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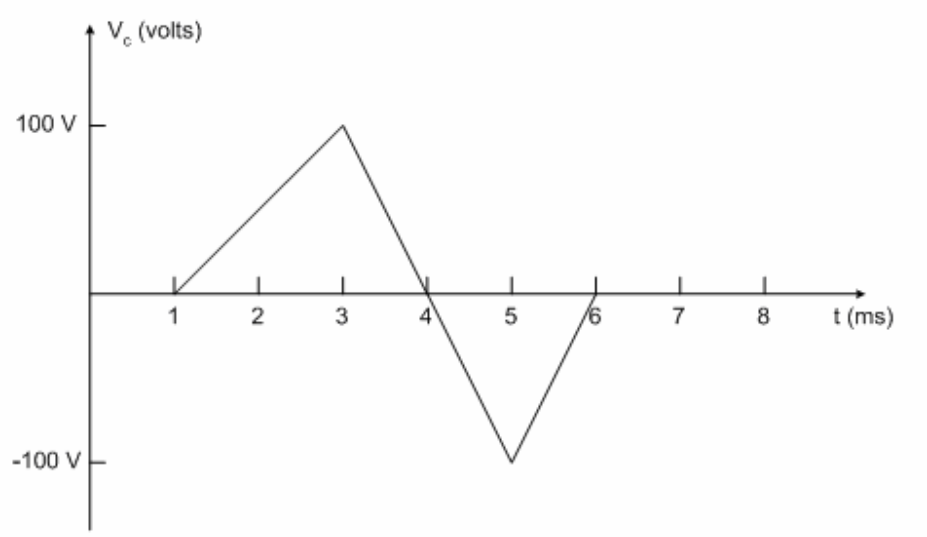
CASE WESTERN RESERVE UNIVERSITY
Case School of Engineering
Department of Electrical Engineering and Computer Science
ENGR 210. Introduction to Circuits and Instruments (4)

Quiz No. 10 4/02/04

PUT ANSWERS IN THE SPACE PROVIDED AND SHOW YOUR WORK IF APPROPRIATE
BE SURE TO STATE ALL ASSUMPTIONS

Problem 1 Power and Energy in Inductors/Capacitors (10 points)

The figure below shows the voltage across a 0.1 μF capacitor.



(a) Sketch the current, power and energy as a function of time. Be sure to indicate the minimum/maximum values of these waveforms.

$$i_c(t) = C\frac{dV_c(t)}{dt} = 0.1\mu F \cdot \frac{dV_c(t)}{dt}$$

From 0 ms~1 ms, $i_c(t) = 0$;

From 1 ms~3 ms, $i_c(t) = C\frac{dV_c(t)}{dt} = 0.1\mu F \cdot \frac{100V}{2ms} = 5mA$;

From 3 ms~5 ms, $i_c(t) = C\frac{dV_c(t)}{dt} = 0.1\mu F \cdot \frac{-200V}{2ms} = -10mA$;

From 5 ms~6 ms, $i_c(t) = C\frac{dV_c(t)}{dt} = 0.1\mu F \cdot \frac{100V}{1ms} = 10mA$;

Base on these calculated values, we can get the plot of i_c as follows.

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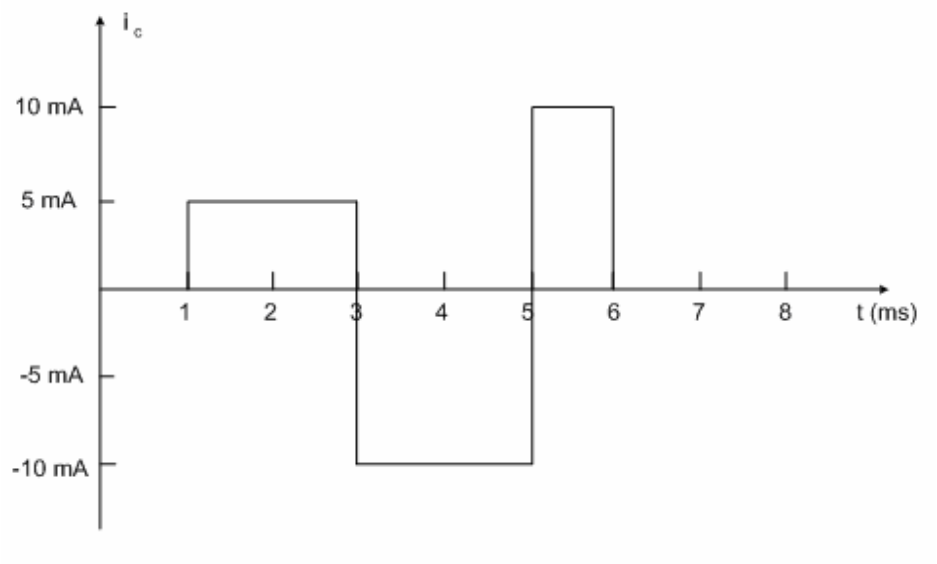


(3 points);

Using $p_c(t) = i_c(t) \cdot V_c(t)$, we can get the values of powers at different times.

