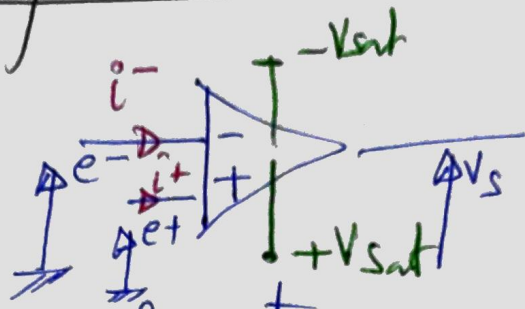
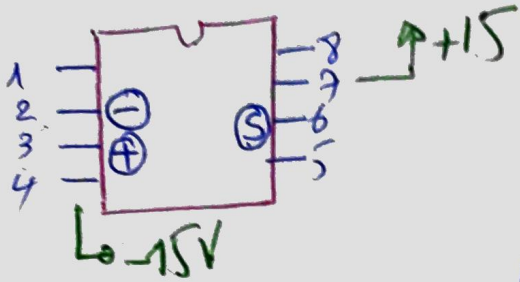


A Opérationnel



i^- et i^+ courants de polarisation
 e^- et e^+ tension d'entrées

$$\pm 15V = V_{sat}$$

• A O idéal = parfait

$$i^+ = i^- = 0$$

• $\varepsilon = e^+ - e^-$ = tension différentielle

• $\varepsilon = 0$ linéaire
 $e^+ = e^-$ (نفس الجهد)

$\left. \begin{array}{l} \varepsilon < 0 \\ \varepsilon > 0 \end{array} \right\} \begin{array}{l} \text{Saturé} \\ \text{Saturé} \end{array}$

$$V_s = -V_{sat}$$

$$V_s = +V_{sat}$$

LX4

$$\bullet V_A \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{2}{Z_C} \right) = \frac{V_E}{R_1} + \frac{0}{R_2} + \frac{V_B}{Z_C} + \frac{V_S}{Z_C}$$

$$V_A \left(\frac{1}{R_1} + \frac{1}{R_2} + 2j(\omega) \right) = \frac{V_E}{R_1} + j\omega V_S + 0$$

$$\bullet V_B \left(\frac{1}{2R_1} + \frac{1}{Z_C} \right) = \frac{V_A}{Z_C} + \frac{V_S}{2R_1} = 0$$

$$V_B = e^- = e^+ = 0$$

linéaire

$$V_A = - \frac{V_S}{2jR_1(\omega)}$$

$$\left(\frac{-V_S}{2jR_1(\omega)} \right) \left(\frac{1}{R_1} + \frac{1}{R_2} + 2j(\omega) \right) = \frac{V_E}{R_1} + j\omega V_S$$

$$(-V_S) \left[\underbrace{\frac{1}{2} \left(\frac{1}{R_1} + \frac{1}{R_2} \right)}_{\frac{1}{R_e}} \frac{1}{j\omega} + 1 \right] = V_E + jR_1\omega V_S$$

$$(-V_s) \left[1 + \frac{1}{j R_e \omega} + j R_1 C \omega \right] = V_e$$

$$\frac{V_s}{V_e} = \frac{\textcircled{-1} H_0 < 0}{1 + j \left(R_1 C \omega - \frac{1}{R_e \omega} \right)}$$

$$= \frac{H_0}{1 + j Q \left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega} \right)}$$

$$\boxed{H_0 = -1}$$

$$\left. \begin{array}{l} \frac{Q}{\omega_0} \stackrel{(1)}{=} R_1 C \\ Q \omega_0 \stackrel{(2)}{=} \frac{1}{R_e C} \end{array} \right\}$$

$$Q^2 = \frac{R_1}{R_e}$$

$$\omega_0 = \frac{1}{C \sqrt{R_1 R_e}}$$

b) في التردد

$$c) Q = \frac{f_0}{\Delta f} \rightarrow \Delta f = \frac{f_0}{Q}$$

$$f_{c1} = f_0 \left[-\frac{1}{2Q} + \frac{1}{2} \sqrt{4 + \frac{1}{Q^2}} \right]$$

$$f_{c2} = f_0 \left[+\frac{1}{2Q} + \frac{1}{2} \sqrt{4 + \frac{1}{Q^2}} \right]$$

