ساره جبر

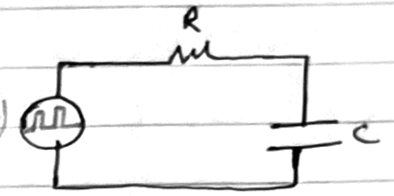
Experiment 6

Capacitors and Inductors

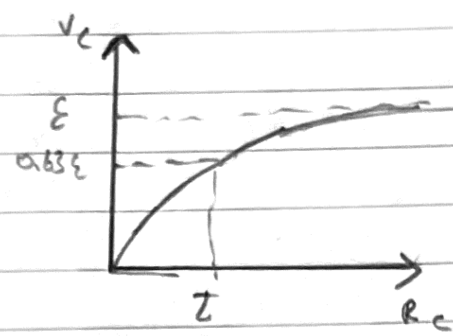
(A) RC circuits : A circuit that contains a resistor and capacitor connected in series and powered by power supply but in our experiment by signal generator

(*) Charging capacitor

During the positive half period of the squre wave



The voltage across the capacitor



$$V_c = \frac{Q}{C}$$

$$Q = \mathcal{E}C(1 - e^{-t/RC})$$

$$\Rightarrow V_c = \mathcal{E}(1 - e^{-t/RC})$$

- at $t = 0 \longrightarrow V_c = \mathcal{E}(1 - e^{0}) = 0$
- at $t = \infty \rightarrow V_c = \mathcal{E}(1 - e^{-\infty}) = \mathcal{E}$
- at $t = \tau = RC \rightarrow V_c = \mathcal{E}(1 - e^{-\frac{RC}{RC}}) = 0.63\,\mathcal{E}$

τ : time constant is a measure of how fast the voltage across the capacitor rises or how fast the charging is

* time constant : the time needed for the potential difference on capacitors to reach 0.63 of the max voltage $\mathcal{E}$

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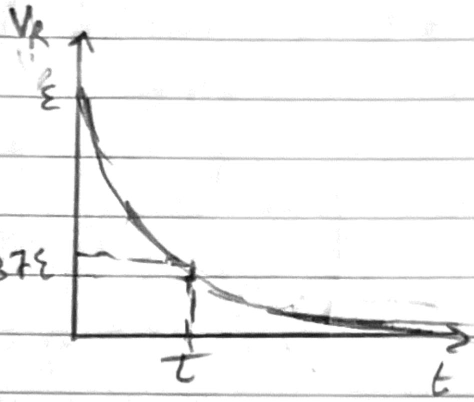
The voltage across the resistor

$V_R = IR \quad , \quad I = \frac{dQ}{dt} \quad , \quad Q = C\mathcal{E}(1 - e^{-t/RC})$

$V_R = \frac{dQ}{dt} R$

$= C\mathcal{E} \frac{1}{RC} e^{-t/RC} R$

$V_R = \mathcal{E} e^{-t/RC}$



- at $t = 0 \rightarrow V_R = \mathcal{E} e^0 = \mathcal{E}$
- at $t = \infty \rightarrow V_R = \mathcal{E} e^{-\infty} = 0$
- at $t = RC \rightarrow V_R = \mathcal{E} e^{-1} = 0.37\mathcal{E}$

(A) Discharging a capacitor

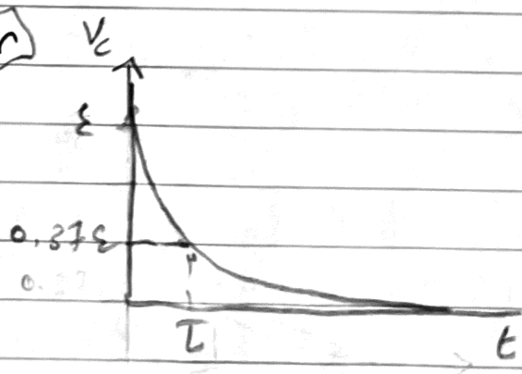
(During the negative half period of the squre wave)

$Q(t) = C\mathcal{E} e^{-t/RC}$

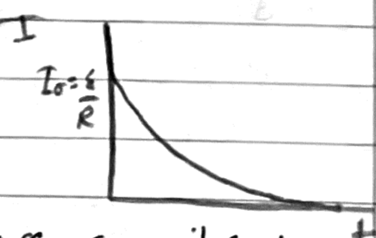
The voltage across the capacitor

$V_C = \frac{Q}{C} = \frac{C\mathcal{E} e^{-t/RC}}{C}$

$\Rightarrow V_C = \mathcal{E} e^{-t/RC}$



- at $t = 0 \rightarrow V_C = \mathcal{E} e^0 = \mathcal{E}$
- at $t = \infty \rightarrow V_C = \mathcal{E} e^{-\infty} = 0$
- at $t = RC = \tau \Rightarrow V_C = \mathcal{E} e^{-1} = 0.37\mathcal{E}$