At t= 1 ms, $p_c(t) = i_c(t) \cdot V_c(t) = 0W$;

At t= 3- ms, $p_c(t) = i_c(t) \cdot V_c(t) = 5mA * 100V = 0.5W$;

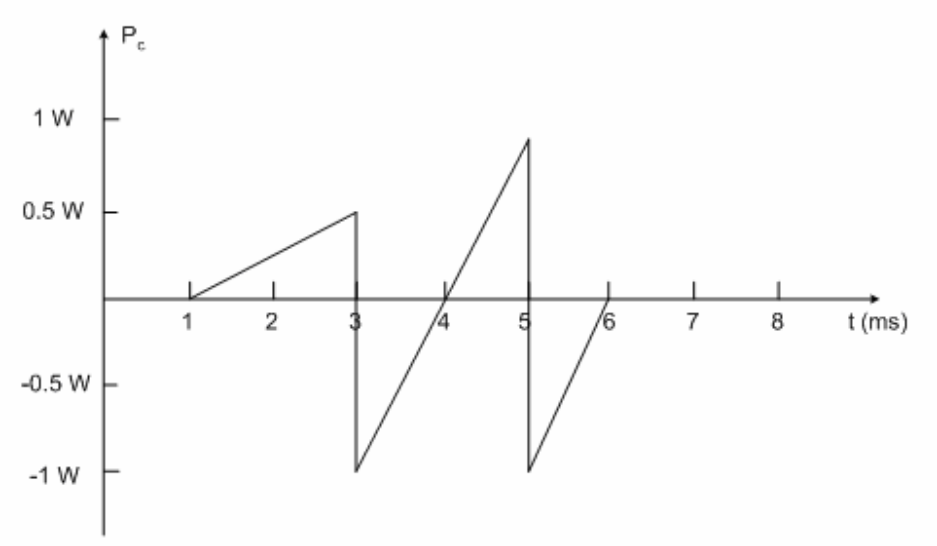
At t= 3+ ms, $p_c(t) = i_c(t) \cdot V_c(t) = -10mA * 100V = -1W$;

At t= 4 ms, $p_c(t) = i_c(t) \cdot V_c(t) = -10mA * 0V = 0W$;

At t= 5- ms, $p_c(t) = i_c(t) \cdot V_c(t) = -10mA * (-100V) = 1W$;

At t= 5- ms, $p_c(t) = i_c(t) \cdot V_c(t) = -10mA * 100V = -1W$;

At t= 6 ms, $p_c(t) = i_c(t) \cdot V_c(t) = 0W$;



(3 points);

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Using $W_c(t) = \frac{1}{2} C V_c^2(t)$, we can also calculate the values at different times.

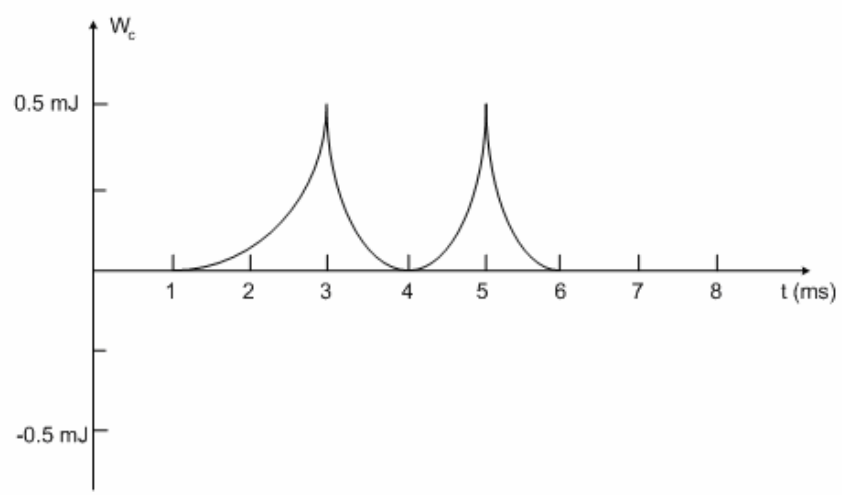
At t=1 ms, $W_c(t) = \frac{1}{2} C V_c^2(t) = 0J$;

At t=3 ms, $W_c(t) = \frac{1}{2} C V_c^2(t) = \frac{1}{2} \cdot 0.1\mu F \cdot (100V)^2 = 0.5mJ$;

At t=4 ms, $W_c(t) = \frac{1}{2} C V_c^2(t) = 0J$;

At t=5 ms, $W_c(t) = \frac{1}{2} C V_c^2(t) = \frac{1}{2} \cdot 0.1\mu F \cdot (-100V)^2 = 0.5mJ$;

At t=6 ms, $W_c(t) = \frac{1}{2} C V_c^2(t) = 0J$;



(3 points)

(b) Indicate on your sketch of power as a function of time when the capacitor is absorbing power, and when it is providing (delivering) power.