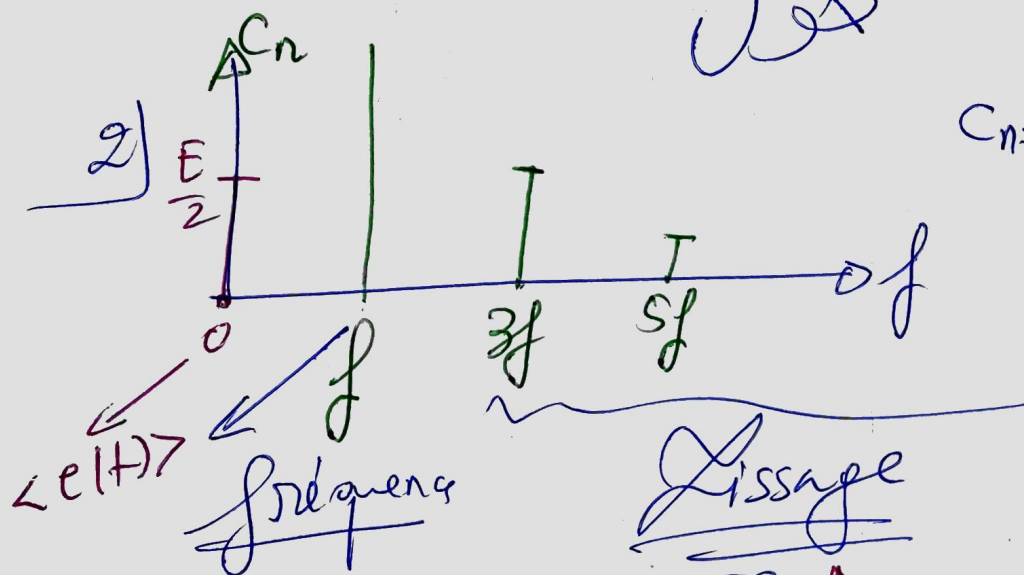
dem

S: $Q \gg 1$

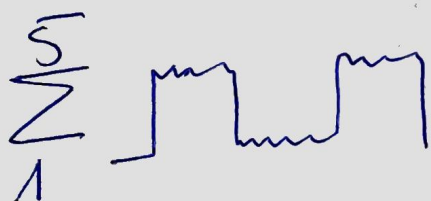
$$f_{c1} = f_0 - \frac{\Delta f}{2}$$

$$f_{c2} = f_0 + \frac{\Delta f}{2}$$

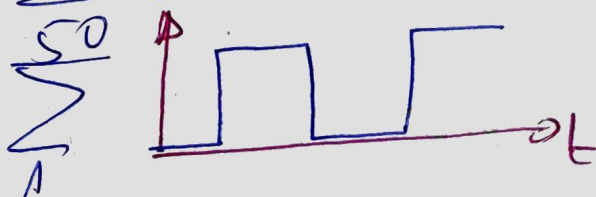
Ver



$$C_n = \sqrt{a_n^2 + b_n^2} > 0$$



Lissage



$$s(t) \approx$$

$$\boxed{f_0 = 3f}$$

فوق حاجة تفهولها

هناك frequency

$$s(t) = \frac{E}{2} H_0 + \frac{2E}{\pi} G(\omega) \left(\sin(\omega t + \Phi_1) \right) + \frac{2E}{3\pi} G(3\omega) \sin(3\omega t + \Phi_3) + \dots$$

$$G(\omega) = \frac{|H_0|}{\sqrt{1 + Q^2 \left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega} \right)^2}}$$

$$G(n\omega) = \frac{1}{\sqrt{1 + Q^2 \left[\frac{n}{3} - \frac{3}{n} \right]^2}}$$

$$G(3f) = 1 \rightarrow \phi(3f) = \arg(H_0)$$

$$G(f) \approx 0$$

$$G(5f) \approx 0$$

$$= \pi$$

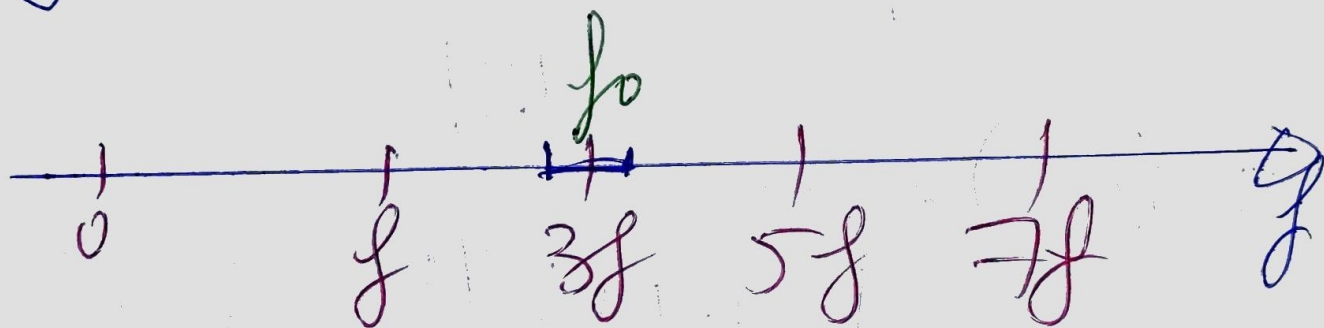
$$s(t) = \frac{2E}{3\pi} \times 1 \times \sin(3\omega t + \pi)$$

2^{me} methode

$$\Delta f = \frac{f_0}{Q} = \frac{3}{20} \text{ (kHz)}$$

$$f_{c1} = f_0 - \frac{\Delta f}{2}$$

$$f_{c2} = f_0 + \frac{\Delta f}{2}$$



$$G(3f) = 1, \quad (f \text{ et } 5f, 7f) \notin [f_{c1}, f_{c2}]$$

EX5

$$V_A \left(\frac{2}{R} + \frac{1}{R_2} + \frac{1}{Z_C} \right) = \frac{V_E}{R} + \frac{V_{S2}}{R_2} + V_{S3} \left(\frac{1}{R} + \frac{1}{Z_C} \right)$$

$$V_B \left(\frac{2}{R} \right) = \frac{V_{S3}}{R} + \frac{V_S}{R}$$

$$V_D \left(\frac{1}{R_2} + \frac{1}{Z_C} \right) = \frac{V_s}{R_2} + \frac{V_{s2}}{Z_C}$$