τ: a measure of how fast the voltage across capacitor decreses

τ: the time needed for potential difference on capacitor to reach 0.37 of the max voltage

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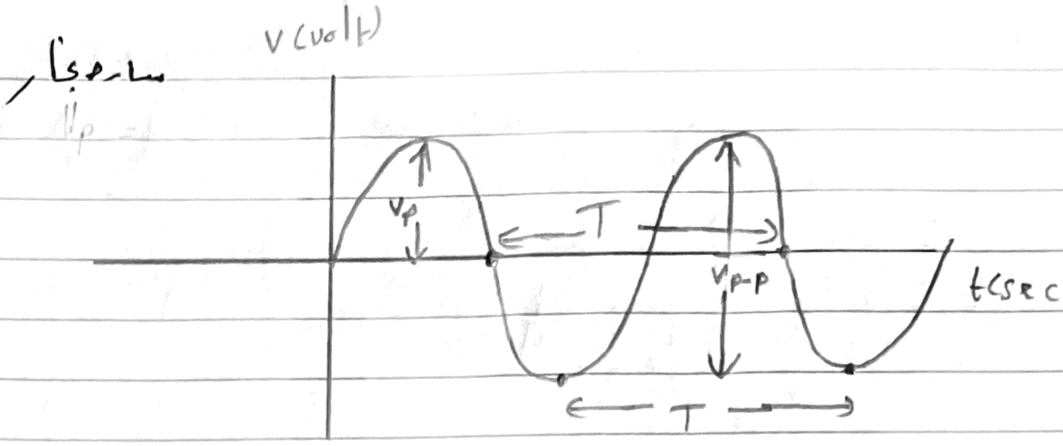
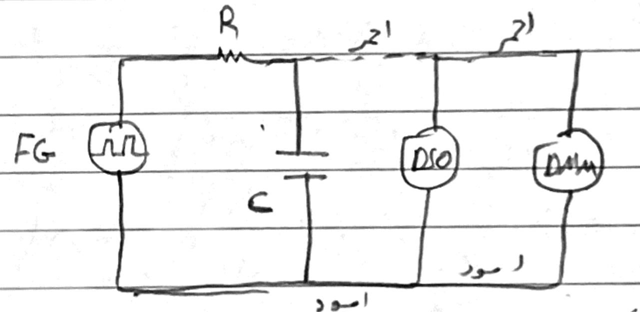


$$f = \frac{1}{T} \quad (\text{unit : Hz})$$

$$V_{p-p} = 2\sqrt{2}\, V_{rms}$$

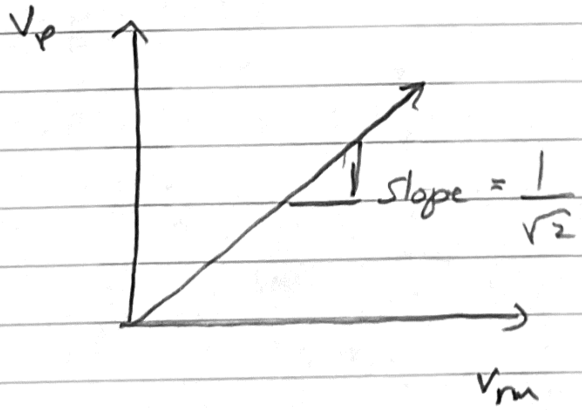
$$V_{rms} = \frac{1}{2\sqrt{2}}\, V_{p-p}$$

$$V_{rms} = \frac{1}{\sqrt{2}}\, V_p$$



قراءة DSO هي V_p او V_{p-p}

قراءة DMM هي V_{rms}



V_{rms} : هي قيمة الجهد التي تكون عندها كمية الطاقة المهدورة عندما يمر DC voltage هي نفس كمية الطاقة المهدورة عندما يمر AC voltage

