

task_tb6pi8dgh0m2e2pw_with_calculation

Student Group

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Exercise E1 Charging Capacitors

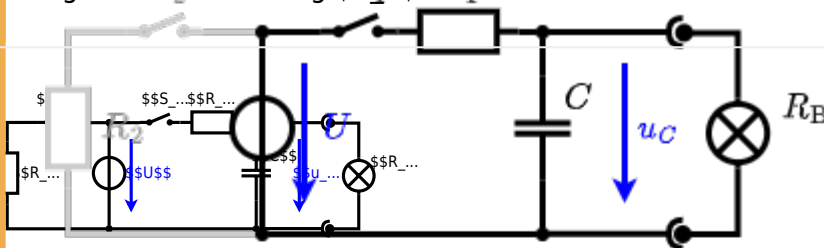
(written test, approx. 16 % of a 60-minute written test, WS2022)

The circuit (without the calculation) also takes into account the charging of a capacitor. The voltage across the capacitor is again 0 V at the moment $t_0 = 0 \text{ s}$ when the switch S_1 is closed. Calculate the voltage $u_c(t_2)$ across the capacitor at $t_2 = 1 \text{ ms}$ after closing the switch.

Solution
To solve this, first create an equivalent linear voltage source from U , R_1 , and R_B .

Solution
The equivalent voltage source is $U_{eq} = U \cdot \frac{R_B}{R_1 + R_B}$ and the internal resistance is $R_{eq} = R_1 \parallel R_B$.

On an alternative view, one can try to create an equivalent linear voltage source again. Then, the internal resistance is given by substituting the ideal voltage source is again short-circuiting R_1 .



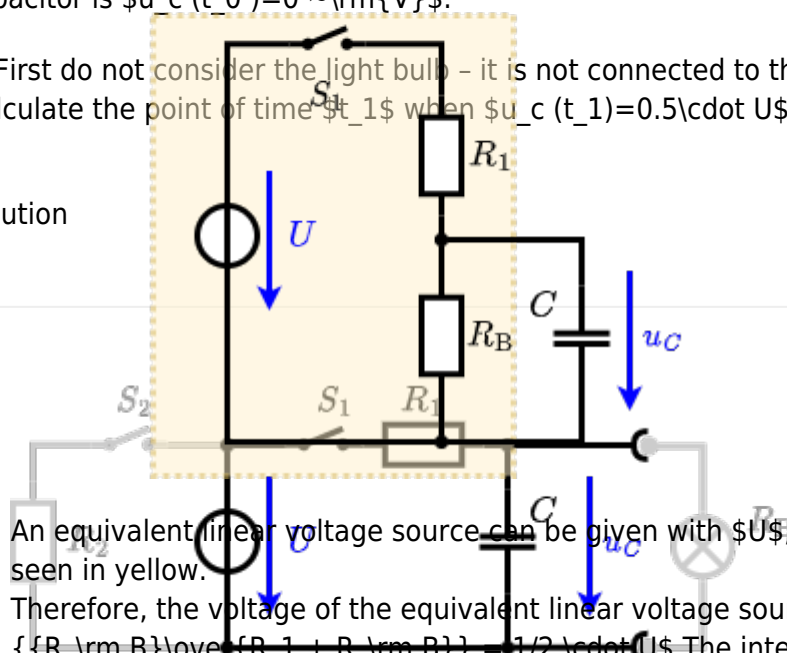
The circuit contains a voltage source $U = 12 \text{ V}$, a switch S_1 , a resistor of $R_1 = 20 \text{ Ohm}$ and a capacitor of $C = 100 \text{ uF}$.

The switch S_2 to an additional consumer R_B will be considered to be open for the first tasks. At the moment $t_0 = 0 \text{ s}$ the switch S_1 is closed, the voltage across the capacitor is $u_c(t_0) = 0 \text{ V}$.

First do not consider the light bulb - it is not connected to the RC circuit.

Calculate the point of time t_1 when $u_c(t_1) = 0.5 \cdot U$.

Solution



An equivalent linear voltage source can be given with U , R_1 , and R_B as seen in yellow.

Therefore, the voltage of the equivalent linear voltage source is: $U_{eq} = U \cdot \frac{R_B}{R_1 + R_B} = 1/2 \cdot U$. The internal resistance is given by substituting the ideal voltage source with its resistance ($= 0 \text{ Ohm}$, short-circuit).

Since R_1 and C give the time constant $\tau = R_1 \cdot C$ and $\omega = \frac{1}{R_1 \cdot C}$

The following formula describes the time course $u_c(t)$ which has $\frac{1}{\omega}$ as τ

$$u_c(t) = 0.5 \cdot (1 - e^{-\omega t}) \cdot (10 - (10 - 0) \cdot e^{-\omega t}) = 0.5 \cdot (1 - e^{-\omega t}) \cdot 10$$
 It has to be rearranged to $(1 - e^{-\omega t}) = 0.5$

$$1 - e^{-\omega t} = 0.5 \implies e^{-\omega t} = 0.5 \implies -\omega t = \ln(0.5) \implies t = \frac{\ln(0.5)}{-\omega} = R_1 \cdot C \cdot \ln(0.5)$$

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