I) We are calculating the impedances related to an inductor and a capacitor. Which of the following is the correct?

A) Inductive reactance translates into a positive imaginary impedance while capacitive reactance translates into a negative imaginary impedance.
B) Both inductive and capacitive reactance translate into a positive imaginary impedance.
C) It depends on the values of the inductor and the capacitor.
D) Inductive reactance translates into a negative imaginary impedance while capacitive reactance translates into a positive imaginary impedance

II) Rapresent the following voltage sources in the phasor form.

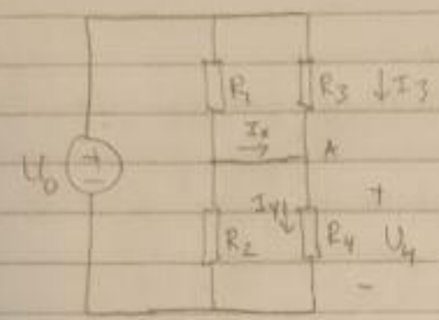
A) $u_{DC}(t) = 150 \text{ V} \rightarrow 150\angle 0° \text{ V}$
B) $u_{s1}(t) = 120\cos(100t + 45°)\ V \rightarrow 120\angle 45° \text{ V}$
C) $u_{s2}(t) = 130\sin(100t)\ V \rightarrow 130\angle -90° \text{ V}$
D) $u_{s3}(t) = 220\sin(100 * 2\pi * t + 75°)\ V \rightarrow 220\angle -15° \text{ V}$

TIP: $\sin(\omega t) = \cos(\omega t - 90°)$

III) What is the configuration of an instrumentational amplifier?

A) Two inverting amplifiers follow by a differential amplifier
B) Two buffer amplifiers follow by a non-inverting amplifier
C) Two differential amplifiers follow by a buffer
D) Two non-inverting amplifiers follow by a differential amplifier

(1)



$R_1 = 70\,\Omega$

$R_2 = 20\,\Omega$

$R_3 = 30\,\Omega$

$R_4 = 5\,\Omega$

$U_0 = 5\text{ V}$

Parallellkoppla $\quad R_{13} = R_1 /\!/ R_3 = \frac{70\cdot 30}{70+30} = 21\,\Omega$

$$R_{24} = R_2 /\!/ R_4 = \frac{20\cdot 5}{20+5} = 4\,\Omega$$

Sp. delning

$$U_4 = U_0 \, \frac{R_{24}}{R_{24}+R_{13}} = 5\cdot\frac{4}{4+21} = \frac{4}{5}\text{ V}$$

KCL i nod A $\quad I_x + I_3 - I_4 = 0$

$$I_4 = \frac{U_4}{R_4} \; ; \; I_3 = \frac{U_0 - U_4}{R_3}$$

$$I_x = I_4 - I_3 = \frac{U_4}{R_4} - \frac{U_0 - U_4}{R_3} =$$

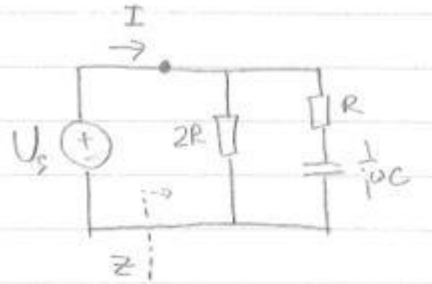
$$= \frac{4}{5\cdot 5} - \frac{\left(5 - \frac{4}{5}\right)}{30} = \frac{4}{25} - \frac{21}{5\cdot 30} =$$

$$= \frac{1}{5}\left(\frac{4}{5} - \frac{7}{10}\right) = \frac{1}{5}\left(\frac{1}{10}\right) = \frac{1}{50}\text{ A}$$

Svar: $U_4 = \frac{4}{5} = 0{,}8\text{ V}$

$I_x = \frac{1}{50} = 0.02\text{ A}$

4. jω-transformera kretsen



$u_s(t) = 12\cos(\omega t + 45^\circ)$ V

$\omega = 4000$ rad/s

$R = 2{,}0\ \Omega$

$$\frac{1}{j\omega C} = -j\frac{1}{4\cdot 10^3 \cdot 250 \cdot 10^{-6}} = -j$$

$$Z = 2R \,/\!/ \left(R + \frac{1}{j\omega C}\right) = \frac{2R\left(R + \frac{1}{j\omega C}\right)}{2R + R + \frac{1}{j\omega C}} = \frac{4(2-j)}{6-j} =$$

$$= \frac{4(2-j)(6+j)}{(6-j)(6+j)} = \frac{4(12+1-j6+j2)}{37} = \frac{4(13-j4)}{37}$$

Z mottager komplex effekt $S = P + jQ$

$$S = \frac{1}{2}U_s I^* = \frac{1}{2}U_s\left(\frac{U_s}{Z}\right)^* = \frac{1}{2}\frac{|U_s|^2}{Z^*}\cdot\frac{Z}{Z} =$$

$$= \frac{1}{2}\frac{|U_s|^2}{|Z|^2}Z$$

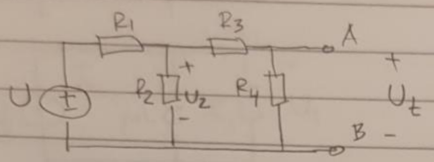
$$|Z| = \frac{4}{37}\sqrt{13^2+4^2} \approx 1{,}47$$

Medeleffekt $P = \mathrm{Re}\{S\} = \frac{1}{2}\frac{|U_s|^2}{|Z|^2}\cdot \mathrm{Re}\{Z\} =$

$$= \frac{1}{2}\frac{12^2}{1{,}47^2}\cdot\frac{4}{37}\cdot 13 = 46{,}8 \text{ W}$$

Svar: $P = 46{,}8$ W

2.