ساره بكار

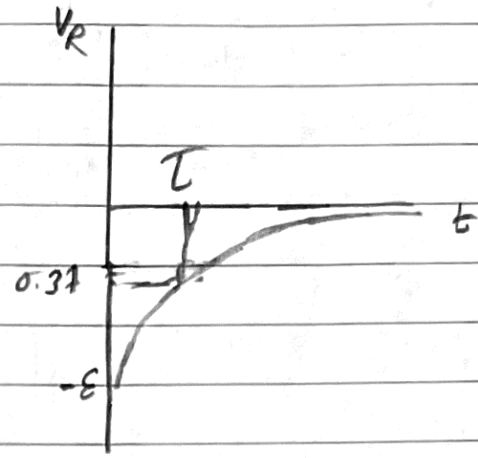
The voltage across the Resistors

$V_R = IR$, $I = \frac{dQ}{dt}$, $Q = C\varepsilon e^{-t/RC}$ disg

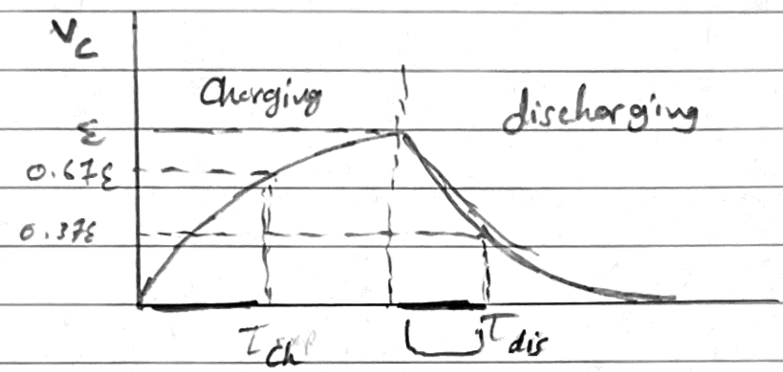
$V_R = \frac{dQ}{dt} R$

$V_R = \frac{-1}{RC} C\varepsilon e^{-t/RC} R$, $I = \frac{dQ}{dt} = \frac{-\varepsilon}{R} e^{-t/RC}$

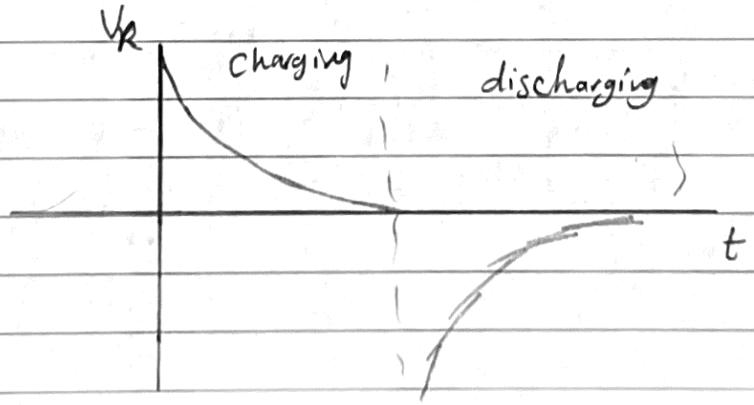
$V_R = -\varepsilon e^{-t/RC}$



- at $t=0 = -\varepsilon e^{0} = -\varepsilon$
- at $t=\infty = -\varepsilon e^{-\infty} = 0$
- at $t = RC = -\varepsilon e^{-1} = 0.37\varepsilon$



$\tau_{exp} = \frac{\tau_{ch} + \tau_{dis}}{2}$, $\tau_{theo} = RC$



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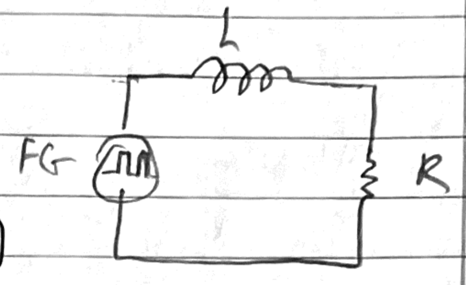
(B) RL Circuit: A circuit that contains an inductor connected in series with a resistance and powered by a power supply but in our experiment by a signal generator

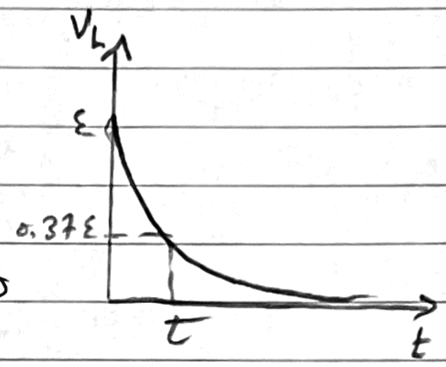
$$I(t) = \frac{\varepsilon}{R}\left(1 - e^{-Rt/L}\right)$$



The voltage across the inductor L

$$V_L = L\frac{dI}{dt} = \cancel{L}\,\frac{\varepsilon}{\cancel{R}}\,\frac{\cancel{R}}{\cancel{L}}\,e^{-Rt/L}$$

$$\Rightarrow \quad V_L = \varepsilon e^{-Rt/L}$$



- at $t = 0 \longrightarrow V_L = \varepsilon e^{0} = \varepsilon$
- at $t = \infty \longrightarrow V_L = \varepsilon e^{-\infty} = 0$
- at $t = \tau = \frac{L}{R} \longrightarrow V_L = \varepsilon e^{-1} = 0.37\,\varepsilon$

