سارة بكر

Experiment 10

RC Filteres

* Filteres: is an electrical circuit that allows signals with a difined frequency range to pass while blocking others with different frequency ranges.

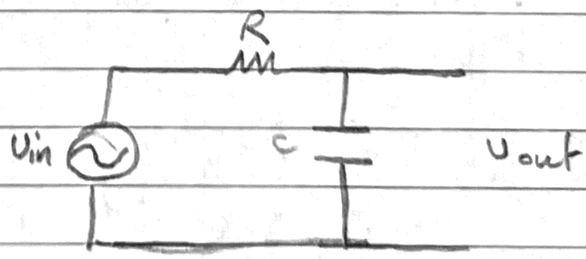
* Filters are useful units in many electrical and electronic devices such as radio, TV, etc

* There are three types of filters: high pass, low pass and band pass filters

* Attenuation is the decrease in amplitude

* In filters unwanted signals are higly attenuated through the circuit while required signals are passed with almost no attenuation.

(A) Low-pass RC filter



* The circuit equivalent impedance $Z_{eq} = R + X_c$

$$\Rightarrow Z_{eq} = R - \frac{j}{\omega c}$$

$$I(t) = \frac{V_{in}(t)}{Z_{eq}} \Rightarrow \boxed{I(t) = \frac{V_{in0} \cos(\omega t)}{R - j/\omega c}}$$

②

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$$V_{out}(t) = V_c(t) = I(t)\, Z_c$$

$$= \frac{V_{ino}\cos(\omega t)}{R - \frac{j}{\omega c}} * \frac{-j}{\omega c}$$

$$= \frac{V_{ino}\cos(\omega t)}{\left(R - \frac{j}{\omega c}\right)\frac{\omega c}{-j}}$$

$$= \frac{V_{ino}\cos(\omega t)}{\frac{j}{j} \times \frac{R\omega c}{-j} + 1}$$

$$j \times -j = \sqrt{-1} \times \sqrt{-1} \times -1 = -1 \times -1 = 1$$

$$V_{out}(t) = \frac{V_{ino}\cos(\omega t)}{1 + jR\omega c}$$

$$\Rightarrow V_c(t) = \frac{V_{ino}\cos(\omega t)}{1 + j\omega cR}$$

$$V_{co} = \frac{V_{ino}}{\sqrt{1 + \omega^2 c^2 R^2}}$$

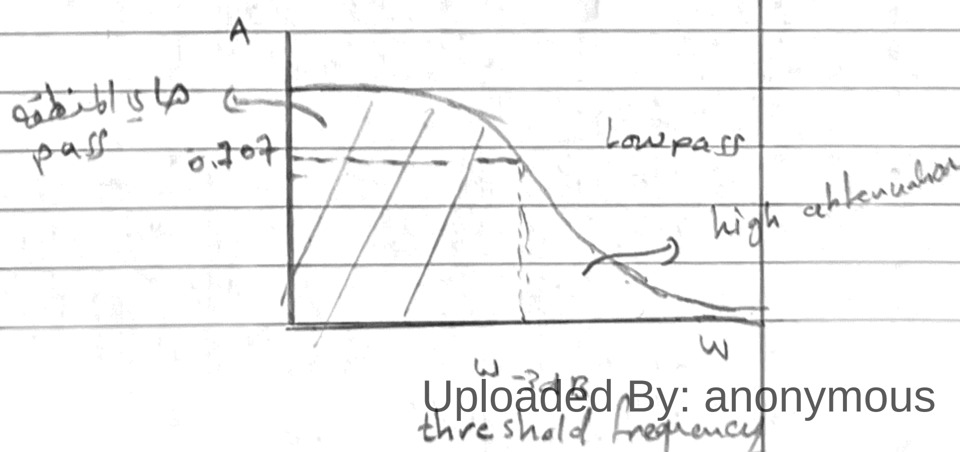
V_{ino} : the amplitude of $V_{in}(t)$ (input)

V_{co} : the amplitude of $V_c(t)$ (output)

* The attenuation factor $A = \frac{V_{co}}{V_{ino}} = \frac{X_c}{\sqrt{R^2 + X_c^2}} = \frac{1}{\sqrt{1 + \omega^2 c^2 R^2}}$

$$\omega_{-3dB} = \frac{1}{Rc}$$

$$A = \frac{1}{\sqrt{1 + \left(\frac{\omega}{\omega_{-3dB}}\right)^2}}$$



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① if $\omega << \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+0}} = 1 \Rightarrow$ pass

The amplitude of the output signal is equal to that of the input signal ⇒ in other word the signal passed without attenuation

② if $\omega >> \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+\infty}} = 0 \Rightarrow$ Attenuated