$R_1 = 200\ \Omega$
$R_2 = 300\ \Omega$
$R_3 = 60\ \Omega$
$R_4 = 220\ \Omega$
$R_5 = 100\ \Omega$
$U = 120\,V$

a) Tomgångsspänning U_t.

Sp. delning $U_2 = U \dfrac{R_2 /\!/ (R_3+R_4)}{R_1 + R_2 /\!/ (R_3+R_4)} =$

$$= U \frac{\frac{R_2(R_3+R_4)}{R_2+R_3+R_4}}{R_1 + \frac{R_2(R_3+R_4)}{R_2+R_3+R_4}} = U \frac{1}{1 + \frac{R_1(R_2+R_3+R_4)}{R_2(R_3+R_4)}} =$$

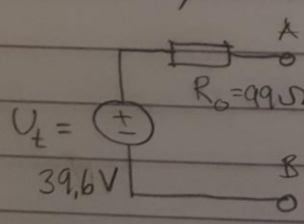
$$= U \cdot \frac{1}{1 + \frac{200(300+60+220)}{300(60+220)}} = \frac{U}{1+\frac{29}{21}} \approx 0{,}42\,U = U_2$$

$$U_t = U_2 \frac{R_4}{R_3+R_4} = \ldots = 39{,}6\,V$$

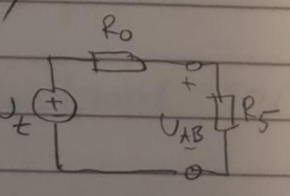
Ekv. Resistans. (Nollställ U)

$$R_0 = R_4 /\!/ (R_3 + R_1 /\!/ R_2) = \frac{R_4 \cdot \left(R_3 + \frac{R_1R_2}{R_1+R_2}\right)}{R_4 + R_3 + \frac{R_1R_2}{R_1+R_2}} = \ldots = 99\ \Omega$$

Svar a)



b)

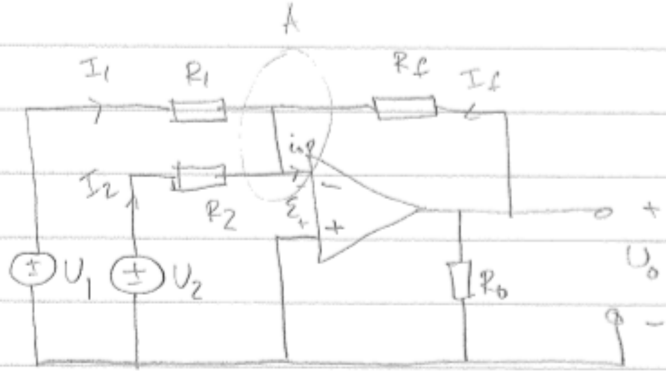


Sp. delning ger

$$U_{AB} = U_t \cdot \frac{R_5}{R_0+R_5}$$

$$\underline{\underline{U_{AB}}} = 39{,}6 \cdot \frac{100}{99+100} = \underline{\underline{19{,}9\ V}}$$

5.



$R_1 = 10\,k\Omega$

$R_2 = 20\,k\Omega$

$R_f = 30\,k\Omega$

$R_0 = 1{,}0\,k\Omega$

Ideal op. först. } Neg. återkoppl. } $\Rightarrow$ $\begin{cases} \varepsilon = 0 \\ i_{op} = 0 \end{cases}$

Summera strömmar i nod A (KCL)

$$I_1 + I_2 + I_f = 0$$

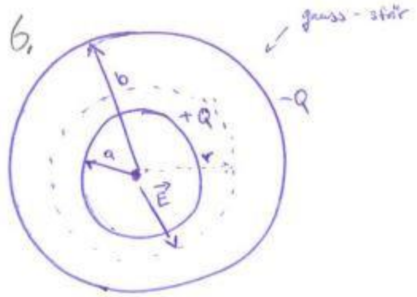
$$\frac{U_1}{R_1} + \frac{U_2}{R_2} + \frac{U_0}{R_f} = 0$$

$$U_0 = -U_1 \frac{R_f}{R_1} - U_2 \frac{R_f}{R_2} =$$

$$= -U_1 \frac{30}{10} - U_2 \frac{30}{20} = -3\left(U_1 + \frac{1}{2} U_2\right) \text{ V}$$

U_1 [V]	U_2 [V]	$U_0 = -3\left(U_1 + \frac{1}{2}U_2\right)$ [V]
1	1	−4,5
1	−1	−1,5
0	−2	3
−2	4	0

6.



a) $r < a$ $\qquad \vec{E} = 0$ $\qquad$ laddningen innesluten i en Gauss-sfär med radien r är 0

$a < r < b$ $\qquad \oiint \vec{E}\, d\vec{a} = \frac{Q}{\varepsilon_0}$

$$E\, 4\pi r^2 = \frac{Q}{\varepsilon_0}$$

$$E = 4\pi\varepsilon_0 r^2$$

riktningen : radiellt utåt $\qquad \vec{E} = \frac{Q}{4\pi\varepsilon_0 r^2}\,\hat{r}$

$r > b$ $\qquad \vec{E} = 0$

b)