

task_tb6pi8dgh0m2e2pw_with_calculation

Student Group

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Exercise E1 Charging Capacitors

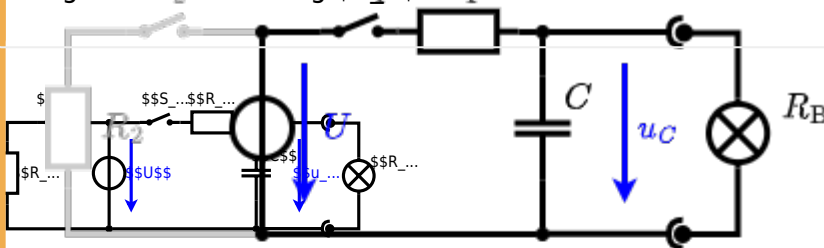
(written test, approx. 16 % of a 60-minute written test, WS2022)

The circuit (without the calculation) also includes a switch S_2 and a light bulb R_B as shown in the figure. 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 as seen in yellow.

Solution
The voltage source is $U_s = U \cdot \frac{R_B}{R_1 + R_B} = 12 \text{ V} \cdot \frac{20 \text{ } \Omega}{20 \text{ } \Omega + 20 \text{ } \Omega} = 6 \text{ V}$. The internal resistance is $R_{int} = R_1 \parallel R_B = 10 \text{ } \Omega$.

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_2 .



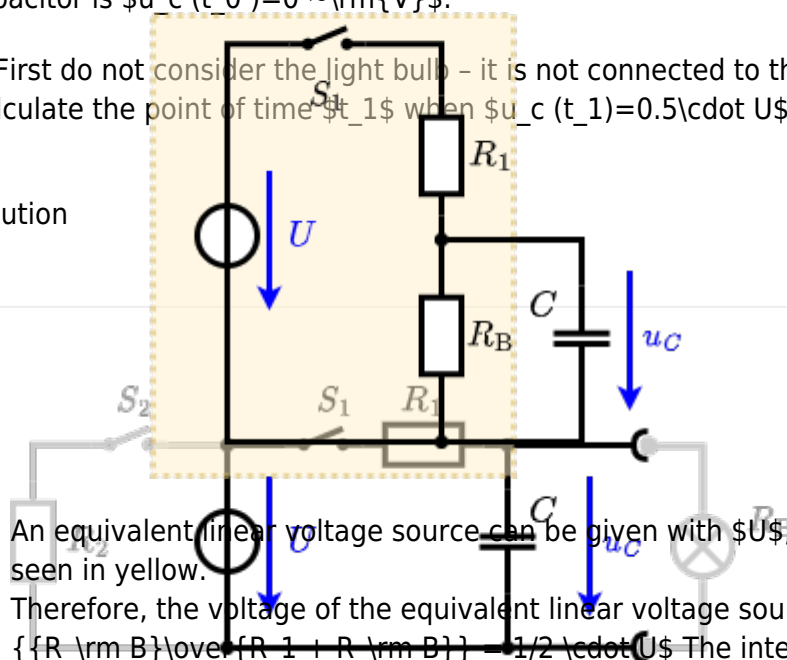
The circuit contains a voltage source $U = 12 \text{ V}$, a switch S_1 , a resistor of $R_1 = 20 \text{ } \Omega$ and a capacitor of $C = 100 \text{ } \mu\text{F}$.

The switch S_2 to an additional consumer R_2 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_s , R_1 , and R_B as seen in yellow.

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

Since only R_1 and C give the time constant, $\omega = \frac{1}{RC}$ \end{align*}

The following formula describes the time course $i(t)$ which has $i(0) = 0$ \end{align*} $i(t) = 0.5 \cdot (1 - e^{-t/\tau})$ \end{align*} It has to be rearranged to $(1 - e^{-t/\tau}) = 0.5$ \end{align*} $e^{-t/\tau} = 0.5$ \end{align*} $t/\tau = \ln(0.5)$ \end{align*} $t = \tau \cdot \ln(0.5)$ \end{align*} $t = R_1 \cdot C \cdot \ln(0.5)$ \end{align*}

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