$$\rightarrow V_D = e^- = e^+ = 0$$

$$V_A = 0, \quad V_B = 0$$

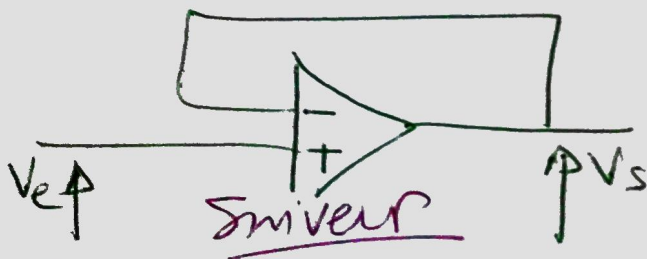
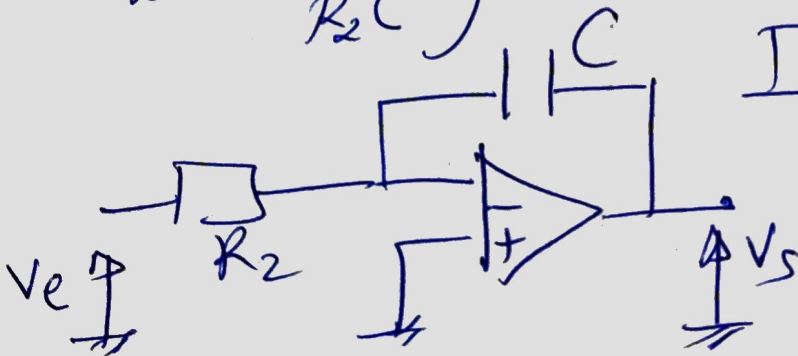
$$\bullet \frac{V_E}{R} + \frac{V_{s2}}{R_2} + V_{s3} \left(\frac{1}{R} + j\omega \right) = 0$$

$$\bullet \boxed{V_{s3} = -V_s} \quad \text{Inverser}$$

$$\bullet \boxed{V_{s2} = -\frac{1}{j\omega R_2 C} V_s}$$

$$V_{s2} = -\frac{1}{R_2 C} \int V_s dt$$

Integrieren

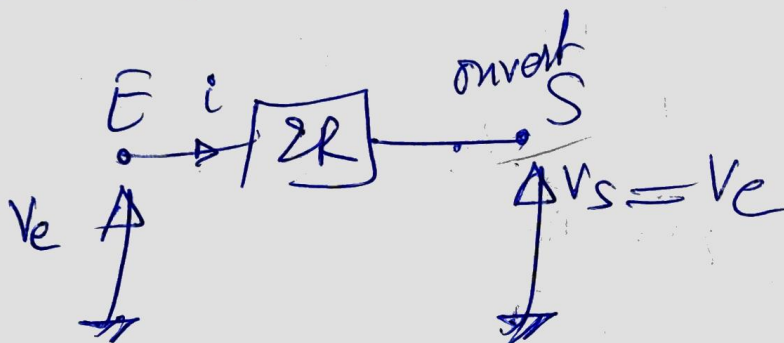
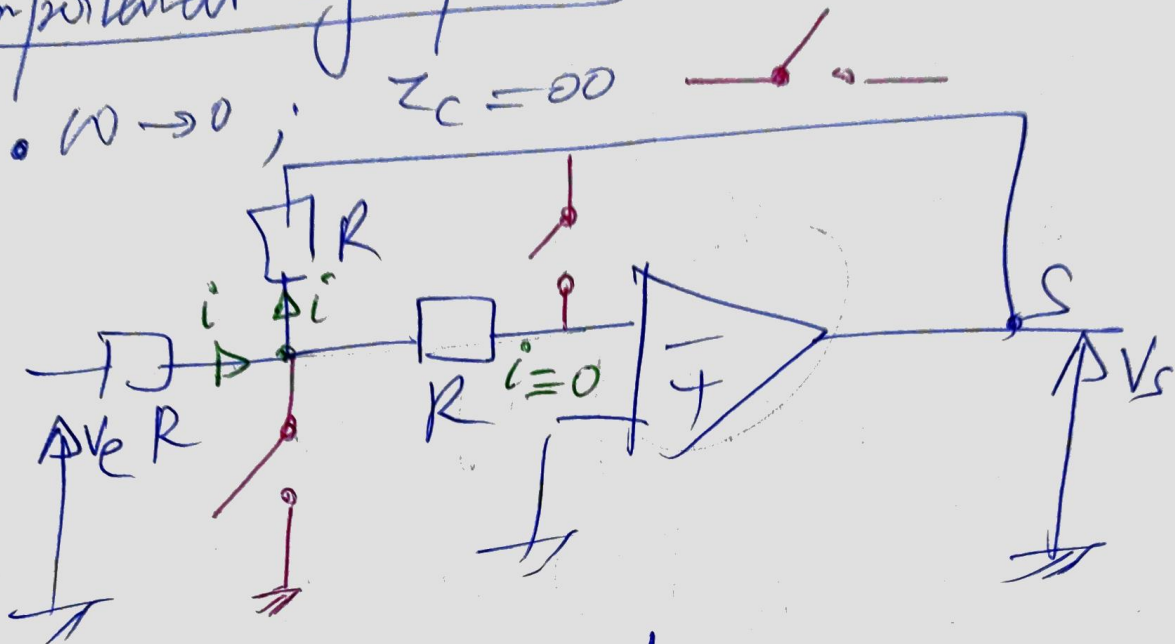


$$\begin{aligned} V_E &= e^+ \\ V_s &= e^- \\ \text{denn } V_s &= V_E \end{aligned}$$