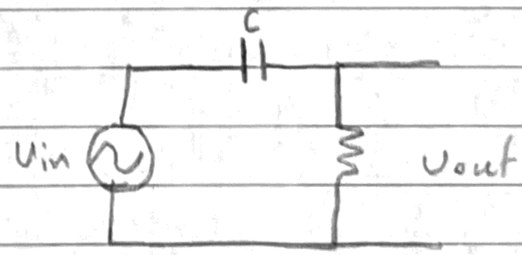
A is extremely small and the output signal is highly attenuated

③ If $\omega = \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+1}} = \frac{1}{\sqrt{2}} = 0.707$

the amplitude of the output signal is 0.707 of the amplitude of the input amplitude. This value set a practical boundery between passed signals and highly attenuated ones

Ⓑ High-pass RC filter

Using exactly the same procedure used in case A this lead to



$(V_{out} = IR) \Rightarrow \left(A = \frac{R}{\sqrt{R^2 + X_c^2}} \right)$

$$A = \frac{1}{\sqrt{1 + \left(\frac{\omega_{-3dB}}{\omega}\right)^2}}$$

سار جدا

(1) if $\omega << \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+\infty}} = 0$ (Attenuated)

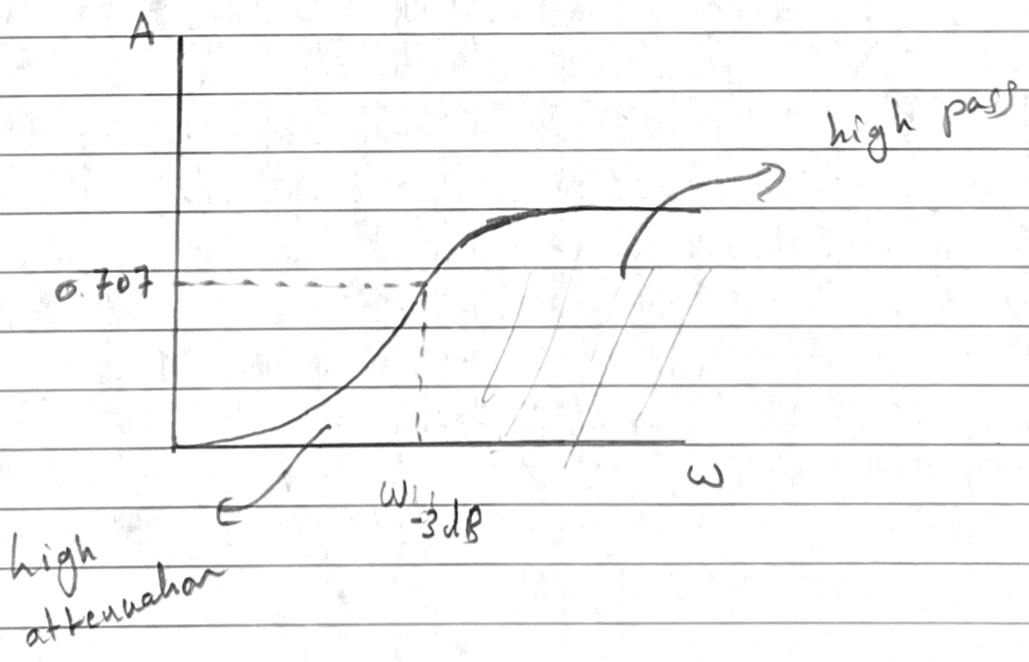
A is extremely small and the output signal is highly attenuated.

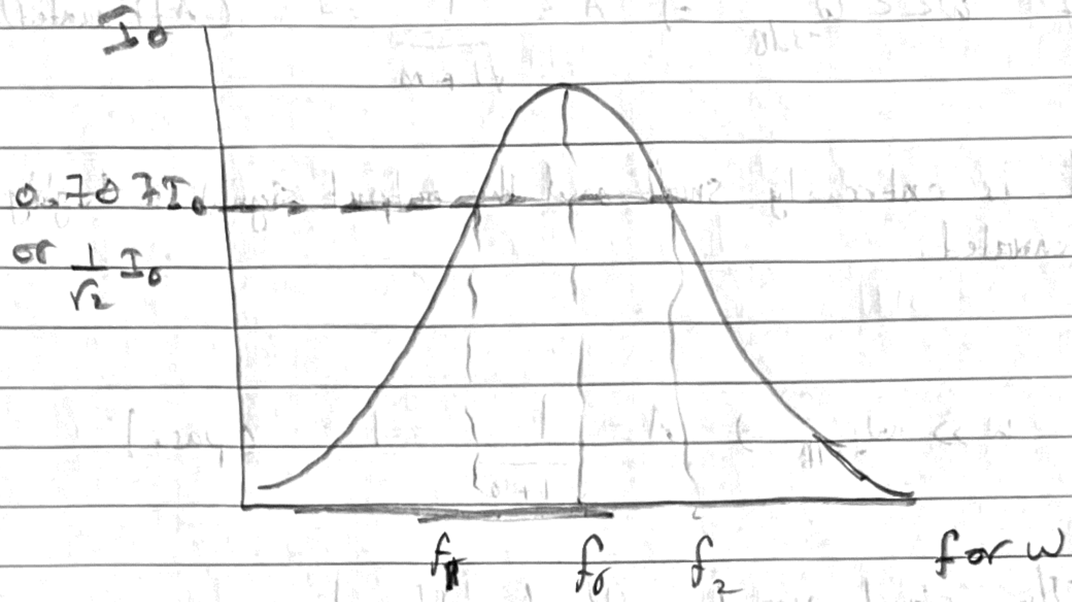
(2) if $\omega >> \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+0}} = 1$ (pass)