τ: a measure of how fast the current rises in the circuit

The voltage across the resistor R

$$V_R = IR = \frac{\varepsilon}{\cancel{R}}\left(1 - e^{-Rt/L}\right)\cancel{R}$$

$$V_R = \varepsilon\left(1 - e^{-Rt/L}\right)$$

- at $t = 0 \rightarrow V_R = \varepsilon(1 - e^{0}) = 0$

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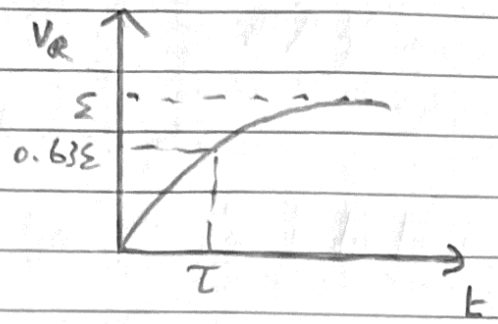
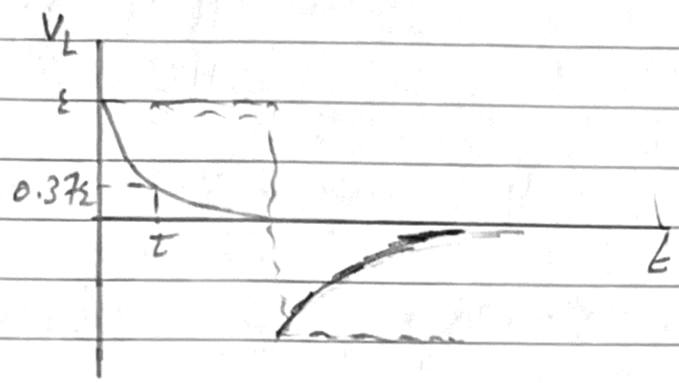
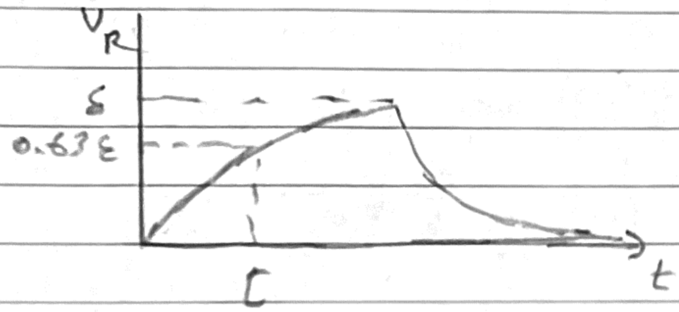
ساعه بار

• at $t = \infty \rightarrow V_R = \varepsilon(1 - e^{-\infty}) = \varepsilon$

• at $t = \frac{L}{R} \rightarrow V_R = \varepsilon(1 - e^{-1}) = 0.63\,\varepsilon$







$$\tau_{exp} = \frac{\tau_{ch.\,ar} + \tau_{dis\,ch.\,L}}{2}$$

$$\tau_{the.} = L/R$$

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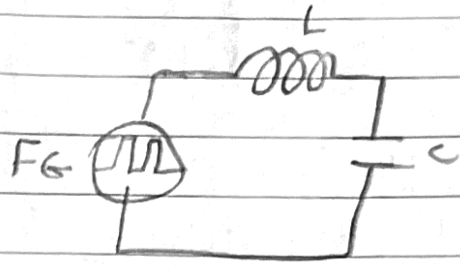
(c) LC circuit (LC tank or LC-osillator)

$$\varepsilon = L\frac{d^2Q}{dt^2} + \frac{Q}{C}$$



$$\Rightarrow Q(t) = Q_0 \cos(\omega t + \phi)$$

$$V_c = \frac{Q}{C} = \frac{Q_0}{C}\cos(\omega t + \phi)$$

$$\Rightarrow V_c = V_0 \cos(\omega t + \phi)$$ simple harmonic oscillator

$$\omega = \frac{1}{\sqrt{LC}}$$ natural angular frequency

$$X_L = \omega L = 2\pi f L$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$\Rightarrow$ at resonance

$$X_L = X_C$$

$$\omega L = \frac{1}{\omega C}$$

$$2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{4\pi^2 LC}$$

$$\Rightarrow f = \frac{1}{2\pi\sqrt{LC}}$$

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