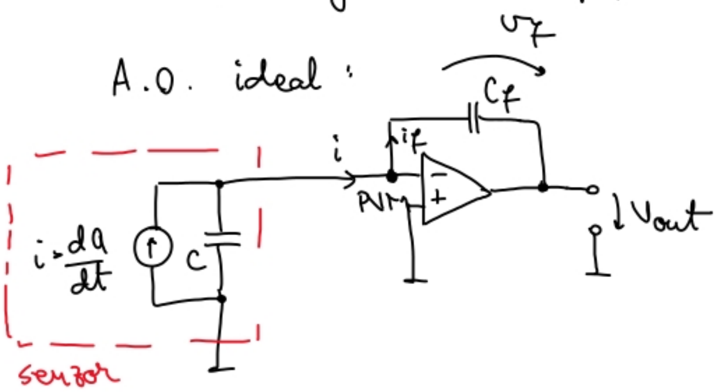
Seminar 5 SIS:

Amplificatorul de sarcină:

„charge (mode) amplifier"

A.O. ideal:



senzor piezoelectric

Dacă $\omega = 0$ (DC) $C_f \equiv R \to \infty \Rightarrow$ A.O. în saturație negativă.

presupunem $i > 0 \Rightarrow V_{out} < 0$

$$i_f = C_f \cdot \frac{dv_f}{dt} = C_f \cdot \frac{d(-v_{out})}{dt}$$

$$\left.\begin{array}{l} i_f = -C_f \cdot \dfrac{dv_{out}}{dt} \\ i = i_f \end{array}\right\} \Rightarrow \left.\begin{array}{l} i = -C_f \cdot \dfrac{dv_{out}}{dt} \\ i = \dfrac{dQ}{dt} \end{array}\right\} \Rightarrow$$

$$\Rightarrow \frac{dQ}{dt} = -C_f \cdot \frac{dv_{out}}{dt} \Rightarrow$$

$$\Rightarrow dv_{out}\, dt = -\frac{1}{C_f} \cdot dQ \cdot dt$$

$$\int_0^t dv_{out}\, dt = -\frac{1}{C_f} \underbrace{\int_0^t dQ\, dt}_{Q}$$

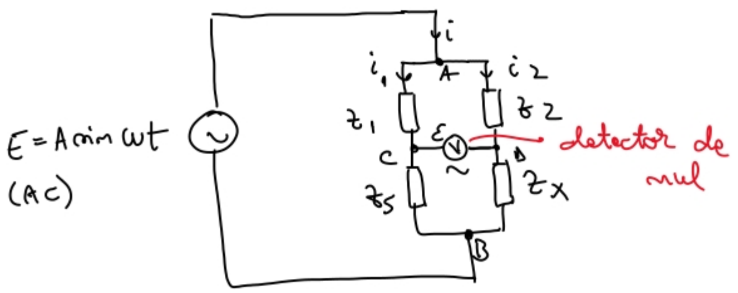
$$\boxed{v_{out} = -\frac{1}{C_f} \cdot Q}$$

$V_{out} \sim Q.$

Punți de măsură AC:

condiții:
- f = ct. sau ω = ct.
- impedanțe în cel puțin 2 brațe
- impedanța necunoscută Z_x
- impedanța standard Z_S

Puntea Wheatstone AC:



$$\mathcal{E} = V_{CB} - V_{DB}$$

$$V_{CB} = i_1 \cdot Z_S = E \cdot \frac{Z_S}{Z_1 + Z_S}$$

$$V_{DB} = i_2 Z_X = E \cdot \frac{Z_X}{Z_2 + Z_X}$$

$$E = i_1 (Z_1 + Z_S)$$

$$E = i_2 (Z_2 + Z_X)$$

$$\mathcal{E} = E\left(\frac{Z_S}{Z_1 + Z_S} - \frac{Z_X}{Z_2 + Z_X}\right)$$

La echilibru $\mathcal{E} = 0$

$$\frac{Z_S}{Z_1 + Z_S} = \frac{Z_X}{Z_2 + Z_X} \Leftrightarrow Z_S Z_2 + Z_S Z_X = Z_X Z_1 + Z_X Z_S$$

$$Z_S Z_2 = Z_X Z_1 + \cancel{Z_X Z_S} - \cancel{Z_X Z_S}$$

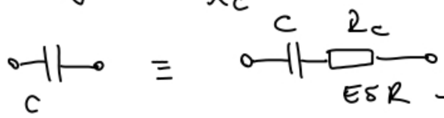
$$\boxed{Z_X = Z_S \cdot \frac{Z_2}{Z_1}}$$

OBS:
- ramuri adiacente cu același comportament (L+L sau C+C)
- ramuri opuse cu comportament complementar (L+C)

Temă 1: Demonstrați că relația $Z_X = Z_S \cdot \frac{Z_2}{Z_1}$ rămâne neschimbată dacă sursa și voltmetrul se schimbă între ele.