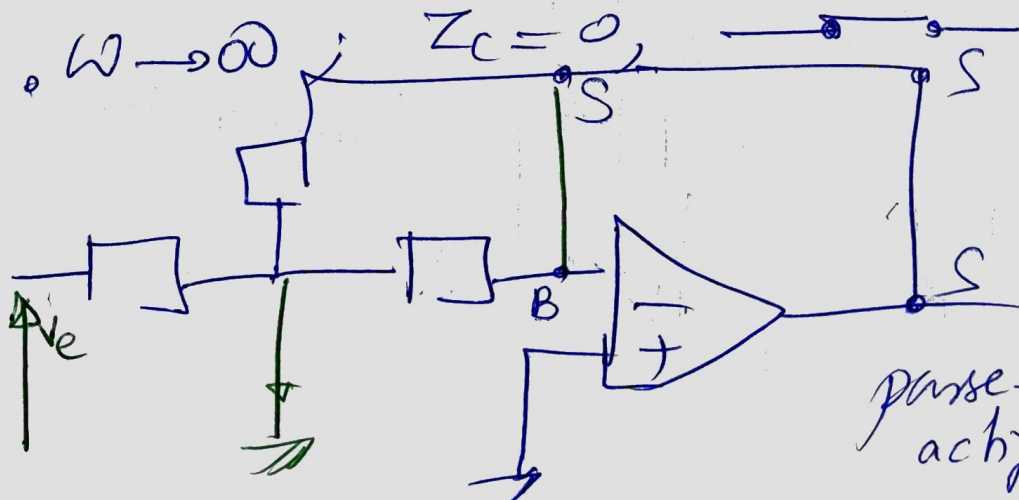
Ex6

amplificateur fréquentiel

$\omega \rightarrow 0$; $Z_C = \infty$



$\omega \rightarrow \infty$; $Z_C = 0$



$V_B = V_s = e^- = e^+ = 0$ 2^{ème} ordre

phase-bro
achf

1)

$$V_A \left(\frac{3}{R} + jC_2\omega \right) = \frac{V_E}{R} + \frac{V_B}{R} + \frac{V_S}{R} + \frac{0}{Z_{C_2}} \quad \checkmark$$

$$V_B () = 0 = \frac{V_A}{R} + jC_1\omega V_S$$

$$V_A = -jRC_1\omega V_S \quad \checkmark$$

$$(-jRC_1\omega)V_S \left(\frac{3}{R} + jRC_2\omega \right) = \frac{(V_E + V_S)}{R} \quad \checkmark$$

$$(-V_S) [3jRC_1\omega - R^2C_1C_2\omega^2 + 1] = V_E$$

$$\frac{V_S}{V_E} = \frac{1}{1 - R^2C_1C_2\omega^2 + j3RC_1\omega}$$

$$= \frac{1}{1 - \left(\frac{\omega}{\omega_0} \right)^2 + j\frac{\omega}{\omega_0 Q}}$$

$\omega = \text{pulsat}^{\circ} \text{ g\u00e9n\u00e9ral}$

$$2) G(\omega) = \frac{|H_0|}{\sqrt{(1 - \omega^2)^2 + \frac{\omega^2}{Q^2}}}$$

$$G(\omega) \text{ for max } \frac{d}{d\omega} \left[(1 - \omega^2)^2 + \frac{\omega^2}{Q^2} \right] = 0$$

$$2(1 - \omega^2)(-2\omega) + \frac{2\omega}{Q^2} = 0$$

$$\omega = 0, \quad \omega_r = \sqrt{1 - \frac{1}{2Q^2}}$$

$$Q > \frac{1}{\sqrt{2}}$$

$$Q = 50 > \frac{1}{\sqrt{2}}$$

$$\cdot \quad \underline{\omega \rightarrow 0} \quad \underline{H} = \frac{H_0}{1} = -1$$

$$\phi(\omega \rightarrow 0) = -\pi$$

$$G_{dB} = 20 \log |H_0| = 0 \text{ dB}$$

$$\underline{\underline{v_s = v_e}}$$

*

$$n \rightarrow \infty; \quad \underline{H} = \frac{H_0}{-n^2} = + \frac{1}{n^2}$$

$$\varphi(n \rightarrow \infty) = 0$$

$$G_{dB} = -20 \log n^2 = -40 \log n$$

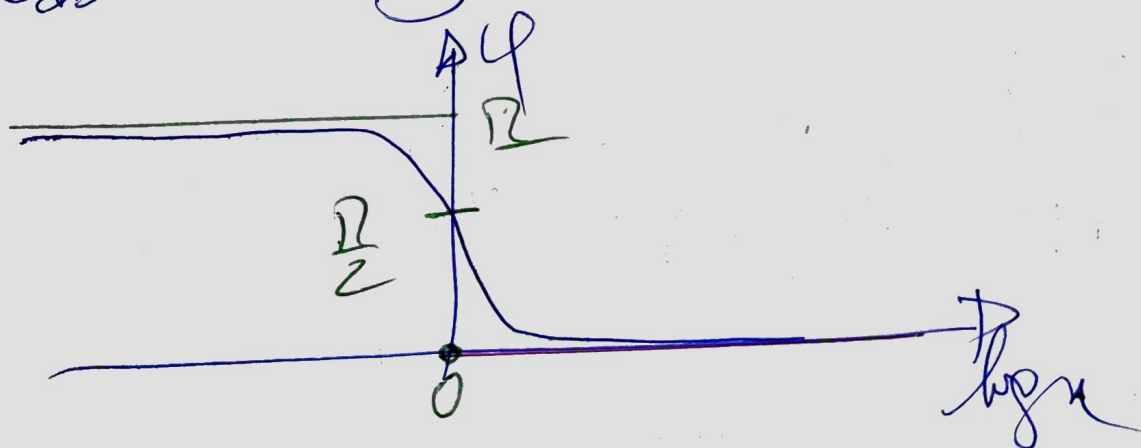
$$n \rightarrow \omega_n = \sqrt{1 - \frac{1}{2Q^2}} \approx 1, \quad \underline{Q = 50}$$

