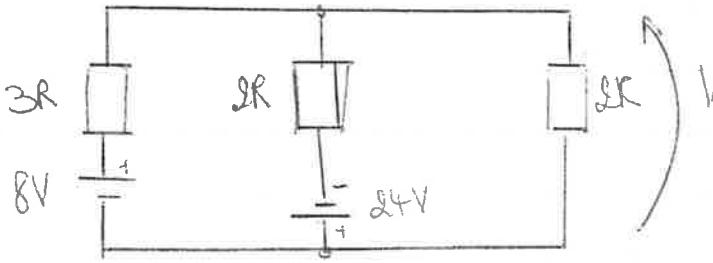
Oefeningen Hoofdstuk 3

Oef 1



$R = 250\,\Omega$

① parallelschakeling $3R // 2R$

$$\frac{1}{R_{tot}} = \frac{1}{2R} + \frac{1}{3R} = \frac{5}{6R}$$

$$\Rightarrow R_{tot} = \frac{6}{5}R$$

② ~~parallelschak. $\frac{6}{5}R // 2R$~~ spanningsdeler

$$V_1 = \frac{6/5R}{2R + \frac{6}{5}R} \cdot 24V = -9V$$

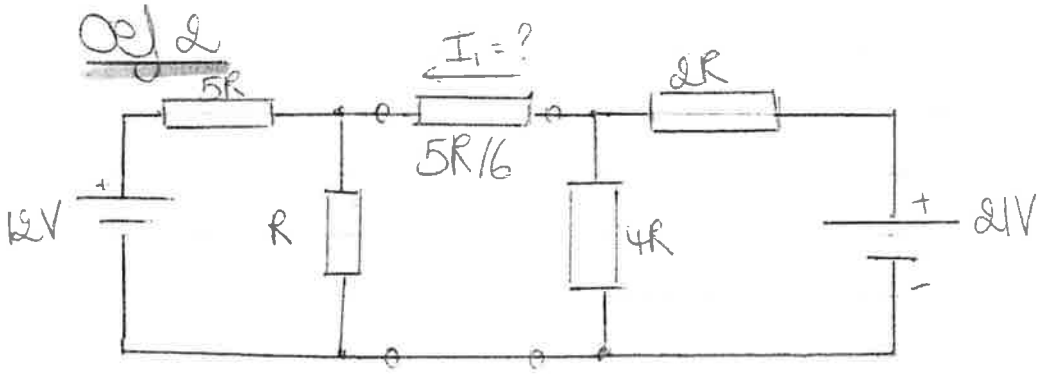
③ parallel $2R // 2R$

$R_{tot} = R$

④ spanningsdeler : $V_1 = \frac{R}{4R} \cdot 8V = 2V$

$$\Rightarrow V_1 = -9V + 2V = -7V$$

Oef 2

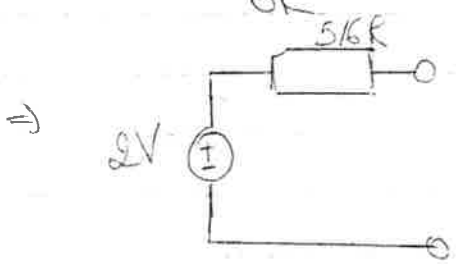


$R = 50\,\Omega$

① Thévenin - equivalent

$1/R_T = \frac{1}{5R} + \frac{1}{R} = \frac{6}{5R} \Rightarrow R_T = \frac{5}{6}R$

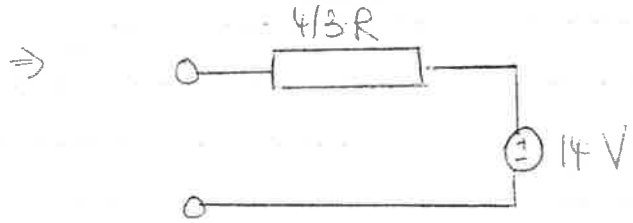
$V_T = \frac{R}{6R} \cdot 12V = 2V$



② Thévenin - equivalent

$1/R_T = \frac{1}{4R} + \frac{1}{2R} = \frac{3}{4}R \Rightarrow R_T = \frac{4}{3}R$

$V_T = \frac{4R}{6R} \cdot 21V = 14V$



③ Serieschakeling: $R = \frac{5}{6}R + \frac{4}{3}R + \frac{5}{6}R = 3R$

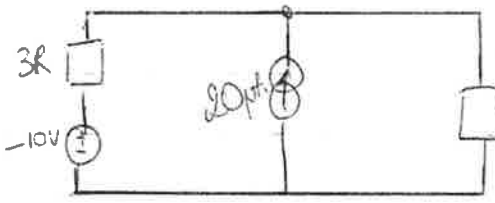
④ superpositie:

$+ I = \frac{V}{R} = \frac{14V}{150\Omega} = 9 \cdot 10^{-2}$

$+ I = \frac{-2V}{150\Omega} = -0,013.$

$\Rightarrow I = 0,08 = 80\ mA$

Oef 3



$R = 500\,k\Omega$

~~① Thévenin-equivalent~~
~~$R_T = 3R$~~

① Stroombron = open keten
+ Serie $R = 4R$

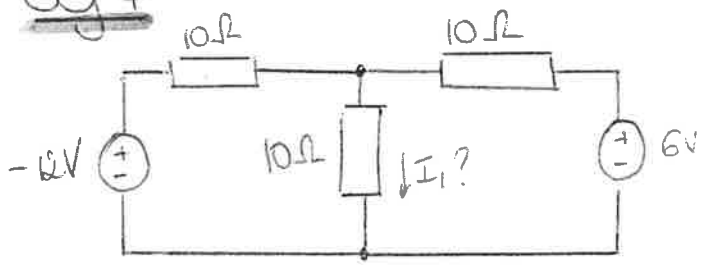
$$I = \frac{V}{R} = \frac{-10V}{4R} = \frac{-10\,V}{2000\,k\Omega} = -5\,\mu A$$

② Spanningsbron = kortsluiting
+ stroomdeler:

$$I_1 = \frac{3R}{4R} \cdot 20\,\mu A = 15\,\mu A$$

③ $I_1 = -5\,\mu A + 15\,\mu A = 10\,\mu A$

Oef 4



→ superpositie

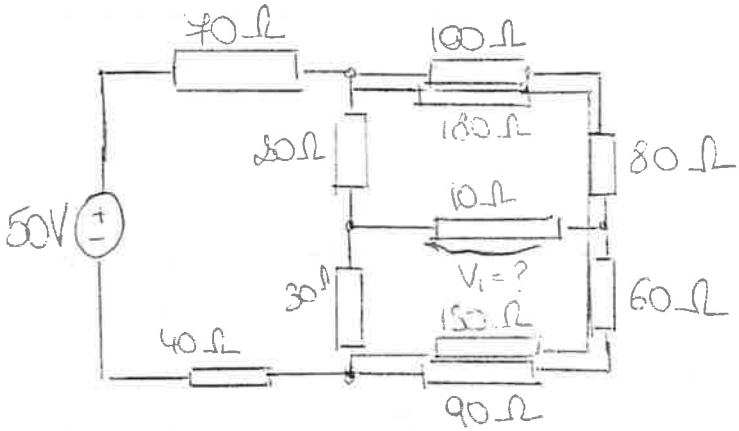
① parallel : $1/R_T = 1/10 + 1/10 = 2/10 \Rightarrow R_T = 5\,\Omega$
→ Spanningsdeler : $V_1 = \frac{5\,\Omega}{15\,\Omega} \cdot -2V = -4V$

② Parallel : $1/R_T = 2/10 \Rightarrow R_T = 5\,\Omega$
→ $V_1 = \frac{5\,\Omega}{15\,\Omega} \cdot 6V = 2V$

$$\Rightarrow V_1 = -4V + 2V = -2V$$

$$I = \frac{V}{R} = \frac{-2V}{10\Omega} = -0{,}2A = -200\,mA$$

Oef 5



① 2x serie: $R_1 = 100\Omega + 80\Omega = 180\Omega$

$R_2 = 90\Omega + 60\Omega = 150\Omega$

② parallel: $\frac{1}{R_3} = \frac{1}{30} + \frac{1}{150} = \frac{1}{25} \Rightarrow R_3 = 25\Omega$

$\frac{1}{R_4} = \frac{1}{20} + \frac{1}{180} = \frac{1}{18} \Rightarrow R_4 = 18\Omega$

$\frac{1}{R_5} = \frac{1}{40} + \frac{1}{25} = \frac{13}{200} \Rightarrow R_5 = 200/13\,\Omega$

