Kortfattade lösningar Elektriska kretsar dec 2012

1. • $I = \dfrac{15V - 9V}{200\Omega + 200\Omega + 100\Omega} = \underline{12mA}$

• $U = 200\Omega \cdot 12mA = \underline{2,4V}$

• $V_A = 0 + 100\Omega \cdot 12mA + 9V = \underline{10,2V}$

2a. Läge 2. Då blir $U_{BE} = 0$. Transistorn strypt!

2b. $R_B = \dfrac{16V - 0,7V}{I_B} - 560\Omega$, $I_B = \dfrac{I_C}{45}$

$I_C = \dfrac{9W}{16V} = 562,5mA \Rightarrow I_B = 12,5mA \Rightarrow$

$R_B \leq \dfrac{15,3V}{12,5mA} - 560\Omega = \underline{664\Omega}$

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3. Summatorkoppling $\Rightarrow$

$U_2 = -\dfrac{100k\Omega}{5k\Omega} \cdot (-0,175V) - \dfrac{100k\Omega}{20k\Omega} \cdot E = \underline{3,5V - 5 \cdot E}$

a. $E = 1,5V \Rightarrow U_2 = 3,5V - 5 \cdot 1,5V = \underline{-4V}$

b. $-15V \leq U_2 \leq 15V \Rightarrow$

$-15V \leq 3,5V - 5 \cdot E \leq 15V \Leftrightarrow$

$-11,5V \leq 5E \leq 18,5V$

$\underline{-2,3V \leq E \leq 3,7V}$

4a. Komplext:

$$u(t) = 10\sin(\omega t + 23^\circ)\,V \longleftrightarrow U = 10\,e^{j(\omega t + 23^\circ)}\,V$$

$$i(t) = |I|\sin(\omega t + \beta) \longleftrightarrow I = |I|\,e^{j(\omega t + 23^\circ)}$$

$$R = 820\,\Omega \longleftrightarrow 820$$

$$C = 680\,nF \longleftrightarrow \frac{1}{j\omega C} = -j\,\frac{1}{600 \cdot 680 \cdot 10^{-9}} = -j2451$$

$$\cdot\ I = \frac{U}{Z}\,;\quad Z = 820 - j2451\,\Omega = 2585 \cdot e^{-j71,5^\circ}\,\Omega \Longrightarrow$$

$$I = \frac{10\,e^{j(\omega t + 23^\circ)}\,V}{2585\,e^{-j71,5^\circ}\,\Omega} = 3,87\,e^{j(\omega t + 94,5^\circ)}\,mA \Longrightarrow$$

$$\underline{i(t) = 3,87 \cdot \sin(600t + 94,5^\circ)\,mA}$$

4b.

$$Z = R + \frac{1}{j\omega C} = R - j\,\frac{1}{\omega C}$$

$i(t)$ 30° före $u(t)$ $\Longrightarrow$ $\arg Z = -30^\circ$ $\Longrightarrow$

$$\frac{\frac{1}{\omega C}}{R} = \tan 30^\circ \Longrightarrow \underline{\omega} = \frac{1}{RC \cdot \tan 30^\circ} =$$

$$= \frac{1}{820 \cdot 680 \cdot 10^{-9} \cdot \tan 30^\circ}\,rad/s = \underline{3106\,rad/s}$$

5. Max-effekt om $R = 20\Omega$. Då blir strömmen genom R 1A $\Rightarrow$

$$P_{max} = 20\Omega \cdot (1A)^2 = \underline{\underline{20W}}$$

6a $P = U_e \cdot I_e \cdot \cos\varphi$

$$U_e = \frac{100V}{\sqrt{2}} \; ; \quad I_e = \frac{15A}{\sqrt{2}} \; ; \quad \varphi = \frac{1}{3} \cdot 180^\circ = 60^\circ \Rightarrow$$

$$P = \frac{100V}{\sqrt{2}} \cdot \frac{15A}{\sqrt{2}} \cdot \cos 60^\circ = \underline{\underline{375W}}$$

6b. $T = 20ms \Rightarrow f = \frac{1}{T} = \underline{\underline{50Hz}} \Rightarrow \omega = 2\pi f = \underline{\underline{314 rad/s}}$

6c. Strömmen ligger efter spänningen.

