aufgabe_7.2.6_mit_rechnung

Student Group

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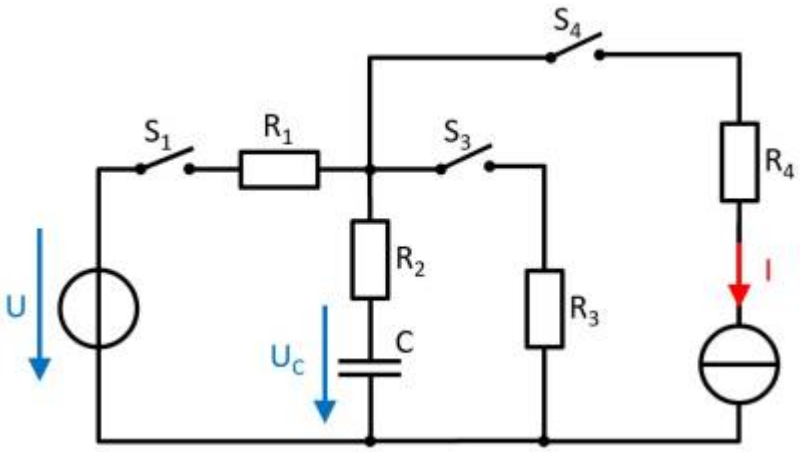

The adjacent circuit with the following data is given:

- $U = 10 V$
- $I = 4 mA$
- $R_1 = 100 \Omega, R_2 = 80 \Omega, R_3 = 50 \Omega, R_4 = 10 \Omega$
- $C = 40 nF$

At first the capacitor is empty and all switches are open. The switsch S1 will be closed at t=0.

1. Determine the time constant τ for this charging process.

Tips

- What equivalent circuit can be found for the mentioned states of the switches?
- What parameter do you need to determine τ?
- The charging current is flown through which component?

Solution

The electrical components R_1, R_2 und C are connected in series with a source U. The time constant τ is therefore: \begin{align*} \tau &= (R_1 + R_2) \cdot C \\ \tau &= 180 \Omega \cdot 40 nF \end{align*}

Final value

\begin{align*} \tau = 7,2 µs \end{align*}

2. How high is the voltage at the capacitor C when $t=10 µs$?

Solution

\begin{align*} U_C(t) = U \cdot (1 - e^{-t/\tau}) \\ U_C(t) = 10 V \cdot (1 - e^{-10 µs/7,2 µs}) \end{align*}

Final value

$$\begin{align*} U_C(t) = 7,506 V -> 7,5 V \end{align*}$$

3. How high is the energy when the capacitor is fully charged?

Solution

$$\begin{align*} W_C &= \frac{1}{2}CU^2 \\ &= \frac{1}{2} \cdot 40nF \cdot (10V)^2 \end{align*}$$

Final value

$$\begin{align*} W_C = 2 µJ \end{align*}$$

4. Determine the new time constant when the capacitor is fully charged. The switch S1 will be opened whereas the switch S2 will be closed simultaneously.

Solution

The capacitor C discharges by the series connected resistors R_2 und R_3.
$$\begin{align*} \tau &= (R_2 + R_3) \cdot C \\ \tau &= 130 \Omega \cdot 40 nF \end{align*}$$

Final value

$$\begin{align*} \tau = 5,2 µs \end{align*}$$

5. When the capacitor is empty all switches will be opend. The switch S4 will be closed at $t = 1µs$.
How high is the voltage at the capacitor C?

Tips

- Through the current source there is a continuous flow of elctric charge into the capacitor.
- The resistors passed by the current on the way to the capacitor are irrelevant. They only increase the voltage of an ideal current source to guarantee the current.

Solution

The voltage U_C is in general: $U_C = \frac{Q}{C}$. In this case the constant current I results in $Q = \int I dt = I \cdot t$ $$\begin{align*} U_C(t) &= \frac{Q}{C} \\ U_C(t) &= \frac{I \cdot t}{C} \\ U_C(1µs) &= \frac{4mA \cdot 1µs}{40nF} = \frac{4 \cdot 10^{-3}A \cdot 1\cdot 10^{-6}s}{40\cdot 10^{-9}F} \\ \end{align*}$$

Final value

$$\begin{align*} U_C(1µs) &= 1V \\ \end{align*}$$

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