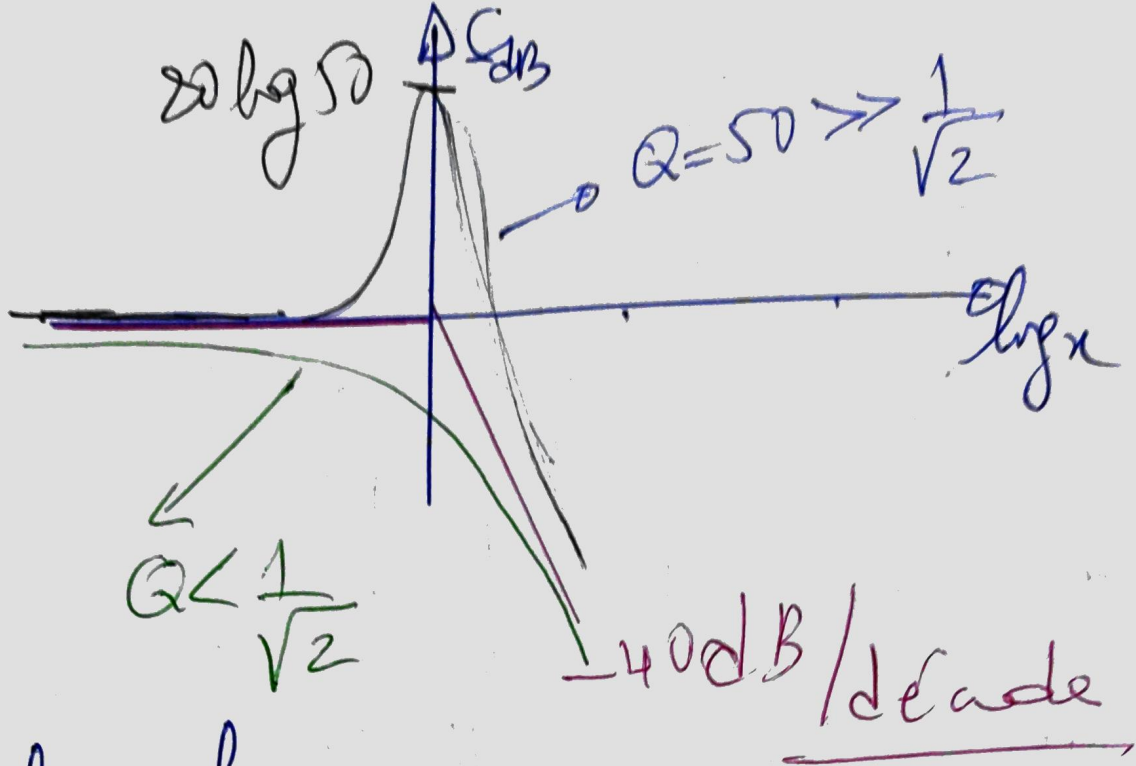
$$\underline{H} = \frac{H_0}{j \frac{1}{Q}} = -j H_0 Q \rightarrow (-1)$$

$$\varphi(n \rightarrow 1) = + \frac{\pi}{2}$$

$$G(n \rightarrow 1) = |H_0| Q = Q$$

$$G_{dB} = 20 \log Q = 20 \log 50$$





3) $f_0 = f$

$G(f) = Q = 50$ $H = +jQ$

$\varphi(f=f_0) = \frac{\pi}{2}$

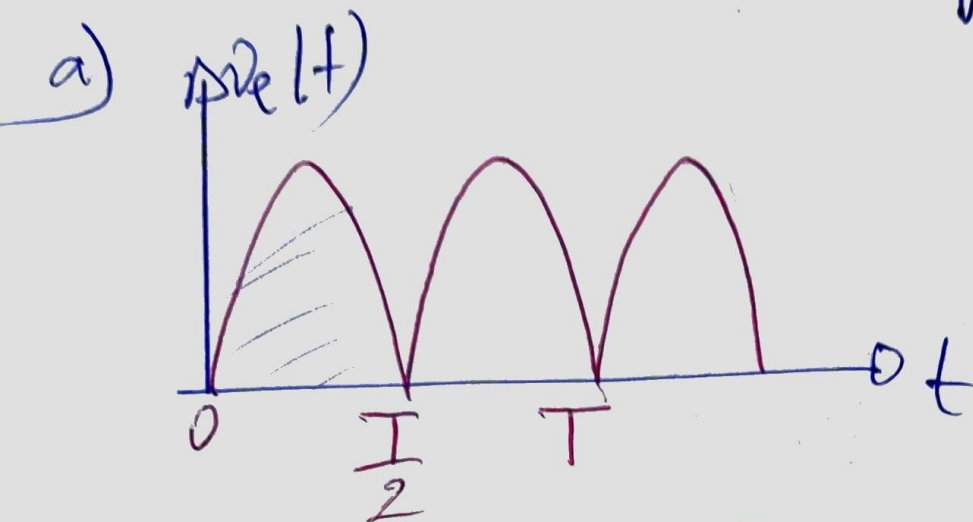
$s(t) = \frac{2E}{\pi} \times 50 \cos(\omega t + \frac{\pi}{2})$

Pg 81 $f_0 = 3f$

$s(t) = -\frac{2E}{3\pi} \times 50 \cos(3\omega t + \frac{\pi}{2})$

$+ \frac{2E}{\pi} G(\omega) \cos(\omega t + \tilde{\Phi}(\omega))$
 ≈ 1

4) $v_e = S_m / \sin(\omega t)$, $\omega = 100\pi$
 $f = 50 \text{ Hz}$
 $\hookrightarrow \text{STEG}$



