

Capacitor, inductor and decoupling

Solutions · step by step

- 01**
1. Convert capacitance: 0.0001 F.
 2. $Q = C \cdot U$.
 3. $Q = 0.0005 \text{ C} = 0.5 \text{ mC}$.

$$Q = CU = 100 \mu\text{F} \cdot 5 \text{ V} = 500 \mu\text{C}$$

- 02**
1. Square voltage: 25 V^2 .
 2. Multiply by C and halve.
 3. $E = 1.25 \text{ mJ}$.

$$E = \frac{1}{2}CU^2 = 1.25 \text{ mJ}$$

- 03**
1. Time constant: $R \cdot C = 1 \text{ s}$.
 2. At $t = 0$ the capacitor is still at 0 V.
 3. Initial $I = 5/10000 = 0.5 \text{ mA}$.

$$\tau = RC = 1 \text{ s}; \quad I_0 = \frac{5}{10000} = 0.5 \text{ mA}$$

- 04**
1. $t/\tau = 1$.
 2. Charging factor: $1 - \exp(-1) = 0.6321$.
 3. Capacitor voltage = 3.161 V.

$$U_C(\tau) = 5(1 - e^{-1}) \approx 3.161 \text{ V}$$

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- 05**
1. Voltage across R is $5 - 3.161 = 1.839$ V.
 2. Divide by $10\text{ k}\Omega$.
 3. $I = 0.1839\text{ mA}$.

$$I(\tau) = I_0 e^{-1} \approx 0.1839\text{ mA}$$

- 06**
1. Remaining fraction is 0.1.
 2. Use logarithm: $t = -\tau \ln(0.1)$.
 3. $t = 2.303\text{ s}$.

$$t = -\tau \ln(1 - 0.9) = 2.303\text{ s}$$

- 07**
1. $\tau = 1\text{ s}$.
 2. Use discharge formula.
 3. Voltage = $5 \cdot \exp(-2) = 0.677\text{ V}$.

$$U_C(t) = U_0 e^{-t/RC} = 5e^{-2} \approx 0.677\text{ V}$$

- 08**
1. No, the RC circuit has no such threshold.
 2. Voltage and current approach zero.
 3. A diode path would require a different circuit model.

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- 09**
1. Ratio: $0.1/5 = 0.02$.
 2. $t = \tau \ln(5/0.1)$.
 3. At 3.912 s it is 0.1 V; thereafter below.

$$t = 1 \text{ s} \cdot \ln(50) \approx 3.912 \text{ s}$$

- 10**
1. $C = 10 \cdot 10^{-6} \text{ F}$.
 2. Form $2\pi fC$ and take its reciprocal.
 3. Reactance magnitude = 159.15 Ω .

$$|X_C| = \frac{1}{2\pi fC} \approx 159.15 \Omega$$

- 11**
1. Reactance halves to 79.58 Ω .
 2. $I = U/X_C$.
 3. Current magnitude doubles.

$$|X_C(2f)| = \frac{|X_C(f)|}{2}$$

- 12**
1. Extra charge: $I \cdot \Delta t = 0.2 \mu\text{C}$.
 2. $C = \Delta Q/\Delta U$.
 3. At least 2 μF in the ideal model.

$$C = \frac{I\Delta t}{\Delta U} = \frac{0.020 \cdot 10^{-5}}{0.1} = 2 \mu\text{F}$$

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- 13**
1. Apply Ohm's law to ESR.
 2. $\Delta U = \Delta I \cdot \text{ESR}$.
 3. $\Delta U = 50 \text{ mV}$; further capacitive droop follows.

$$\Delta U_{\text{ESR}} = 0.5 \cdot 0.1 = 0.050 \text{ V}$$

- 14**
1. Wires have inductance.
 2. Fast current changes create voltage drops across it.
 3. Short supply and return paths reduce loop area.

- 15**
1. R and C form a high-pass.
 2. $RC = 0.01 \text{ s}$.
 3. Cutoff = 15.92 Hz.

$$f_c = \frac{1}{2\pi RC} \approx 15.92 \text{ Hz}$$

- 16**
1. Coupling: capacitor in series with signal, blocks steady DC.
 2. Decoupling: capacitor across supply, supports local current peaks.
 3. Same component type, different purpose.

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- 17**
1. $L = 0.01 \text{ H}$.
 2. Square current and multiply by $L/2$.
 3. $E = 0.2 \text{ mJ}$.

$$E_L = \frac{1}{2}LI^2 = 0.0002 \text{ J}$$

- 18**
1. $\tau = L/R = 0.1 \text{ ms}$.
 2. The ideal inductor has zero steady DC voltage.
 3. Final $I = 5/100 = 50 \text{ mA}$.

$$\tau = \frac{L}{R} = 0.1 \text{ ms}$$

- 19**
1. Time equals τ .
 2. Current rises to 63.21% of final value.
 3. $I = 31.61 \text{ mA}$.

$$I(\tau) = 50 \text{ mA}(1 - e^{-1}) = 31.61 \text{ mA}$$

- 20**
1. Slope: $\Delta I/\Delta t = 20000 \text{ A/s}$.
 2. $U = L \cdot \Delta I/\Delta t = 200 \text{ V}$.
 3. A limiting current path, such as a suitable flyback diode, prevents uncontrolled spikes.

$$|U_L| = L \left| \frac{\Delta I}{\Delta t} \right| = 200 \text{ V}$$