Indian Institute of Technology Bombay

Dept of Electrical Engineering

Handout 7 **EE 101 Electrical & Electronic Circuits**

Tutorial 5 Aug 19, 2011

Question 1) Which of the following series RLC circuits are (i) under-damped, (ii) critically damped and (iii) over-damped? The capacitors and inductors were de-energized at $t < 0$. If a step voltage of $2V$ ($v = 0$ for $t < 0$ and $v = 2V$ for $t \geq 0$) is applied to the circuits, determine the current in each case.

1. $R = 4\Omega, L = 2H, C = \frac{1}{2}F$ – **critically damped**
2. $R = 2\Omega, L = 1H, C = \frac{1}{2}F$ – **under damped**
3. $R = 5\Omega, L = 3H, C = \frac{1}{3}F$ – **under damped**

Question 2) The initial conditions are zero for the circuit in Figure 2. A step voltage of V_{in} Volts is applied at time $t = 7s$. This means that the applied voltage is zero before time $7s$ and the level changes to V_{in} there after. You are required to find the voltage $v_c(t)$ across the capacitor.

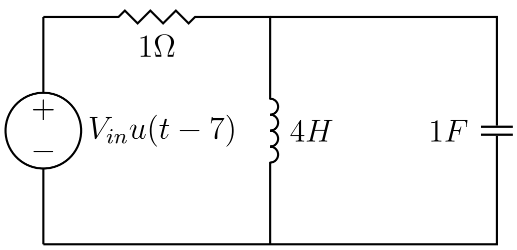

Figure 2

Hint: This can be solved faster, if you know the current solution of the series RLC circuit. In particular, this circuit is in some sense a dual of the RLC circuit we extensively discussed in class.

<u>Solution</u>

$$v_c(t) = V_{in}.(t-7)e^{-\frac{t-7}{2}}u(t-7)\,Volts$$

Question 3) The switch in Figure 3 is closed at time $t = 0$.

1. What is the voltage across the capacitor at $t = 0$? **ans:** $80\,Volts$.
2. What are the values of $i_1(t)$ and $i_2(t)$.

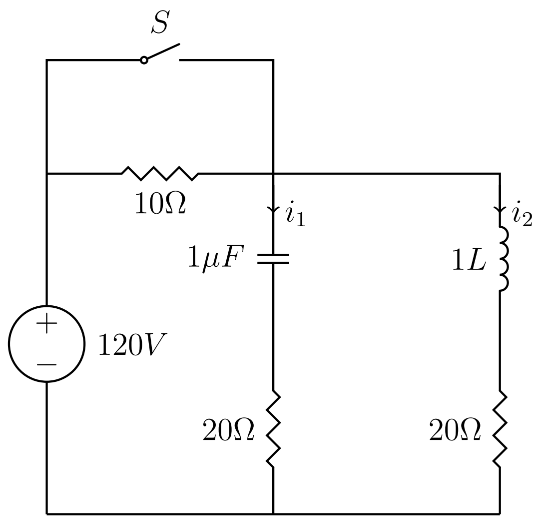

Figure 3.

Solution

$$i_1(t) = 2e^{-5\times 10^4 t}u(t)\ Amps \tag{1}$$
$$i_2(t) = (6 - 2e^{-20t})u(t)\ Amps \tag{2}$$

Question 4) The switch in Figure 4 is at position a for a long time. At $t = 5:00pm$ today, the switch was moved to position b. Find the voltage $v_c(t)$ across the capacitor for all time.

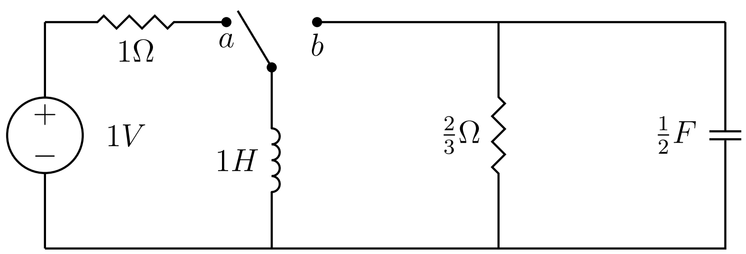

Figure 4

Solution

$$v_c(t) = (2e^{-2(t-t_0)} - e^{-(t-t_0)})u(t - t_0) \tag{3}$$

where t_0 is the time when switch was moved.

Question 5) Find $v_1(t)$ and $v_2(t)$ if the voltage is $6(1 - u(t))$. (This is to compensate for Problem 5 of Tutorial 4, where a switch was present, which renders the circuit currents to zero after time zero. So you can ignore Problem 5 from Tutorial 4).

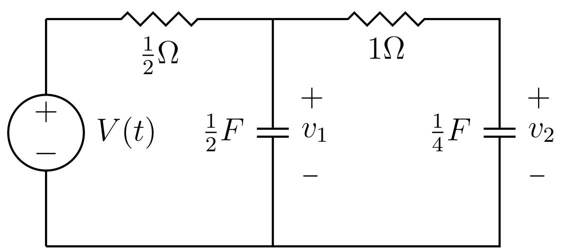

Figure 5

Solution

$$v_1(t) = \begin{cases} 6V, \text{ if } t < 0 \\ 8e^{-2t} - 2e^{-8t}V \text{ otherwise} \end{cases} \quad (4)$$

$$v_1(t) = \begin{cases} 6V, \text{ if } t < 0 \\ 4e^{-2t} + 2e^{-8t}V \text{ otherwise} \end{cases} \quad (5)$$

Question 6) Find $v(t)$ and $i(t)$ if the input $V(t) = 12(1 - u(t))$.

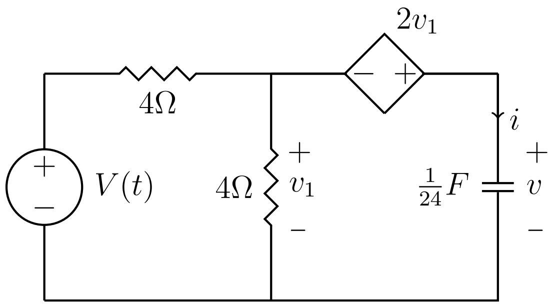

Figure 6

Solution

$$v(t) = 18e^{-4t}V,\ t > 0$$

$$i(t) = -3e^{-4t}A,\ t > 0$$

Question 7) If $K_1 = -3$, find the voltage across the capacitor $v_c(t)$.

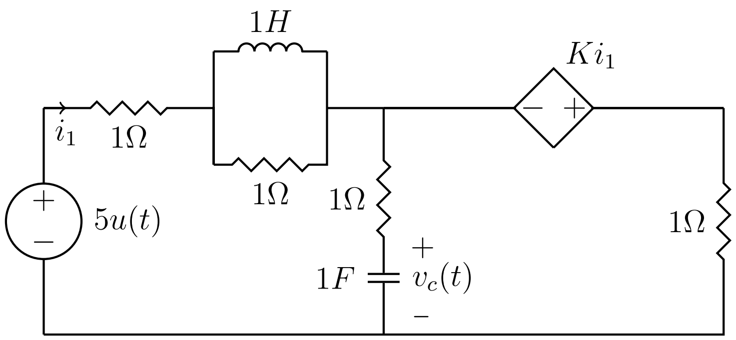

Figure 7

Solution

$$v_c(t) = 4 - e^{-\frac{3}{4}t}(2\sin\frac{t}{4} + 4\cos\frac{t}{4})u(t)Volts$$