6d. $$|Z| = \frac{|U|}{|I|} = \frac{100V}{15A} = 6{,}67\Omega \; ; \quad \varphi = 60^\circ \Rightarrow$$

$$Z = 6{,}67 \cdot e^{j60^\circ}\,\Omega = 3{,}33\Omega + j\,5{,}77\Omega = R + j\omega L \Rightarrow$$

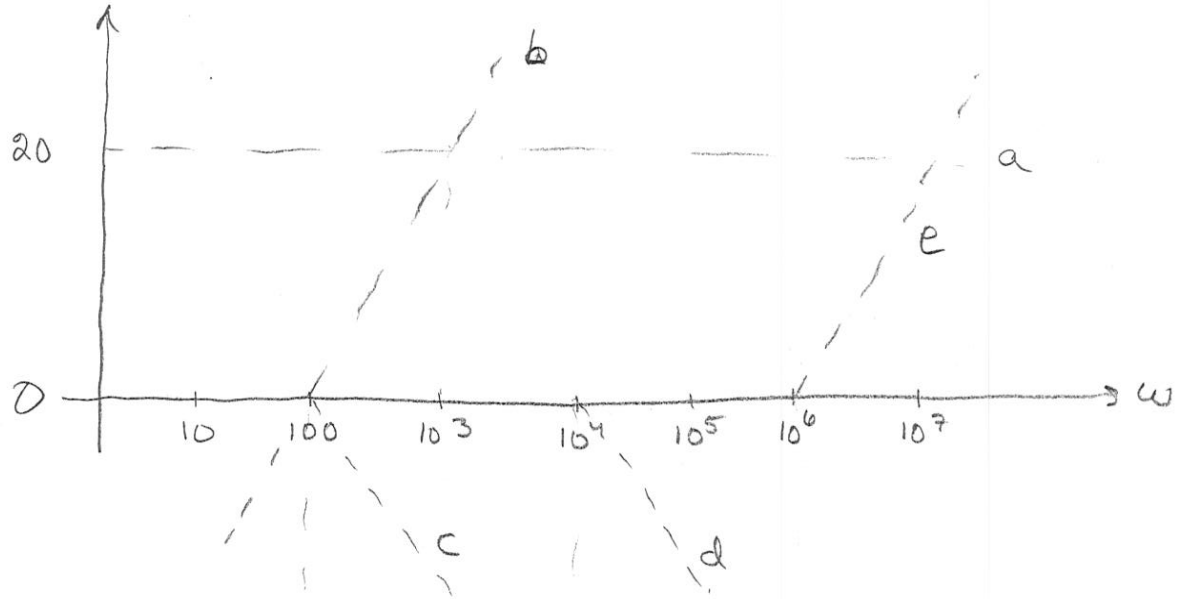
$$\underline{\underline{R = 3{,}33\Omega}} \qquad \omega L = 5{,}77\Omega \Rightarrow$$

