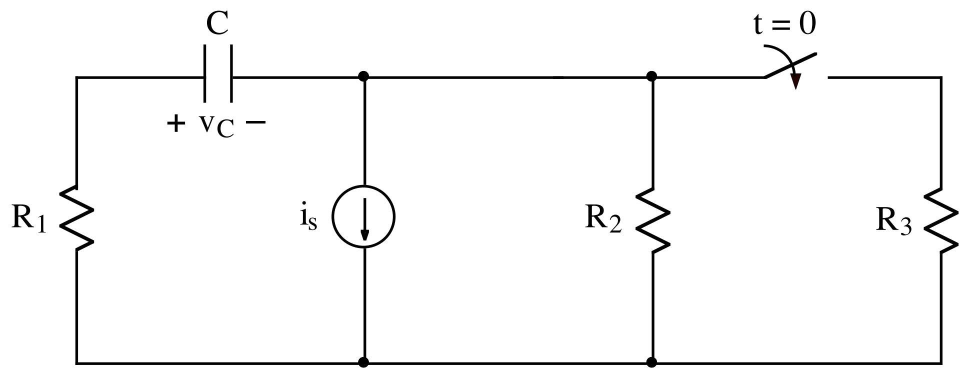
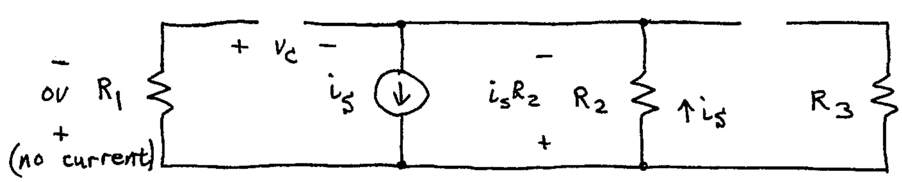
Ex:



After being open for a long time, the switch closes at t = 0. Write an expression for $v_c(t \geq 0)$ in terms of R_1, R_2, R_3, i_s, and C.

Sol'n: At $t = 0^-$ the switch is open and C = open.

$t = 0^-$:



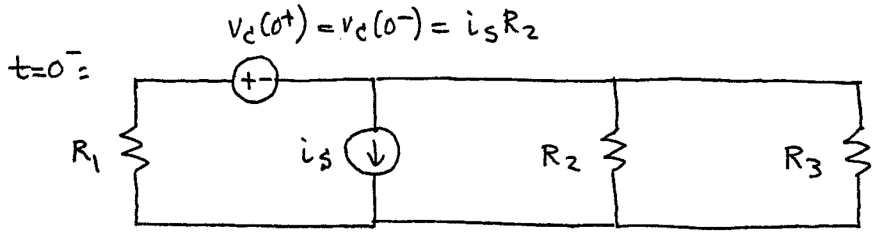
i_s flows thru R_2 producing v-drop $i_s R_2$.

Since there is no current in R_1, this voltage appears across C.

$$v_c(0^-) = i_s R_2$$

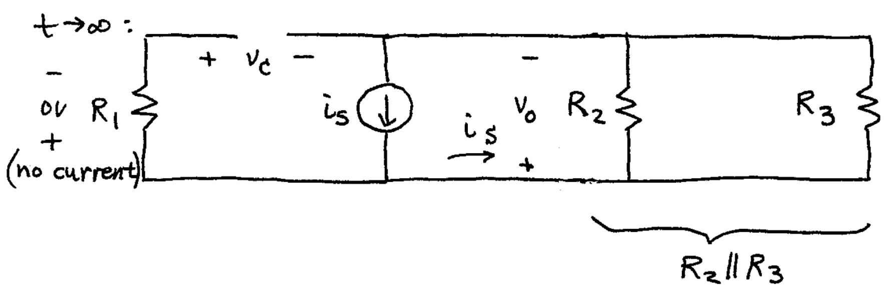
Note that + sign of $i_s R_2$ v-drop connects to + sign of v_c thru R_1 (0V drop ≈ wire) and − sign of $i_s R_2$ v-drop connects to − sign of v_c thru wire.

At $t=0^+$, we treat C as v-source with value $v_C(0^+) = v_C(0^-)$. Switch is closed.



Since the value we need is $v_C(0^+)$, there is nothing further to solve.

For $t \to \infty$, we treat C as open, switch closed.

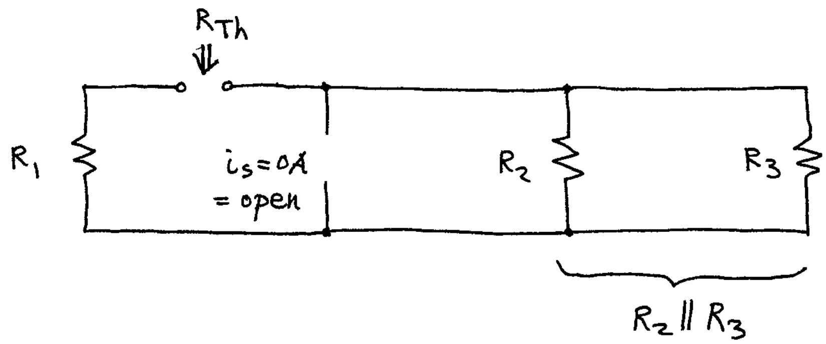


Now we have $v_C = i_S \cdot R_2 \| R_3$. This is the same as $t=0^-$ except that we have $R_2 \| R_3$ instead of R_2.

$$v_C(t \to \infty) = i_S \, R_2 \| R_3$$

The time constant is $R_{Th} C$.

We remove C and look into the circuit from terminals where C attaches. We also turn off i_S. What we see is R_{Th}.



We have $R_{Th} = R_1 + R_2 \| R_3$

Now plug terms into general sol'n:

$$v_C(t>0) = v_C(t\to\infty) + [v_C(0^+) - v_C(t\to\infty)]e^{-t/R_{Th}C}$$

Here, we have:

$$v_C(t>0) = i_s \cdot R_2 \| R_3 + (i_s R_2 - i_s R_2 \| R_3)e^{\frac{-t}{(R_1 + R_2 \| R_3)C}}$$