$$C_n = \sqrt{a_n^2 + b_n^2}$$

b) $\langle v_e(t) \rangle = \frac{1}{T} \int_0^T v_e(t) dt$

$$= \frac{2}{T} \int_0^{T/2} S_m / \sin(\omega t) dt$$

$$= \frac{2S_m}{T} \left[\frac{-\cos(\omega t)}{\omega} \right]_0^{T/2}$$

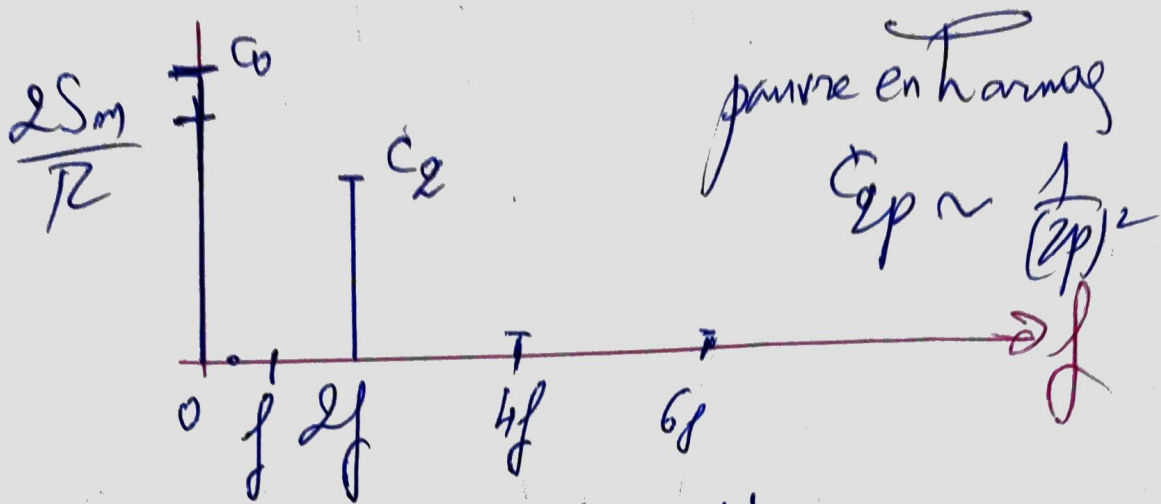
$$= \frac{2S_m}{2\pi} [1 - 1] = \frac{+2S_m}{\pi}$$

c) $V_{\text{avg}} = \frac{2S_m}{\pi} = C_0$ | $C_2 = \frac{4S_m}{\pi \cdot 3}$

$$C_{2p} = \frac{4S_m}{\pi((2p)^2 - 1)} > 0$$

$$C_4 = \frac{4S_m}{\pi \times 15}$$

$$C_6 =$$



4) $f_0 \ll 2f = 100 \text{ Hz}$

5) $Q = \frac{1}{\sqrt{2}}$

$$s(t) = \boxed{S_0} + \frac{4 S_m}{-3\pi} G(2\omega) \cos(2\omega t + \Phi)$$

↓ Modulation

a) $H = \frac{H_0}{1 - n^2 + j n \sqrt{2}}$

$$G(n) = \frac{|H_0|}{\sqrt{(1 - n^2)^2 + 2n^2}} = \frac{1}{\sqrt{1 + n^4}}$$

$$b) S_0 = \frac{2S_m}{\pi} H(0) \quad \text{pulse-bus}$$

$\hookrightarrow -1 \leq H_0$

$$G(2\omega) = \frac{1}{\sqrt{1 + \left(\frac{2\omega}{\omega_0}\right)^4}}$$

$$\Phi(2\omega) = \arg H(j2\omega)$$

$$= \arg \frac{1}{(1-x^2) + jx\sqrt{2}}; \quad x = \frac{2\omega}{\omega_0}$$

$$z = x + jy$$

$$\arg z = \operatorname{arctg}\left(\frac{y}{x}\right); \quad x > 0$$

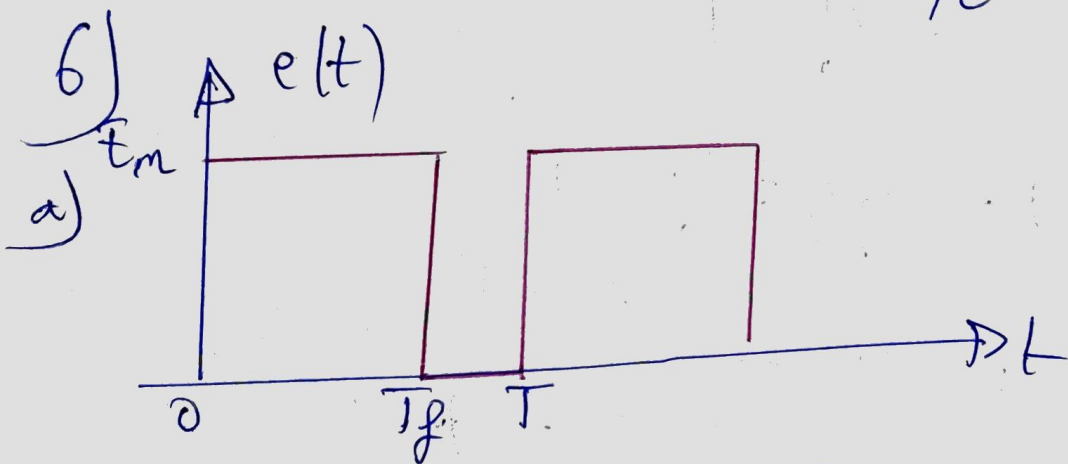
$$= \operatorname{arctg}\left(\frac{y}{x}\right) + \pi \quad x < 0$$

$$\Phi = \arg \left(\frac{j}{x\sqrt{2} + j(x^2 - 1)} \right)$$

$$= \frac{\pi}{2} - \operatorname{arctg} \left(\frac{x^2 - 1}{x\sqrt{2}} \right)$$

$$\tau_{\text{ond}} = \frac{(V_{\text{ond}})_{\text{eff}}}{V_{\text{moy}}}$$

$$\tau_{\text{ond}} = \frac{4 S_m G(2\omega)}{3\pi \sqrt{2}} \quad \frac{1}{\frac{2 S_m \times L}{\pi}} < 1\%$$



$$\frac{T_f}{T} = \alpha \text{ rapport cyclique}$$

b) $\langle e(t) \rangle = \alpha E_m$

$$\begin{aligned} \langle e(t) \rangle &= \frac{1}{T} \int_0^{T_f} E_m dt = E_m \frac{T_f}{T} \\ &= \alpha E_m \end{aligned}$$