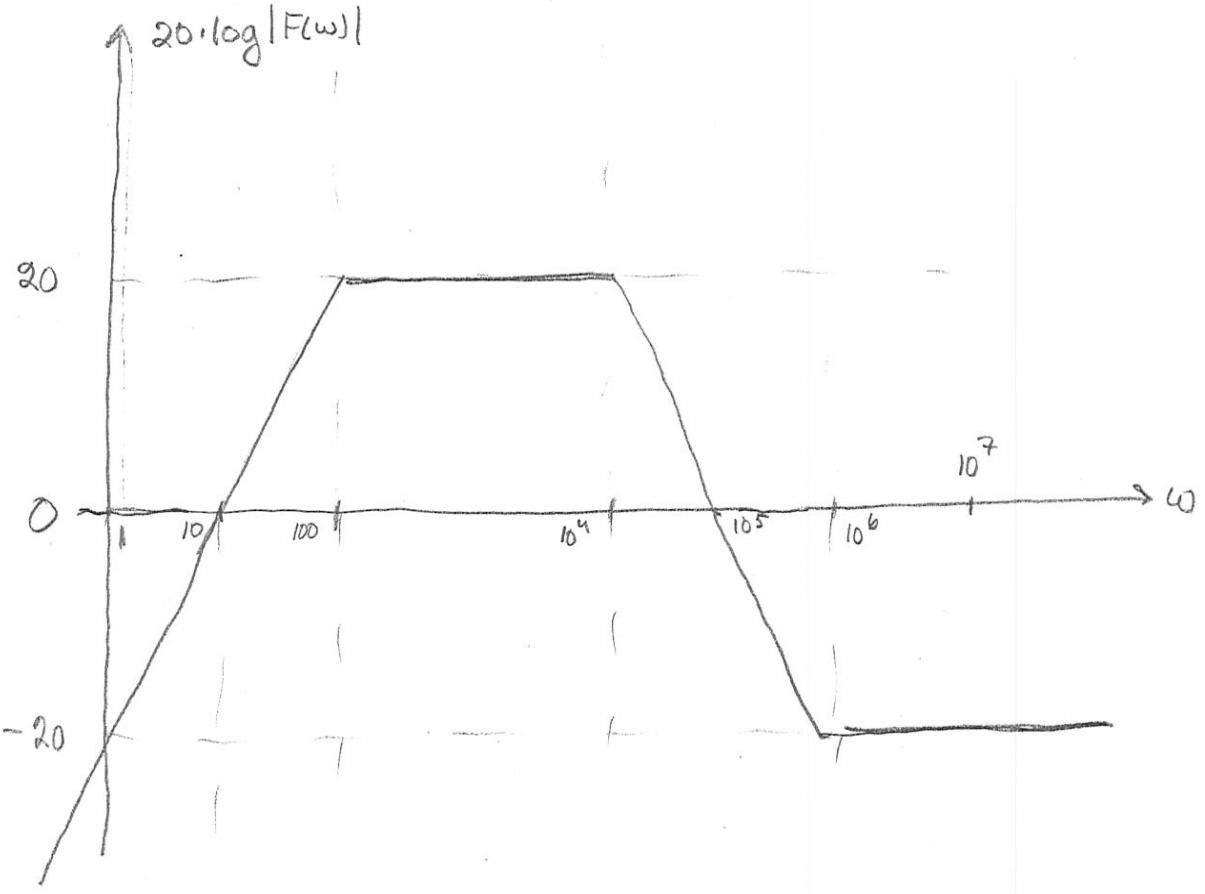
$$L = \frac{5{,}77\Omega}{314 rad/s} = \underline{\underline{18{,}4mH}}$$

7.

$$F(\omega) = 10 \cdot \frac{j\omega \cdot \left(1 + j\frac{\omega}{10^6}\right)}{10\left(1 + j\frac{\omega}{100}\right) \cdot 10\left(1 + j\frac{\omega}{10^4}\right)} =$$

$$= \frac{100}{10} \cdot \frac{j\frac{\omega}{100}\left(1 + j\frac{\omega}{10^6}\right)}{\left(1 + j\frac{\omega}{100}\right)\left(1 + j\frac{\omega}{10^4}\right)} = \underset{a}{10} \cdot \frac{\overset{b}{j\frac{\omega}{100}} \cdot \overset{e}{\left(1 + j\frac{\omega}{10^6}\right)}}{\underset{c}{\left(1 + j\frac{\omega}{100}\right)}\underset{d}{\left(1 + j\frac{\omega}{10^4}\right)}}$$