If $P_c>0$, then capacitor is absorbing power;

If $P_c<0$, then capacitor is delivering power;

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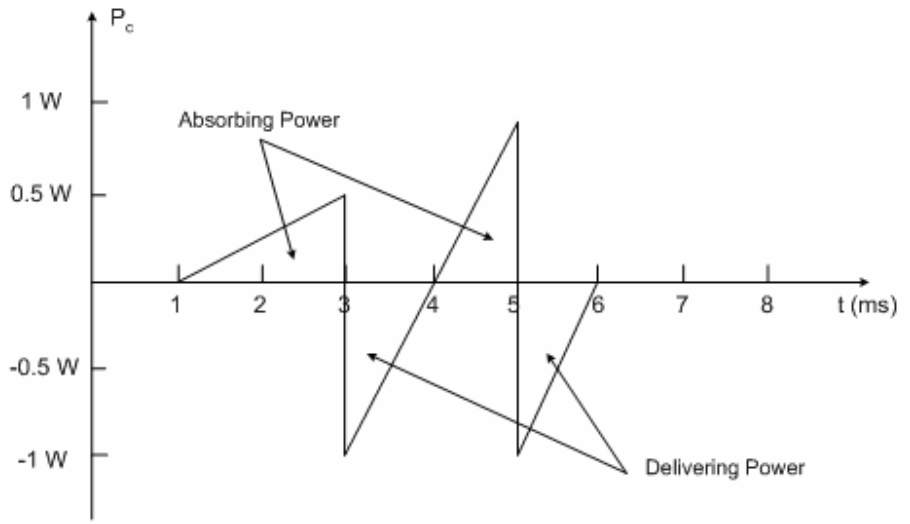

(1 points)

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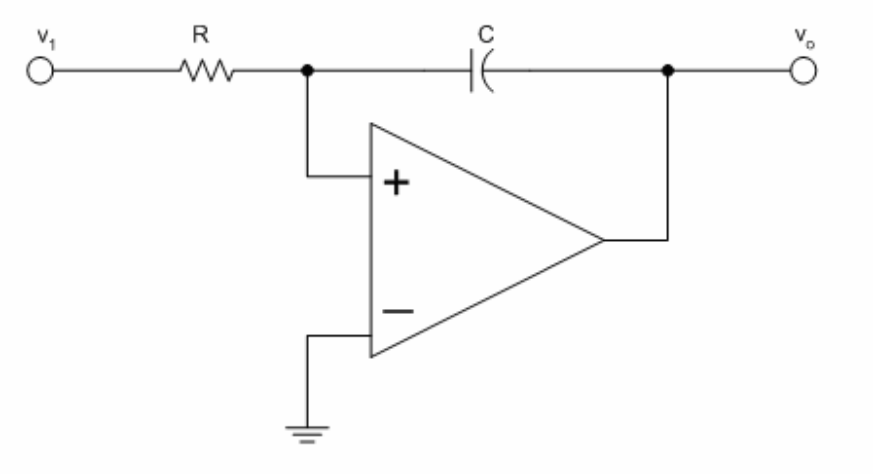
Problem 2 OP AMP integrator/differentiator (10 points)

Consider the OP AMP circuit shown below. There is no energy initially stored in the capacitor. A voltage of 6 volts is applied at t=0. The OP AMP is powered from a ±15V volt power supply.



(a) If R=10 kΩ and C=0.25 μF, determine the output voltage as a function of time.

The circuit acts as an integrator as $v_o(t) = v_o(t) - \frac{1}{RC}\int_0^t v_1(t)$. For this problem, $v_1(t)=6u(t)V$ and $-\frac{1}{RC} = -\frac{1}{10k\Omega \cdot 0.25\mu F} = -400$.

So $v_o(t) = v_o(t) - \frac{1}{RC}\int_0^t v_1(t) = -400\int_0^t 6dt = -2400t$ (5 points)

(b) When will the output voltage reach saturation?

When voltage is equal to ±15V, the output voltage reaches saturation.

So $-2400t = -15V \Rightarrow t = 6.25ms$ (5 points)