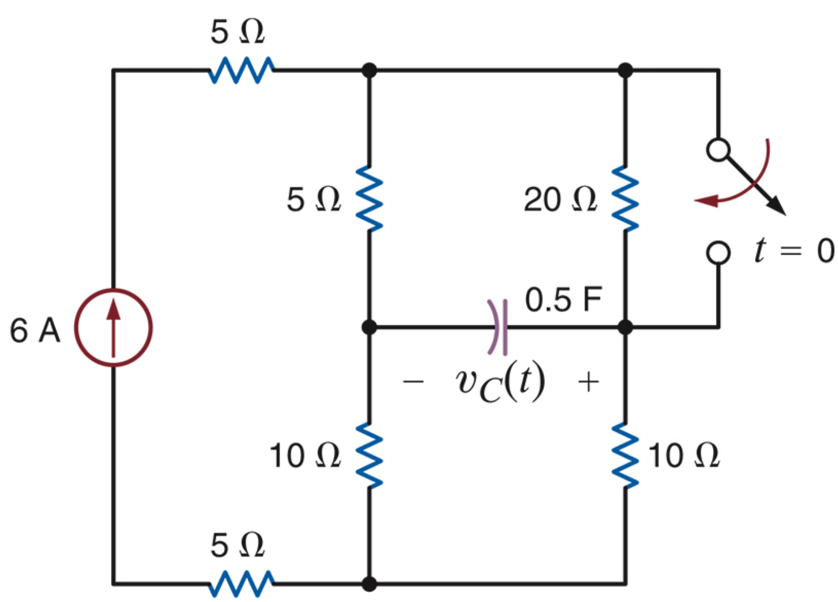

Figure 14: Circuit for Exercise 4