$\frac{1}{R_6} = 1/18 + 1/70 = \frac{22}{315} \Rightarrow R_6 = 315/22\,\Omega$

$\frac{1}{R_7} = \frac{13}{200} + \frac{22}{315} \Rightarrow R_7 =$

ej 6

* $1/R_T =$

* Serie : $R_{tot} = 50 + 50 = 100$

* Thévenin : $1/R_T = \frac{1}{100} + \frac{1}{100} \Rightarrow R_T = 50$

$$V_T = \frac{100}{200} \cdot 20 = 10V$$

* Serie : $R_{tot} = 50 + 25 + 25 = 100$

ej 8

* Thévenin : $1/R_T = \frac{1}{30} + \frac{1}{30} = \frac{2}{30} \Rightarrow R_T = 15\,\Omega$

$$V_T = \frac{30}{60} \cdot 48V = 24V$$

* Serie : $R_{tot} = 15\,\Omega + 15\,\Omega = 30\,\Omega$

* Thévenin : $1/R_T = \frac{1}{30} + \frac{1}{30} \Rightarrow R_T = 15\,\Omega$

$$V_T = \frac{30}{60} \cdot 24V = 12V$$

* Serie : $R_{tot} = 15\,\Omega + 15\,\Omega = 30\,\Omega$
* Thévenin : $1/R_T = \frac{1}{30} + \frac{1}{30} \Rightarrow R_T = 15\,\Omega$
$V_T = 6V$
* Serie : $R_{tot} = 30\,\Omega$
* Thévenin : $1/R_T = \frac{1}{30} + \frac{1}{15} \Rightarrow R_T = 10\,\Omega$

$$V_T = \frac{15}{45} \cdot 6V = 2V$$

Ex 8

$$\frac{1}{R_1} = \frac{2}{15} \Rightarrow R_1 = \frac{15}{2}$$

$$\frac{1}{R_2} = \frac{2}{15} + \frac{1}{30} = \frac{5}{30} \Rightarrow R_2 = 6$$

$$\frac{1}{R_3} = \frac{1}{15} + \frac{1}{6} = \frac{7}{30} \Rightarrow R_3 = \frac{30}{7}$$

$$\frac{1}{R_4} = \frac{7}{30} + \frac{1}{30} = \frac{8}{30} \Rightarrow R_4 = \frac{30}{8} = \frac{15}{4}$$

$$\frac{1}{R_5} = \frac{1}{15} + \frac{4}{15} = \frac{5}{15} \Rightarrow R_5 = 3$$

$$\frac{1}{R_6} = \frac{1}{30} + \frac{1}{3} \Rightarrow R_6 = \frac{30}{11}$$

$$\frac{1}{R_7} = \frac{1}{30} + \frac{11}{30} \Rightarrow R_7 = \frac{30}{12} = \frac{15}{6} = \frac{5}{2}$$

oefeningen hoofdstuk 4

oef 1

1) + knooppunt: $-i_{R_1} + I_A - i_L = 0$

$\Rightarrow i_{R_1} = I_A - i_L$

lusregel: $R_1 . i_{R_1} + R_2 i_{R_2} - V_L = 0$

formule spoel: $V_L(t) = L . \frac{d i_L(t)}{dt}$

$\Leftrightarrow R_1 I_A - R_1 i_L - R_2 i_{R_2} - L \frac{d i_L(t)}{dt} = 0$

$R_1 I_A = (R_1 + R_2) i_L + L \frac{d i_L(t)}{dt}$ (LINVCC)

① K.V.: $L . \lambda + R_1 + R_2 = 0$

$\lambda = -\frac{(R_1 + R_2)}{L} = -\frac{1}{\tau}$ met $\tau = \frac{L}{R_1 + R_2}$

A.O.: $i_L = B . e^{-t/\tau}$

② $e(t) = \frac{R_1 I_A}{R_1 + R_2}$

③ A.O.: $i_L = B . e^{-t/\tau} + \frac{R_1 I_A}{R_1 + R_2}$

④ B? $i_L(0) = 0 \Rightarrow 0 = B + \frac{R_1 I_A}{R_1 + R_2}$

$B = -\frac{R_1 I_A}{R_1 + R_2} = -0,01 = -10\,mA$

$i_L(t) = -10\,mA . e^{-t/\tau} + 10\,mA$

$= 10\,mA (1 - e^{-t/\tau})$

2) $V_L(t) = L \cdot \frac{di_L(t)}{dt} = -L \cdot \frac{R_1 I_A}{R_1 + R_2} \cdot \left(\frac{-1}{\tau}\right) \cdot e^{-t/\tau}$

$= +L \frac{R_1 I_A}{R_1 + R_2} \cdot \frac{R_1 + R_2}{L} \cdot e^{-t/\tau}$

$= 20V \cdot e^{-t/\tau}$

3) $t_1 = 1\mu s \cdot \ln(2)$

$\Rightarrow \frac{-t_1}{1\mu s} = -\ln 2$

$e^{-t_1/\tau} = e^{-\ln 2} = \frac{1}{2}$

$i_L(t) = 10mA\left(1 - \frac{1}{2}\right) = 5mA$

$V_L(t) = 10V$

Oef 2

1) ~~$V_2(t)$ dusver: $V_A - V_{C1} - V_{C2} = 0$~~ dusver: $V_A - V_{R1} - V_2 = 0$