The signal passed without attenuation

(3) if $\omega = \omega_{-3dB} \Rightarrow \frac{1}{\sqrt{1+1}} = \frac{1}{\sqrt{2}} = 0.707$

boundary between passed signals and highly attenuated ones.





band bass filter

سلام يا

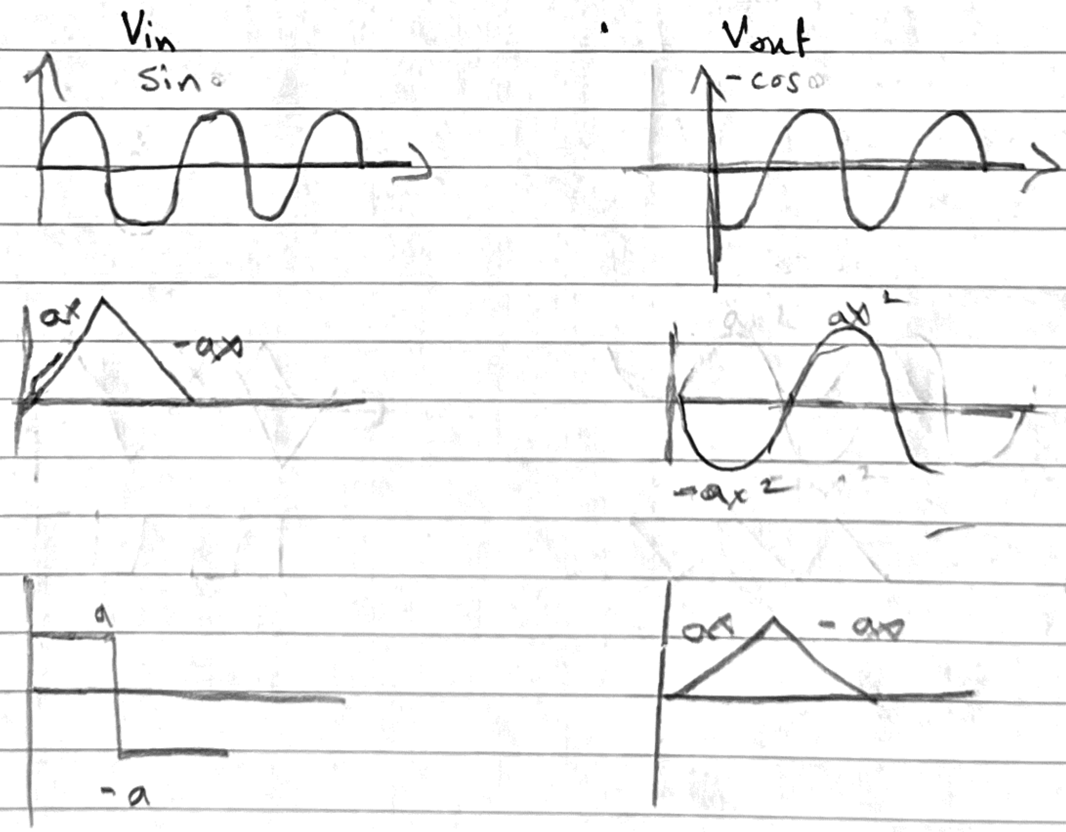
Differnitators and Integrators

(A) Low pass filter

* For $\omega \gg \omega_{-3dB}$ $V_{out}(t)$ is extremely small
* for $\omega \gg \omega_{-3dB}$ $V_{in}(t) \simeq V_R(t)$
* For $\omega \gg \omega_{-3dB}$, The output voltage is just the integral of input voltage (V_R)

$\Rightarrow$ under such conditions this circuit acts as an <u>integrator</u>

$\omega \gg \omega_{-3dB}$



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B) High pass filter

* For $\omega << \omega_{-3dB}$ $V_{out}(t)$ is extremely small

* For $\omega << \omega_{-3dB}$ $V_{in}(t) \simeq V_c(t)$

* For $\omega << \omega_{-3dB}$ The output voltage is just the derivative of the input voltage ($V_c(t)$)

⇒ under such conditions this circuit acts as a differentiator