$$A_n = \frac{1}{T} \int_0^{T_f} E_m \cos(n\omega t) dt$$

$$A_n = \frac{E_m}{T} \left[\frac{\sin(n\omega t)}{n\omega} \right]_0^{T/2}$$

$$A_n = \frac{E_m}{2\pi n} \sin(n 2\pi \alpha)$$

$$B_n = \frac{1}{T} \int_0^T E_m \sin(n\omega t) dt$$

$$C_n = \sqrt{A_n^2 + B_n^2}$$

2^{de} méthode

$$C_n = 2/|D_n|$$

$$\underline{D_n} = \frac{1}{T} \int_0^T e(t) e^{-jn\omega t} dt$$

$$= \frac{E_m}{T} \left[\frac{e^{-jn\omega t}}{-jn\omega} \right]_0^{T/2}$$

$$= \frac{E_m}{T\omega} \frac{(e^{jn\pi\alpha} - 1)}{(-jn)}$$

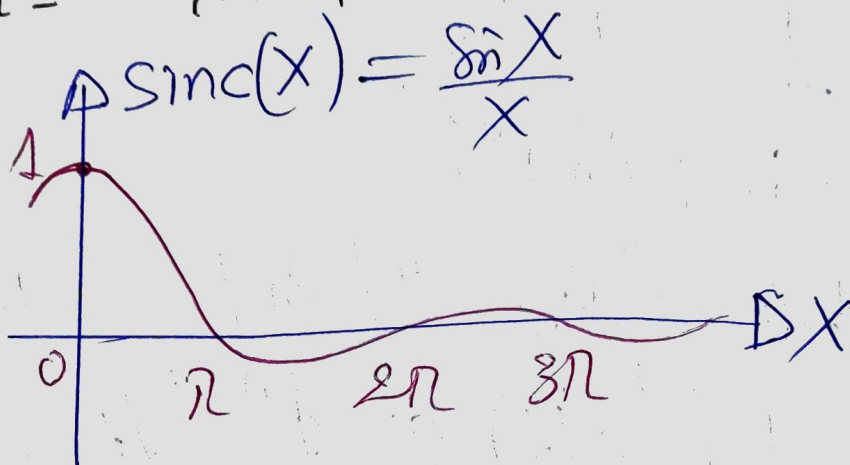
$$= \frac{E_m}{2\pi} \frac{(-2j \sin(\frac{n\pi\alpha}{2}))}{(-jn)} e^{-jn\pi\alpha/2}$$

$$\underline{D_n} = \frac{E_m}{\pi} \frac{\sin(n\pi\alpha)}{n} e^{-jn\pi\alpha/2}$$

$$C_n = \frac{2E_m}{\pi} \frac{|\sin(n\pi\alpha)|}{n}$$

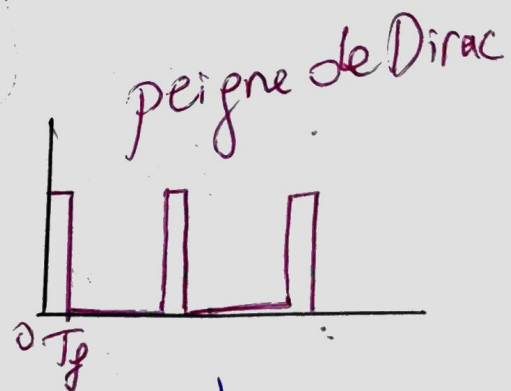
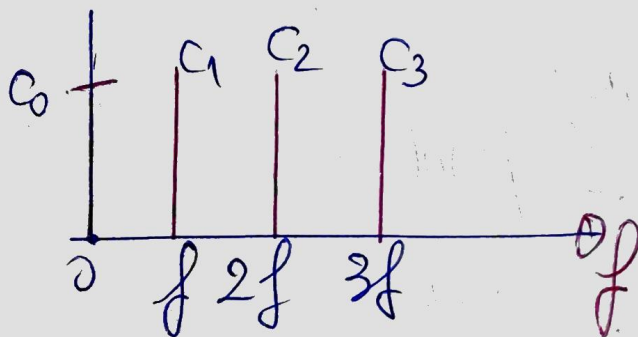
$$C_n = 2E_m\alpha \frac{|\sin(n\pi\alpha)|}{\pi n\alpha}$$

$$C_n = 2E_m\alpha |\text{sinc}(n\pi\alpha)|$$



Eq $\alpha \ll 1$

$$C_n \simeq 2E_m\alpha$$



$$p(t) = p_0 + \sum p_n \cos(n\omega t)$$

$$\omega = 80 \text{ Hz}$$

$$f = 1000 \text{ Hz}$$

$$\omega \ll f$$

$$s(t) = \alpha E_m H(\omega)$$

$$\Rightarrow s(t) = S_0 + S_1 \cos(\omega t + \Phi_1 + \arg(H_1)) + S_2 \cos(2\omega t + \Phi_2 + \arg(H_2))$$

$$S_1 = \frac{2E_m}{\pi} \left| \sin(0,8\pi) \right| \times \frac{1}{\sqrt{1 + \left(\frac{\omega}{\omega_0}\right)^4}}$$

$$S_2 = \frac{2E_m}{2\pi} \left| \sin(1,6\pi) \right| \frac{1}{\sqrt{1 + \left(\frac{2\omega}{\omega_0}\right)^4}}$$