~~$V_A = V_{C1} + V_{C2}$~~

$V_{R1} = V_A - V_2$

$V_2 = V_{R2}$

$V_A - V_1 - V_2 = 0$

$V_2 = V_A - V_2$

~~$V_{C1} = E$~~

Knoopsver: $i_{R1} + i_{C1} = i_{R2} + i_{C2}$

$\frac{V_{R1}}{R_1} + C_1 \frac{dV_{C1}}{dt} = \frac{V_{R2}}{R_2} + C_2 \cdot \frac{dV_{C2}}{dt}$

$R_1 = R_2$ ↓

dusver ↓

$\frac{1}{R}(V_{R1} - V_{R2}) = C_1\left(\frac{dV_2}{dt} - \frac{dV_1}{dt}\right)$

$\frac{1}{R}(V_A - 2V_2) = C\left(\frac{dV_2}{dt} - \frac{d(V_A - V_2)}{dt}\right)$

Oef 3

a) $V_{th} = V_C + R_1 \cdot i_1$

$= V_C + R_1 \cdot C \cdot \frac{dV_C(t)}{dt}$

① K.V. : $1 + R_1 \cdot C \cdot \lambda = 0$

$\lambda = -\frac{1}{R_1 C} = -\frac{1}{\tau}$ met $\tau = R_1 \cdot C$

$= 120\ \mu s$

② A.O. $V_C(t) = B \cdot e^{-t/\tau}$

③ $e(t) = \frac{V_{th}}{1} = 20\ V$

④ A.O. : $V_C(t) = B \cdot e^{-t/\tau} + 20\ V$

⑤ Beginvoorwaarden : $V_C(0) = B + 20\ V = 0$

$\Rightarrow B = -20\ V$

$V_C(t) = -20V \cdot e^{-t/\tau} + 20\ V = 20V(1 - e^{-t/\tau})$

$V_C(t_1) = 120\ \mu s \cdot \ln 2$

$\frac{t_1}{120} = \ln 2$

$\Rightarrow e^{-t_1/\tau} = \frac{1}{2} \Rightarrow V_C(t_1) = 20V\left(1 - \frac{1}{2}\right) = 10V$

b) $V_{th} = V_C + R_1 \cdot i_1 + R_1\ i_2$

$= V_C + R_1 \cdot C \cdot \frac{dV_C(t)}{dt} + \frac{V_C}{R_2} \cdot R_1 = V_C\ \frac{R_2 + R_1}{R_2} + R_1 C \frac{dV_C}{dt}$

① K.V. $\frac{R_2 + R_1}{R_2} + R_1 C \lambda = 0$

$\Rightarrow \lambda = -\frac{(R_2 + R_1)}{R_2 R_1 C} = -\frac{1}{\tau}$ met $\tau = \frac{R_2 R_1 C}{R_2 + R_1}$

$= 30\ \mu s$

A.O. : $V_C(t) = A \cdot e^{-t/\tau}$

② $e(t) = V_A \cdot \frac{R_2}{R_1+R_2} = 5V$

A.O. $A \cdot e^{-\frac{(t-t_1)}{\tau}} + 5V = V_C(t)$

③ Beginvoorwaarden: $0 = A \cdot e^{-(0-t_1)/\tau} + 5V$

$\Rightarrow A = +5V$

$\Rightarrow V_C(t) = 5V(1 + e^{-t/\tau})$

$-\frac{t_2}{30\mu s} = .5.\ln 2$

$e^{-\frac{(t-t_1)}{5\tau}} = \frac{1}{32}$

$= 5V(1+\frac{1}{2}) = 7{,}5V$

Oef 4

a) Knooppunt: $I_A = i_{R_1} - i_L - i_{R_2} = 0$

$i_{R_1} = I_A - i_L - i_{R_2}$

lussen: $R_1 i_{R_1} - V_L = 0$

$R_1(I_A - i_L - i_{R_2}) - L \cdot \frac{di_L(t)}{dt} = 0$

$R_1 I_A - R_1 i_L - i_{R_2} \cdot R_1 - L \cdot \frac{di_L(t)}{dt} = 0$

$R_1 I_A = L \cdot \frac{di_L(t)}{dt} + R_1 i_L + V_L$

$= 2L \frac{di_L(t)}{dt} + R_1 i_L$

① K.V.: $2L\lambda + R_1 = 0$

$\lambda = -\frac{R_1}{2L} = -\frac{1}{\tau}$ met $\tau = \frac{2L}{R_1} = 40ns$

A.O. $A \cdot e^{-t/\tau} = i_L(t)$

② $e(t) = \frac{R_1 I_A}{R_1} = I_A = 40\,mA$

A.O: $i_L(t) = A \cdot e^{-t/\tau} + 40mA$

③ B.V: $i_L(0) = A + 40\,mA = 0$

$\Rightarrow A = -40\,mA$

A.O: $i_L(t) = 40mA\,(1 - e^{-t/\tau})$

$t_1 = 80\,\mu s \cdot \ln 2$

$\frac{t_1}{40\mu s} = 2 \cdot \ln 2$

$e^{-\frac{t_1}{\tau}} = \frac{1}{4}$

$i_L(t_1) = 40mA\left(1 - \frac{1}{4}\right) = 30mA$

b) $L \cdot \frac{di_L(t)}{dt} = -R_2 \cdot i_L$ (a aporte kring)