8. Icke-inverterande koppling $\Rightarrow$

- $F(\omega) = \dfrac{R_1 + Z}{R_1}$

- $Z = R_2 // \dfrac{1}{j\omega C_2} = \dfrac{R_2 \cdot \frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}} = \dfrac{R_2}{1 + j\omega R_2 C_2} \Rightarrow$

$$F(\omega) = \frac{R_1 + \frac{R_2}{1+j\omega R_2 C_2}}{R_1} = \frac{R_1 + R_2 + j\omega R_1 R_2 C_2}{R_1(1+j\omega R_2 C_2)} =$$

$$= \frac{R_1 + R_2}{R_1} \cdot \frac{1 + j\omega \frac{R_1 R_2}{R_1 + R_2} \cdot C_2}{1 + j\omega R_2 C_2} =$$

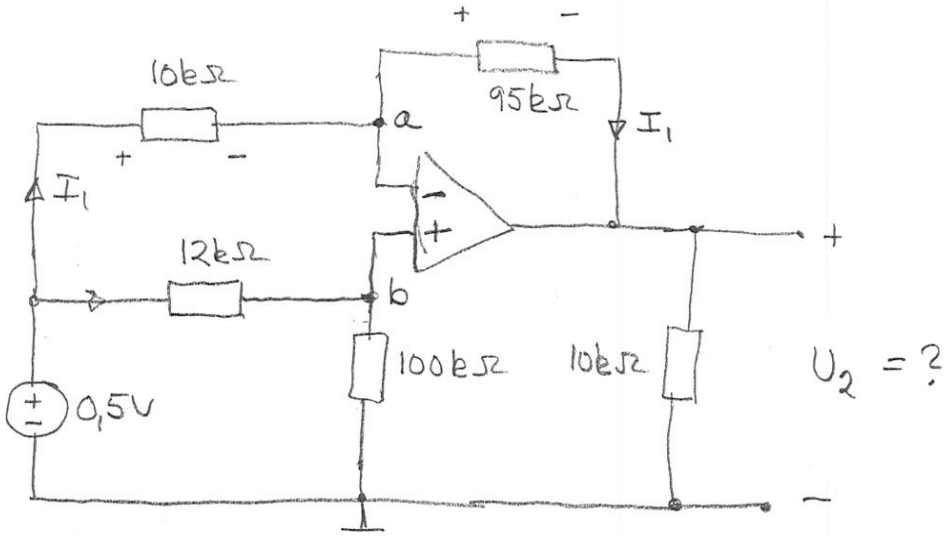
$$= 101 \cdot \frac{1 + j\frac{\omega}{55101}}{1 + j\frac{\omega}{546}} \Rightarrow$$

$\underline{K = 101}$

$\omega_1 = 55{,}1$ krad/s

$\omega_2 = 546$ rad/s

9.



Ideal motkopplad OP ⇒ • $V_a = V_b$

• strömmar = 0

• $U_2 = V_a - 95k\Omega \cdot I_1$

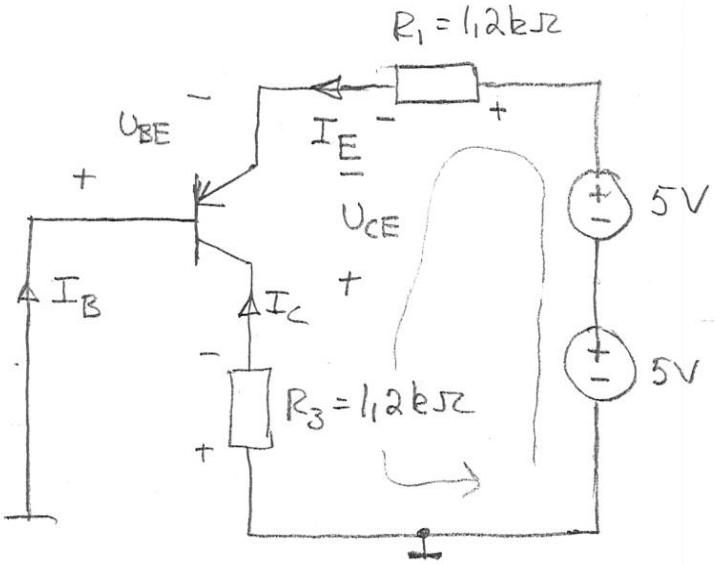
• $I_1 = \frac{0,5V - V_a}{10k\Omega}$

• $V_a = V_b = \frac{100k\Omega}{100k\Omega + 12k\Omega} \cdot 0,5V = 0,4464V$ (spänningsdelning)

