task_p8yrdjr60k6bvc4n_with_calculation

Student Group

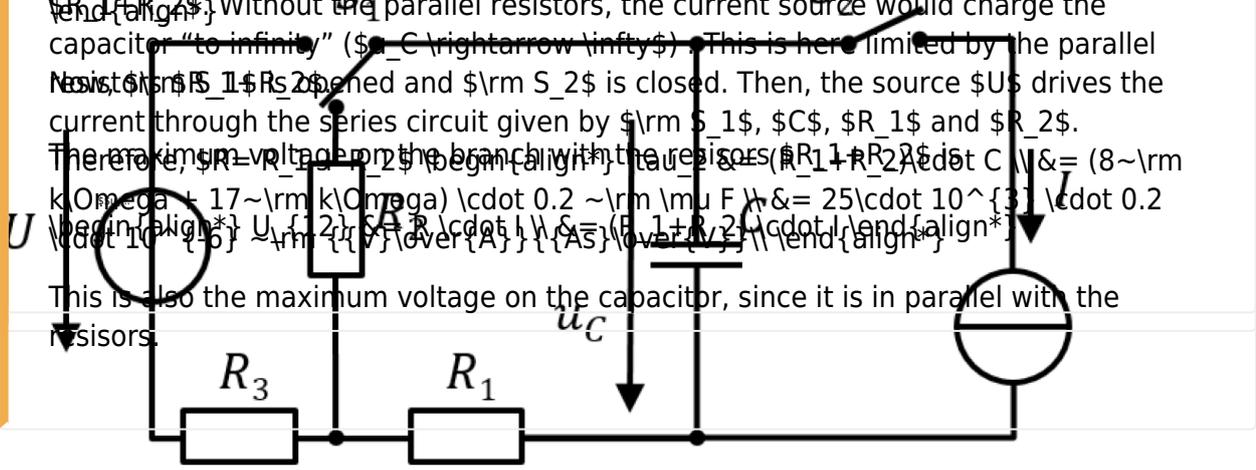| First Name	Surname	Matrikel Nr.

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charging, capacities, exam ee1 SS2023

Exercise E8 (Dis)Charging Capacities
(written test, approx. 14 % of a 60-minute written test, SS2023)

The circuit with the capacitor is to be charged with the R_3 C R_1 components shown in the diagram below. What will be the
Result appropriate is the case, when S_1 switches to the situation shown in the drawing. What is
the new time constant?
- $U = 10 ~\rm V$
- $C_1 = 200 ~\rm nF$
- $R_1 = 8.0 ~\rm k\Omega$

Solution

\begin{align*} \tau_2 &= 8.3.36~\rm ms \end{align*}

\begin{align*} u_C &= 50~\rm V \end{align*}

\begin{align*} u_C(t) &= U_0 \cdot(1 - e^{-t/\tau}) \\ &= 10~\rm V \cdot(1- e^{-4~ms/3~ms}) \end{align*}

Again, the time constant is generally given as: \begin{align*} \tau &= R\cdot C \end{align*} Without the parallel resistors, the current source would charge the capacitor "to infinity" ($u_C \rightarrow \infty$). This is here limited by the parallel resistors.

Now, $\rm S_1$ is opened and $\rm S_2$ is closed. Then, the source U drives the current through the series circuit given by $\rm S_1$, C, R_1 and R_2.
Therefore, $R= R_1 + R_2$ \begin{align*} \tau &= (R_1+R_2)\cdot C \\ &= (8~\rm k\Omega + 17~\rm k\Omega) \cdot 0.2 ~\rm \mu F \\ &= 25\cdot 10^{3} \cdot 0.2 \cdot 10^{-6} ~\rm {{V}\over{A}}{{As}\over{V}}\\ \end{align*}

\begin{align*} U_{12} &= R \cdot I \\ &= (R_1+R_2)\cdot I \end{align*}

This is also the maximum voltage on the capacitor, since it is in parallel with the resistors.

Before t_0 all switches are switched as shown and the capacitor is fully discharged.
At $t_0=0 ~\rm s$ the switch S_1 shall switch to the voltage source.

1. Calculate the time constant for charging the capacitor.

Solution

The time constant is generally given as: \begin{align*} \tau &= R\cdot C \end{align*}

Once S_1 is closed and S_2 is open at t_0, the source U drives the current through the series circuit given by S_1, C, R_1 and R_3.
Therefore, $R= R_1 + R_3$ \begin{align*} \tau_1 &= (R_1+R_3)\cdot C \\ &= (8~\rm k\Omega + 7~\rm k\Omega) \cdot 0.2 ~\rm \mu F \\ &= 15\cdot 10^{3} \cdot 0.2 \cdot 10^{-6} ~\rm {{V}\over{A}}{{As}\over{V}}\\ \end{align*}

Both courses of the voltage for charging and discharging are described with an exponential function. However, the curve for charging increases first steep and flattens out for longer time scales ($\propto (1-e^{-x})$).

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