$L \cdot \frac{di_L(t)}{dt} + R_2 \cdot i_L = 0$

① K.V: $L \cdot \lambda + R_2 = 0$

$\lambda = -\frac{R_2}{L} = -\frac{1}{\tau_2}$ onde $\tau_2 = \frac{L}{R_2} = 20\mu s$

A.O: $i_L(t) = A \cdot e^{-(t-t_1)/\tau_2}$

② $e(t) = 0$

③ B.V: $i_L(t_1) = 30mA = A$

$i_L(t) = 30\,mA \cdot e^{-(t-t_1)/\tau_2}$

entra ej

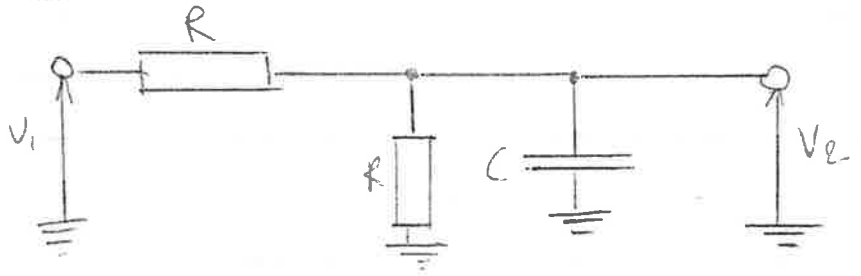
+ Kirchhoff: $I_{R_1} + I_A - I_B + I_L + \frac{V_{R_2}}{R_2} = 0 \Rightarrow I_{R_1} = -I_A + I_B - I_L - \frac{V_{R_2}}{R_2}$

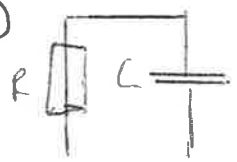
Kirchhoff: $R_1 i_{R_1} - V_L = 0$

$R_1 I_B - R_1 I_A - V_L - R_1 \frac{V_{R_2}}{R_2} - V_L = 0$

Oefeningen #5

Oef 1



① 

→ parallel

$$Z_C = \frac{1}{j\omega C} = \frac{1}{pC} \quad \text{met } p = j\omega$$

$\Rightarrow$ 

$$\frac{1}{Z_{tot}} = \frac{1}{R} + pC = \frac{1+RpC}{R}$$

$$\Rightarrow Z_{tot} = \frac{R}{1+RpC}$$

② spanningsdeler

$$V_2 = \frac{Z_{tot}}{R + Z_{tot}} \cdot V_1$$

$$\frac{V_2}{V_1} = \frac{\frac{R}{1+RpC}}{R + \frac{R}{1+RpC}}$$

$$= \frac{1}{2 + RpC}$$

$$= \frac{1}{2} \cdot \frac{1}{1 + \frac{RpC}{2}} \qquad p = j\omega = j2\pi f$$

$$= \frac{1}{2} \cdot \frac{1}{1 + RC j\pi f}$$

$$= \frac{1}{2} \cdot \frac{1}{1 + j\frac{f}{f_c}} \quad \text{met } f_c = \frac{1}{RC\pi} = 600\ \text{Hz}$$