$\Rightarrow I_1 = \frac{0,5V - 0,4464V}{10k\Omega} = 5,357\mu A \Rightarrow$

$U_2 = 0,4464V - 95k\Omega \cdot 5,357\mu A = \underline{-62,5mV}$

10 a



$h_{FE} = 20$

$U_{BE} = -0{,}7V$

$I_C = h_{FE} \cdot I_B = 20\, I_B \Rightarrow I_E = -21\, I_B$

KVL : $+5V + 5V - 1{,}2k\Omega \cdot I_E + U_{CE} + 1{,}2k\Omega \cdot I_C = 0 \Rightarrow$

$U_{CE} = -10V + 1{,}2k\Omega (I_E - I_C)$

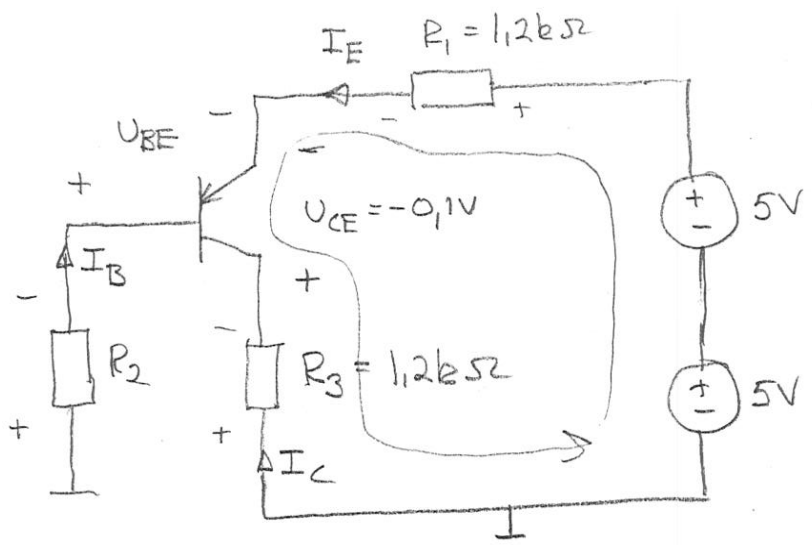
KVL ger I_E : $10V - 1{,}2k\Omega \cdot I_E + U_{BE} = 0 \Rightarrow$

$I_E = \frac{10V + (-0{,}7V)}{1{,}2k\Omega} = 7{,}75mA \Rightarrow I_B = -0{,}37mA \Rightarrow I_C = -7{,}38mA$

$\Rightarrow U_{CE} = -10V + 1{,}2k\Omega (7{,}75mA + 7{,}38mA) = 8{,}16V$

$U_{CE} > -0{,}1V \Rightarrow$ bottnad

10b.



$$I_C = 20\,I_B \;;\; I_E = -21\,I_B \Rightarrow I_E = -\frac{21}{20}\,I_C$$

KVL: $+5V + 5V - 1{,}2k\Omega \cdot I_E + U_{CE} + 1{,}2k\Omega \cdot I_C = 0 \Rightarrow$

$$1{,}2k\Omega\,(I_C - I_E) = -10V - U_{CE} = -9{,}9V \Rightarrow$$

$$1{,}2k\Omega\left(I_C + \frac{21}{20}\,I_C\right) = -9{,}9V \Rightarrow I_C = -4{,}02mA$$

$$\Rightarrow I_E = 4{,}23mA \;;\; I_B = -0{,}201mA$$

KVL i basbretsen ger

$$+10V - 1{,}2k\Omega \cdot I_E + U_{BE} + R_2 I_B = 0 \Rightarrow$$

$$10V - 1{,}2k\Omega \cdot 4{,}23mA - 0{,}7V + R_2 \cdot (-0{,}201mA) = 0 \Rightarrow$$

$$R_2 = \frac{10V - 1{,}2k\Omega \cdot 4{,}23mA - 0{,}7V}{0{,}201mA} = \underline{21k\Omega}$$