$$\frac{S_2}{S_1} \approx 20\%$$

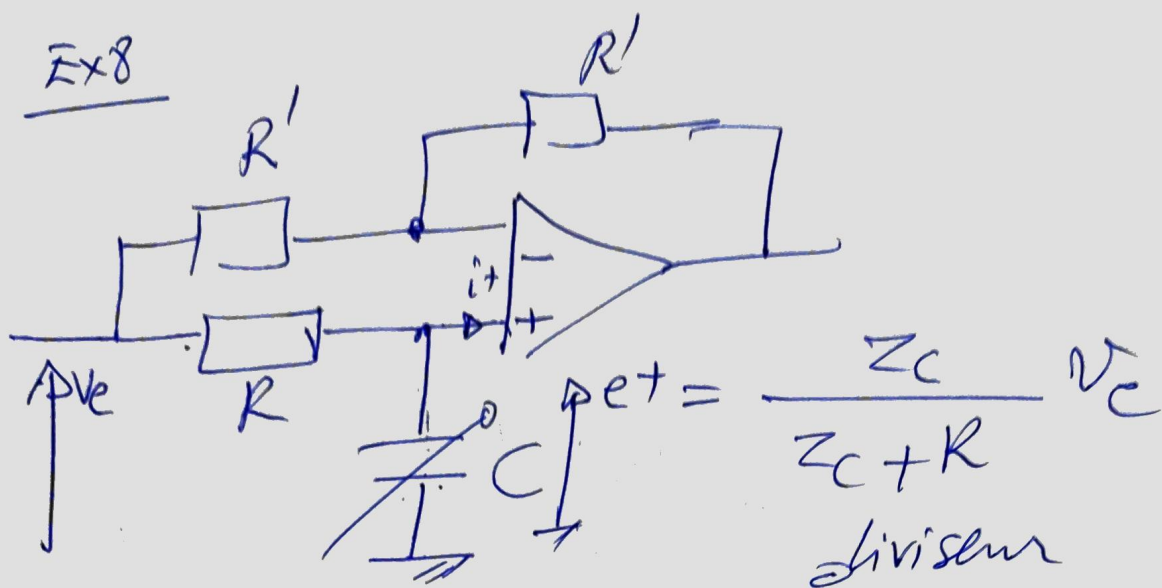
$$s(t) \approx S_0 + S_1 \cos(\omega t + \Phi_1 + \arg(H_1))$$

$$S_{\max} = S_0 + S_1$$

$$C_{\text{ond}} = \frac{2S_1}{S_0}$$

$$S_{\min} = S_0 - S_1$$

Ex 8



$$e^+ = \frac{1}{1 + R \gamma_c} v_e = \frac{1}{1 + j\omega RC} v_e$$

$$e^- \left(\frac{2}{R'} \right) = \frac{v_e}{R'} + \frac{v_s}{R'} \Rightarrow$$

$$e^- = e^+ \quad (\text{تساوی})$$

$$e^- = \frac{v_e + v_s}{2} = e^+ = \frac{v_e}{1 + j\omega RC}$$

$$(v_e + v_s)(1 + j\omega RC) = 2v_e$$

$$v_e [1 + j\omega RC - 2] + v_s (1 + j\omega RC) = 0$$

$$v_e (j\omega RC - 1) + v_s (1 + j\omega RC) = 0$$

$$\frac{v_s}{v_e} = \frac{(1 - j^x)}{(1 + j^x)} = \underline{H}$$

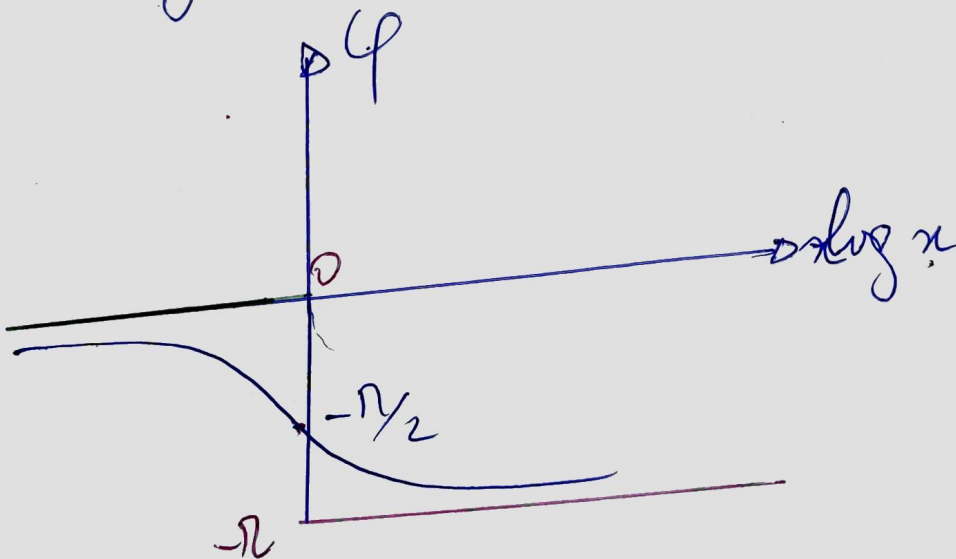
$$2) \quad x \rightarrow 0 \quad \underline{H} = 1 \quad \varphi \rightarrow 0$$

$$x \rightarrow \infty \quad \underline{H} = -1 \quad \varphi = -\pi$$

$$x \rightarrow 1, \quad \omega = \omega_0 = \frac{1}{RC}$$

$$\frac{1 - j}{1 + j} = \frac{e^{-j\pi/4}}{e^{j\pi/4}} = e^{-j\pi/2} \rightarrow 0$$

$$\arg(H(x=1)) = -\frac{\pi}{2}$$



$G(x) = 1 \quad \forall \omega$
passé fort déphasé

$$\arg H = \arg(1 - jx) - \arg(1 + jx)$$

$$\phi(x) = -2 \arctan x$$

$$\phi = -\frac{\pi}{2} \Rightarrow$$

$$x = 1 = \frac{\omega}{\omega_0} = \omega RC$$

$$\omega = \omega_0 = \frac{1}{RC}$$

$$f_0 = 100 \text{ pHz}$$

$$1 \text{ pHz} = 10^{-12} \text{ Hz}$$