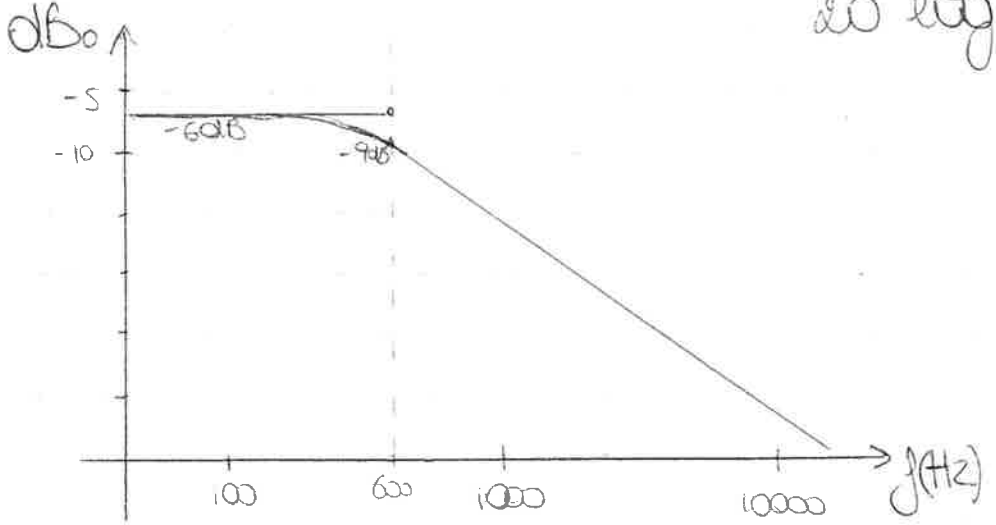
③ Amplitude transfert

$$\left|\frac{V_2}{V_1}\right| = \frac{1}{2} \cdot \frac{1}{\sqrt{1+\left(\frac{f}{f_c}\right)^2}}$$

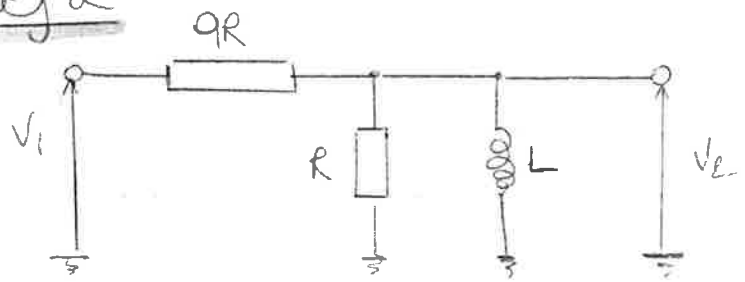
wanneer $f \ll f_c$: $\left|\frac{V_2}{V_1}\right| \approx \frac{1}{2} \Rightarrow \#dB = 20 \log \frac{1}{2} = -6dB$

$f = f_c$: $\left|\frac{V_2}{V_1}\right| = \frac{1}{2\sqrt{2}} \Rightarrow \#dB = 20 \log\left(\frac{1}{2\sqrt{2}}\right) = -9dB$

$f \gg f_c$: $\left|\frac{V_2}{V_1}\right| \approx \frac{1}{2} \cdot \frac{f_c}{f} \Rightarrow \#dB = 20 \log f_c - 20 \log f + 20 \log\left(\frac{1}{2}\right)$



Oef 2



① $Z_L = j\omega L$ & $Z_R = R$ & parallel

$$\Rightarrow \frac{1}{Z_{tot}} = \frac{1}{R} + \frac{1}{j\omega L} = \frac{R + j\omega L}{Rj\omega L}$$

$$\Rightarrow Z_{tot} = \frac{Rj\omega L}{R + j\omega L} = \frac{RpL}{R + pL} \text{ met } p = j\omega$$

② Spanningsdeler: $V_2 = \frac{Z_{tot}}{9R + Z_{tot}} \cdot V_1$

$$\frac{V_2}{V_1} = \frac{\frac{RpL}{R+pL}}{9R + \frac{RpL}{R+pL}}$$

$$= \frac{pL}{9R + 10pL}$$

$$= \frac{pL}{9R}\left(\frac{1}{1 + \frac{10pL}{9R}}\right)$$

$p = jw = j2\pi f$

$$= \frac{j2\pi fL}{9R}\left(\frac{1}{1 + \frac{20j\pi fL}{9R}}\right)$$

(*) (**)

(*) $= A \cdot j\frac{f}{f_c}$

$\Leftrightarrow A \cdot \frac{20\pi L}{9R} = \frac{2\pi L}{9R} \Rightarrow A = \frac{1}{10}$

(**) $\frac{1}{1 + j\frac{f}{f_c}} \Rightarrow f_c = \frac{9R}{20\pi L} = \frac{9}{10} \cdot \frac{R}{2\pi L} = 0{,}9\,kHz$

$$\Rightarrow \frac{V_2}{V_1} = \frac{1}{10} \cdot \frac{jf/f_c}{1 + j\frac{f}{f_c}}$$