Detta är gränsfallet $\Rightarrow$

Transistorn bottnad för $R_2 < 21k\Omega$

11a Komplext

$$e(t) = 10\sin(10^4 t + 20^\circ)\,V \iff \underline{E} = 10\,e^{j(10^4 t + 20^\circ)}\,V$$

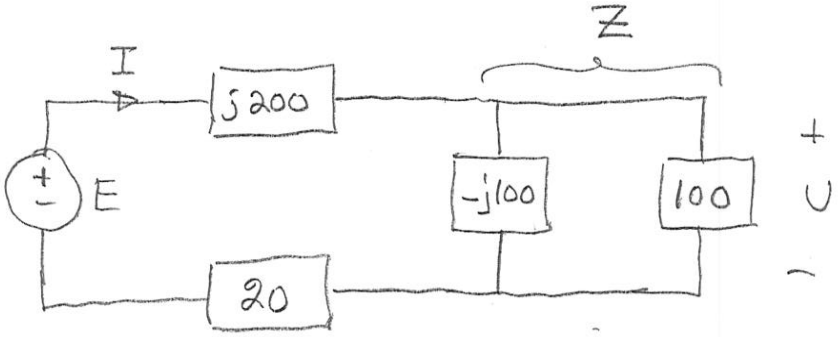
$$u(t) = |U|\sin(10^4 t + \alpha) \iff U = |U|\,e^{j(10^4 t + \alpha)}$$

$$L \iff j\omega L = j10^4 \cdot 20\cdot 10^{-3} = j200$$

$$C \iff \frac{1}{j\omega C} = -j\frac{1}{10^4 \cdot 10^{-6}} = -j100$$

$$R_1 \iff 20$$

$$R_2 \iff 100$$



$$U = \frac{Z}{Z + j200 + 20}\cdot E;\quad Z = 100 /\!/ -j100 = \frac{100\cdot(-j100)}{100 - j100} =$$

$$= \frac{-j100}{1-j} = 50 - j50 = 50\sqrt{2}\cdot e^{-j45^\circ} \Longrightarrow$$

$$U = \frac{50\sqrt{2}\,e^{-j45^\circ}}{50 - j50 + j200 + 20}\cdot E = \frac{50\sqrt{2}\,e^{-j45^\circ}}{70 + j150}\cdot E =$$

$$= \frac{50\sqrt{2}\,e^{-j45^\circ}}{165{,}5\,e^{j65^\circ}}\cdot 10\cdot e^{j(10^4 t + 20^\circ)}\,V = 4{,}27\cdot e^{j(10^4 t - 90^\circ)}\,V \Longrightarrow$$

$$\underline{u(t) = 4{,}27\cdot\sin(10^4 t - 90^\circ)\,V}$$

11b. Fasförskjutning mellan $e(t)$ och $i(t)$ $20^\circ \Rightarrow$

$$\arg Z_{TOT} = \pm 20^\circ$$

$$Z_{TOT} = R_1 + j\omega L + Z = 20 + j10^4 L + 50 - j50 =$$

$$= 70 + j(10^4 L - 50) \Rightarrow$$

$$\frac{10^4 L - 50}{70} = \pm \tan 20^\circ = \pm 0{,}364 \Rightarrow$$

$$10^4 L - 50 = \pm 25{,}48 \Rightarrow$$

$$10^4 L = 50 \pm 25{,}48 = \begin{cases} 75{,}48 \\ 24{,}52 \end{cases} \Rightarrow$$

$L = 7{,}55$ mH eller $L = 2{,}45$ mH

induktiv krets
$i(t)$ 20° efter $e(t)$

kapacitiv krets
$i(t)$ 20° före $e(t)$