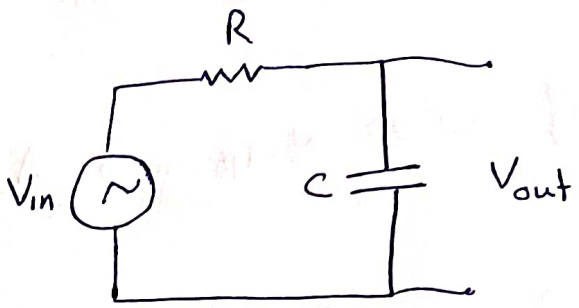
Exp 10 : RC Filters

→ low-pass Filter :



$$I(t) = \frac{V_{in}(t)}{Z_{eq}} = \frac{V_{in}(t)}{R - \frac{j}{\omega C}}$$

$$V_{in}(t) = V_{ino}\cos\omega t \Rightarrow I(t) = \frac{V_{ino}\cos\omega t}{R - j/\omega C}$$

$$V_{out} = V_c(t) = I(t)\,Z_c = \frac{V_{ino}\cos\omega t}{R - j/\omega C}\left(\frac{-j}{\omega C}\right)$$

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

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

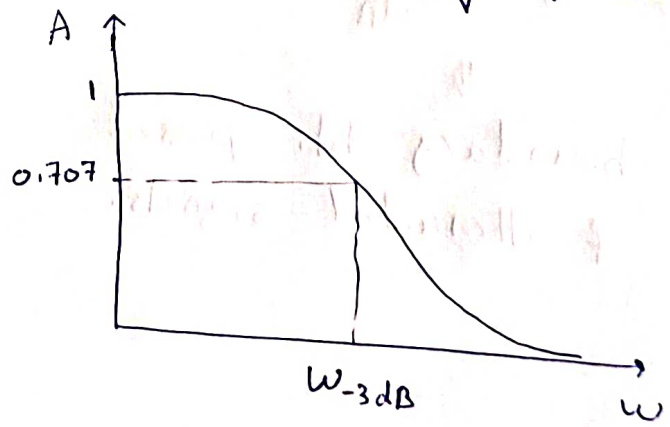
, V_{co} : Amp. of $V_c(t)$ [output]

V_{ino} : Amp. of $V_{in}(t)$ [input]

• The Attenuation factor (A) $= \frac{V_{co}}{V_{ino}} = \frac{1}{\sqrt{1 + \omega^2 C^2 R^2}}$

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

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



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

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

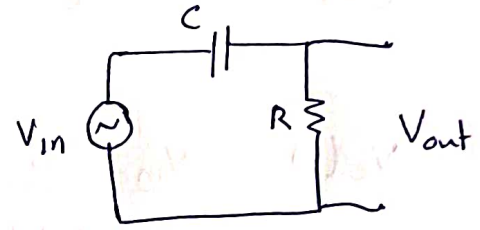
3- if $\omega = \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+1}} = \frac{1}{\sqrt{2}} = 0.707$

$\Downarrow$

practical boundary between passed signals & highly attenuated ones.

$\Rightarrow$ low pass filter (small ω)

* High pass RC filter:



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

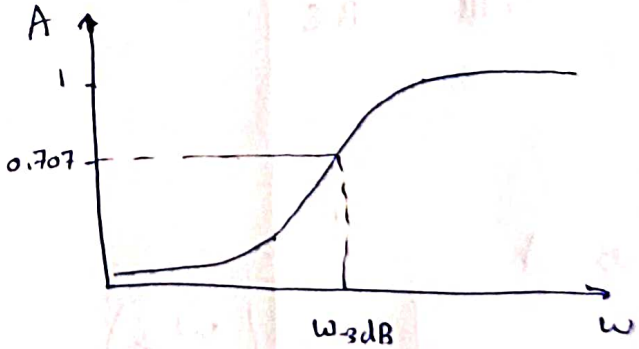
① if $\omega \ll \omega_{-3dB} \Rightarrow A = \frac{1}{\sqrt{1+\infty}} \Rightarrow 0$ (Attenuated)

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

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

$\Downarrow$

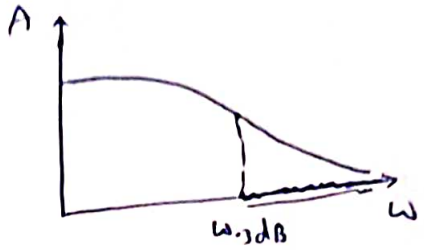
boundary bt. passed & attenuated signals.



* Differentiators & integrators

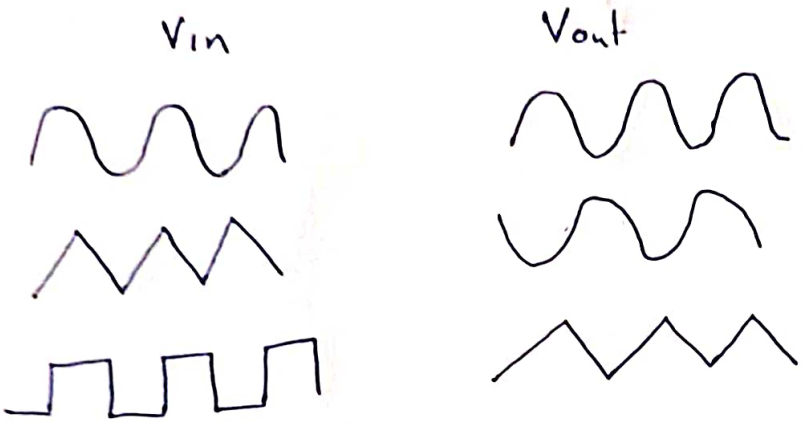
→ Low pass filter:

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



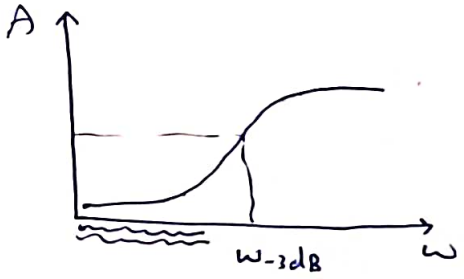
The output voltage is just the integral of the input voltage. ⇒ (integrator)

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



→ High pass filter:

when $\omega \ll \omega_{-3dB}$



The output voltage is just the derivative of the input voltage

⇒ (differentiator)

$(\omega \ll \omega_{-3dB})$