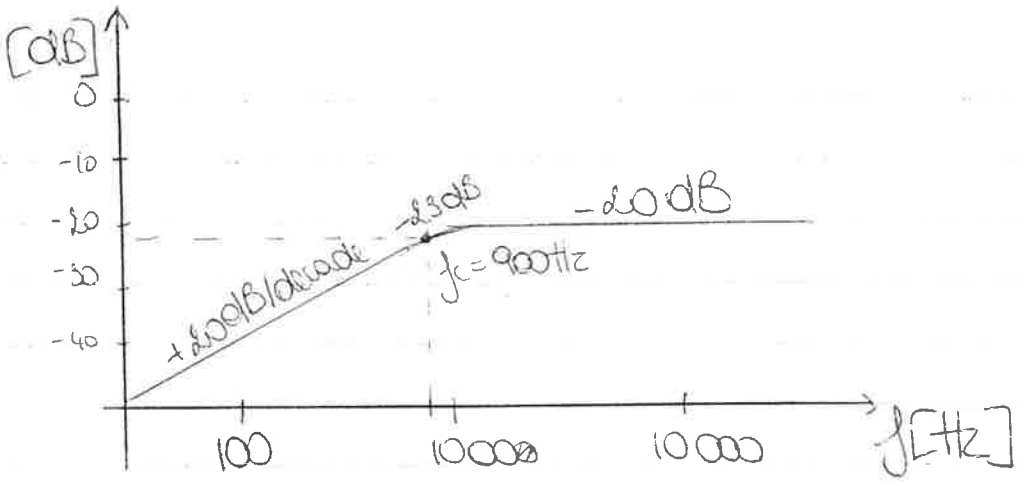
③ Amplitude transfer: $\left|\frac{V_2}{V_1}\right| = \frac{1}{10} \cdot \frac{jf/f_c}{\sqrt{1 + \left(\frac{f}{f_c}\right)^2}}$

+ dus $\rightarrow$

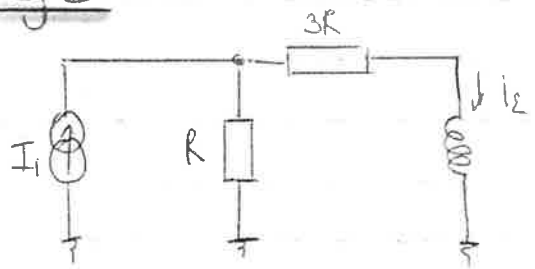
$f \ll f_c$: $\left|\frac{V_2}{V_1}\right| \approx \frac{1}{10}\frac{jf}{f_c} \Rightarrow \#dB = 20\log f + 20\log\frac{1}{10} - 20\log f_c$

$f = f_c$: $\left|\frac{V_2}{V_1}\right| = \frac{1}{10\sqrt{2}} \Rightarrow \#db = -23\,dB$

$f \gg f_c$: $\left|\frac{V_2}{V_1}\right| \approx \frac{1}{10} \Rightarrow \#dB = 20\log\frac{1}{10} = -20$



Oef 3



① $Z_R = 3R$ & $Z_L = j\omega L$ & serie
$\rightarrow Z_{tot} = 3R + j\omega L$

② Stroomdeler: $I_2 = \frac{R}{R+Z_{tot}} \cdot I_1$

$$\frac{I_2}{I_1} = \frac{R}{R+3R+j\omega L} = \frac{R}{4R+pL} \quad \text{met } p = j\omega = j2\pi f$$

$$= \frac{1}{4} \cdot \frac{1}{1+\frac{pL}{4R}} = \frac{1}{4} \cdot \frac{1}{1+\frac{j2\pi fL}{4R}} = \frac{1}{4} \cdot \frac{1}{1+j\frac{f}{f_c}}$$

met $f_c = \frac{2R}{\pi L} = 2 \cdot \frac{1}{2}\,kHz = 1\,kHz$

Hoe zet je seconden om in Hz? $Hz = s^{-1}$
dus $\frac{\pi L}{R} = 2\,ms$

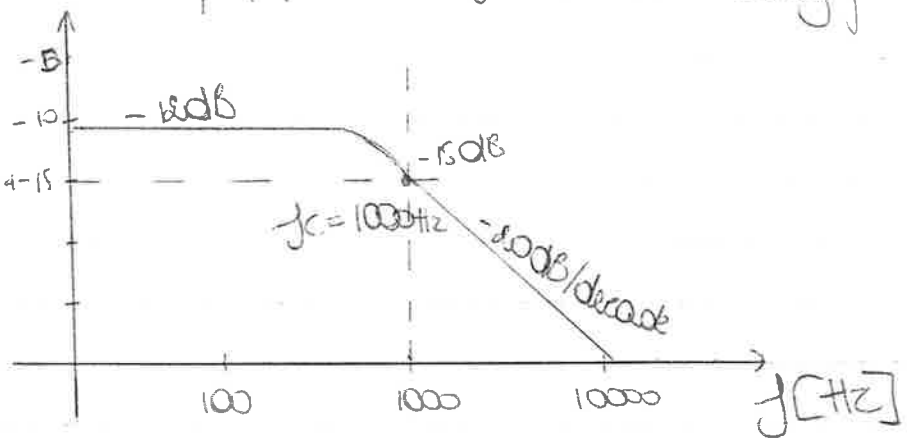
$\Rightarrow \frac{R}{\pi L} = \frac{1}{2}\,kHz$

