P-SET 03 EXERCISE 1: Circuit Analysis of Source-Driven Circuits

The questions below are due by 5:00 pm on Monday 9th November 2019

Consider the RC circuit below

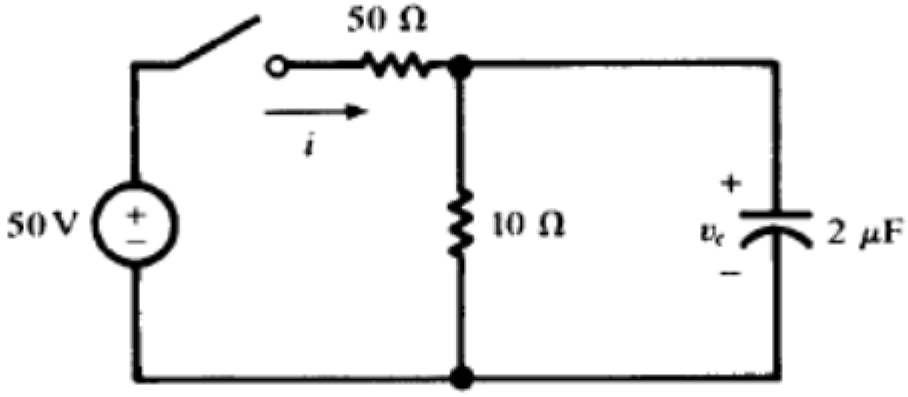

Figure 1: Source-Driven RC Circuit

a) We want to determine the relevant pre-switching and post-switch diagram necessary to obtain the output voltage $v_c(t)$ across the 2 μF capacitor for all times.

i. Prior to $t = 0$, the switch in the network shown above is open, and the network reaches equilibrium. Determine the equilibrium capacitor voltage v_c at $t = 0^-$. Draw and label the pre-switching diagram.

ii. The switch closes at $t = 0$. Determine the capacitor voltage v_c at $t = 0^+$, just after it closes. After the switch closes, as $t \to \infty$, the network again reaches equilibrium. Draw and label the post-switching diagram.

b) The output voltage $v_c(t)$ is the sum of the natural response and forced response.

i. Use the post-switching diagram to derive the homogenous/natural response of $v_c(t)$.

ii. Use the post-switching diagram to derive the particular solution/forced response of $v_c(t)$.

iii. Derive the complete expression for $v_c(t)$ for $t \geq 0^+$. Sketch and label $v_c(t)$ for $t \geq 0^+$. Using the sketch, estimate the time-constant of the circuit and the steady-state value $v_c(\infty)$.

c) Here, we verify the above results using computer-aided circuit simulation and analysis

i. Connect the circuit diagram, as shown in Figure 1, in LTspice schematic editor.

ii. Obtain the steady-state value $v_c(\infty)$ from LTspice , and compare with that obtained in b) iii

iii. Obtain the transient response plot of from LTspice, and compare it with that of b) iii

iv. Evaluate the steady-state current through the 10Ω resistor. If the 10Ω is replaced with a 5Ω resistor, how would it affect the transient response and steady-state value of the current? Justify your answer with the aid of response plots obtained from LTspice.