Pt. inductanțe $Q = \frac{X_L}{R_L}$ (factorul de calitate)

Pt. capacități $D = tg\,\delta = \frac{ESR}{X_C}$ sau $D = \frac{R_C}{X_C}$



ESR → pierderi
(equivalent series resistance)

Exemplu: $\mathcal{E}=0$ dacă $Z_1 = 5\ k\Omega$

$Z_2 = 0.5\ k\Omega$

$Z_S = 800\Omega + 10\ nF$

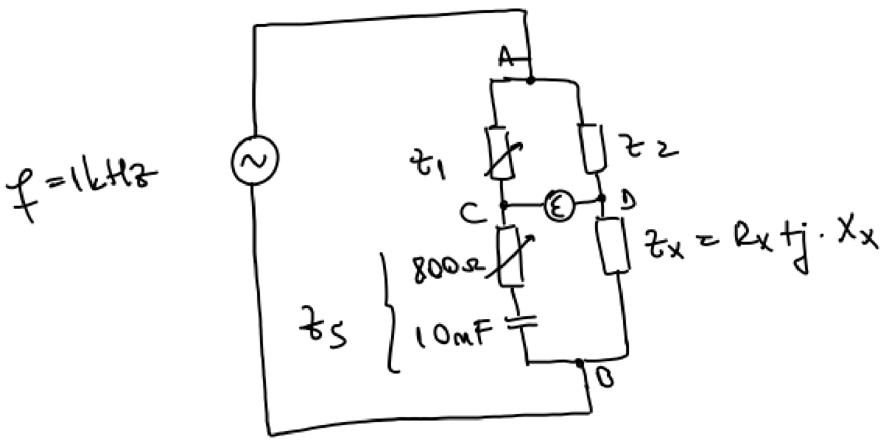
Se cere

$Z_x = ?$

$C_x = ?$

$R_x = ?$

$D = ?$



$Z = R + j \cdot X$

$$Z_x = Z_S \cdot \frac{Z_2}{Z_1} =$$

$$= Z_S \cdot \frac{0.5\ \cancel{k\Omega}}{5\ \cancel{k\Omega}}$$

$$Z_x = 0.1 Z_S = 0.1\left(800 - j \cdot \frac{1}{2\pi f C_S}\right) =$$

$$= \underbrace{80}_{R_x} - j \cdot \frac{0.1}{2\pi f C_S} = 80 + j \cdot \underbrace{\left(-\frac{0.1}{2\pi f C_S}\right)}_{X_x}$$

$R_x = 80\ \Omega$

$$X_x = -\frac{0.1}{2\pi \cdot 10^3 \cdot 10 \cdot 10^{-9}} = -\frac{1}{2\pi \cdot 10^{-4}} = -\frac{1}{2\pi} \cdot 10^4$$

$$-\frac{1}{2\pi f C_x} = -\frac{1}{2\pi} \cdot 10^4$$

$$-\frac{1}{2\pi \cdot 10^3 C_x} = -\frac{1}{2\pi} \cdot 10^4$$

$$\cancel{\frac{1}{2\pi}} \cdot 10^{-3} \cdot \frac{1}{C_x} = \cancel{\frac{1}{2\pi}} \cdot 10^4$$

$$\frac{1}{C_x} = 10^7 \Rightarrow C_x = 10^{-7} F$$

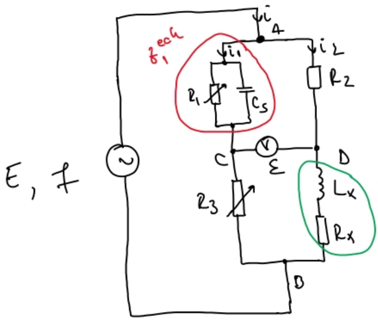
$C_x = 100\ nF$

$$D = \frac{R_x}{|X_x|} = \frac{R_x}{\frac{1}{2\pi f C_x}} = R_x \cdot 2\pi f \cdot C_x =$$

$$= 80 \cdot 2\pi \cdot 10^3 \cdot 10^{-7} = 80 \cdot 2\pi \cdot 10^{-4} = 0.05024$$

Puntea Maxwell:

→ măsurarea L_x, R_x, Q
→ nu depinde de frecvență



$$Z_x^{ech} = R_x + j\cdot X_x = R_x + j\cdot\omega\cdot L_x$$

$$\mathcal{E} = U_{CB} - U_{DB}$$

$$\left.\begin{aligned} U_{CB} &= i_1\cdot R_3 \\ E &= i_1\left(Z_1^{ech} + R_3\right)\end{aligned}\right\} \Rightarrow U_{CB} = \frac{R_3}{Z_1^{ech}+R_3}\cdot E$$

$$\left.\begin{aligned} U_{DB} &= i_2\cdot Z_x \\ E &= i_2\left(R_2 + Z_x\right)\end{aligned}\right\} \Rightarrow U_{DB} = \frac{Z_x}{R_2+Z_x}\cdot E$$

$$\mathcal{E} = E\left(\frac{R_3}{Z_1^{ech}+R_3} - \frac{Z_x}{R_2+Z_x}\right)$$

La echilibru $\mathcal{E} = 0$

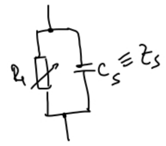
$$\frac{R_3}{Z_1^{ech}+R_3} = \frac{Z_x}{R_2+Z_x}$$

$$R_3R_2 + R_3Z_x = Z_x\left(Z_1^{ech} + R_3\right)$$

$$R_2R_3 + \cancel{R_3Z_x} = Z_xZ_1^{ech} \cancel{+Z_xR_3}$$

$$Z_x = \frac{R_2R_3}{Z_1^{ech}}$$

Z_1^{ech} →



$$\frac{1}{Z_1^{ech}} = \frac{1}{R_1} + \frac{1}{Z_S}$$

$$Z_x = R_2R_3\left(\frac{1}{R_1} + \frac{1}{Z_S}\right) =$$

$$= \underbrace{\frac{R_2R_3}{R_1}}_{R_x} + R_2R_3\cdot\left(\frac{1}{-\frac{j}{\omega C_S}}\right) =$$

$$= \frac{R_2R_3}{R_1} + j\cdot\omega C_S\cdot R_2R_3 =$$

$$= R_x + j\omega L_x$$

$$\cancel{j\omega}L_x = \cancel{j\omega}C_S\cdot R_2R_3$$

$$L_x = R_2R_3C_S$$

$$Q = \frac{X_x}{R_x} = \frac{\omega L_x}{R_x}$$

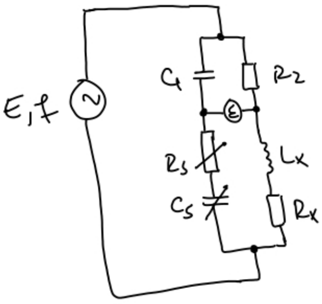
Tema 2: Punte Maxwell echilibrată ($\varepsilon = 0$)

$C_S = 0.1\,\mu F$
$R_1 = 1k\,\Omega$
$R_3 = 1.33\,k\Omega$
$R_2 = 870\,\Omega$

Se cere
$L_x = ?$
$R_x = ?$
$Q = ?$ ($f = 10\,kHz$).

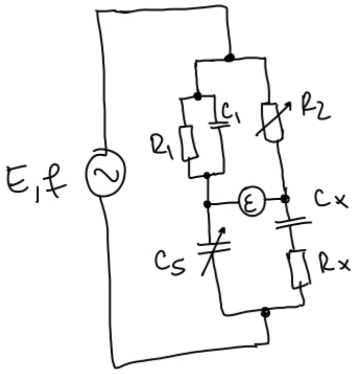
Tema 3: Puntea Owen: (det. L_x, R_x, Q)

$L_x = ?$ $R_x = ?$ $Q = ?$



Tema 4: Puntea Schering (det. C_x, R_x, D)

$C_x = ?$
$R_x = ?$
$D = ?$

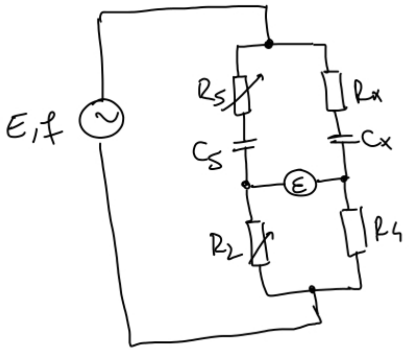


Temă BONUS (facultativă)

Puntea De Sauty (det. C_x, R_x, D)

a)

$C_x = ?$
$R_x = ?$
$D = ?$



b) $\varepsilon = 0$ atunci când

$C_S = 0.1\,\mu F$
$R_4 = 1k\,\Omega$
$R_2 = 10.25\,k\Omega$
$R_S = 2.25\,k\Omega$

$C_x = ?$
$R_x = ?$
D ($f = 10\,kHz$)