③ Amplitude transfer $= \left|\frac{I_2}{I_1}\right| = \frac{1}{4} \cdot \frac{1}{\sqrt{1+\left(\frac{f}{f_c}\right)^2}}$

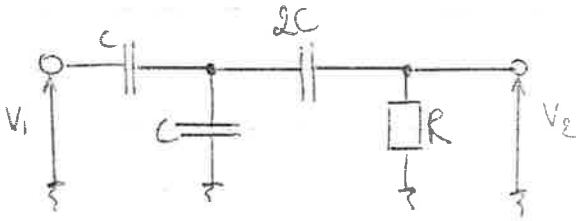
* $f << f_c$: $\left|\frac{I_2}{I_1}\right| \approx \frac{1}{4} \Rightarrow \#dB = 20 \log \frac{1}{4} = -12dB$

* $f = f_c$: $\left|\frac{I_2}{I_1}\right| = \frac{1}{4\sqrt{2}} \Rightarrow \#dB = -15dB$

* $f >> f_c$: $\left|\frac{I_2}{I_1}\right| = \frac{1}{4} \frac{f_c}{f} \Rightarrow \#dB = 20 \log f_c - 20 \log f + 20 \log \frac{1}{4}$



Oef 4



$\tau RC = 100\ \mu s$

$\frac{1}{\tau RC} = \frac{1}{100\ 10^{-6}} Hz = 10kHz$

① $Z_C = \frac{1}{j\omega C} \Rightarrow \frac{1}{Z_{tot}} = j\omega C + j\omega C = 2j\omega C$

$\Rightarrow Z_{tot} = \frac{1}{2j\omega C}$

② $\frac{1}{Z_{tot_2}} = 2j\omega C + 2j\omega C = 4j\omega C \Rightarrow Z_{tot_2} = \frac{1}{4j\omega C} = \frac{1}{4pC}$

③ Spanningsdeler: $V_2 = \frac{Z_{tot}}{R + Z_{tot}} \cdot V_1$

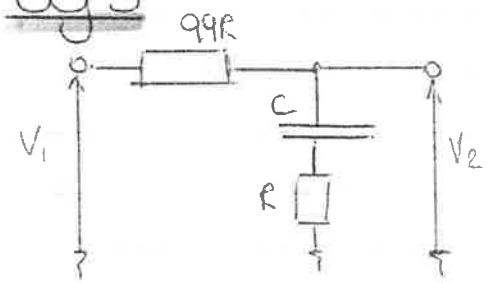
$\frac{V_2}{V_1} = \frac{\frac{1}{4pC}}{R + \frac{1}{4pC}}$

$$= \frac{1}{1 + 4RpC}$$

$$= \frac{1}{1 + 4RCj\omega\pi j}$$

$$= \frac{1}{1 + \frac{j}{f_c}} \quad \text{met } f_c = \frac{1}{8\pi RC} =$$

oef 5



$$\frac{1}{\pi RC} = \frac{1}{50 \cdot 10^{-6}\,s} = 20\,kHz$$

① $Z_R = R$ + & $Z_C = \frac{1}{j\omega C}$ & serie

$$\Rightarrow Z_{tot} = R + \frac{1}{j\omega C} = \frac{Rj\omega C + 1}{j\omega C} = \frac{RpC + 1}{pC}$$

met $p = j\omega = j2\pi f$

② Spanningsdeler: $V_2 = \frac{Z_{tot}}{99R + Z_{tot}} \cdot V_1$

$$\frac{V_2}{V_1} = \frac{RpC + 1}{pC} \Big/ 99R + \frac{RpC + 1}{pC}$$

$$= \frac{RpC + 1}{1 + 100RpC}$$

$$= \frac{Rj2\pi fC + 1}{1 + 100Rj2\pi fC}$$

$$= \frac{1 + j\frac{f}{f_{c2}}}{\text{met } f_{c2} = \frac{1}{R2\pi C} = 10\,kHz}$$

$$\frac{1 + j\frac{f}{f_{c1}}}{\text{met } f_{c1} = \frac{1}{100R2\pi C} = 100\,Hz}$$

$$= \frac{1 + jf/f_{c2}}{1 + jf/f_{c1}}$$

③ Amplitudetransfer: $\left|\frac{V_2}{V_1}\right| = \frac{1 + jf/f_{c2}}{\sqrt{1 + (f/f_{c1})^2}}$

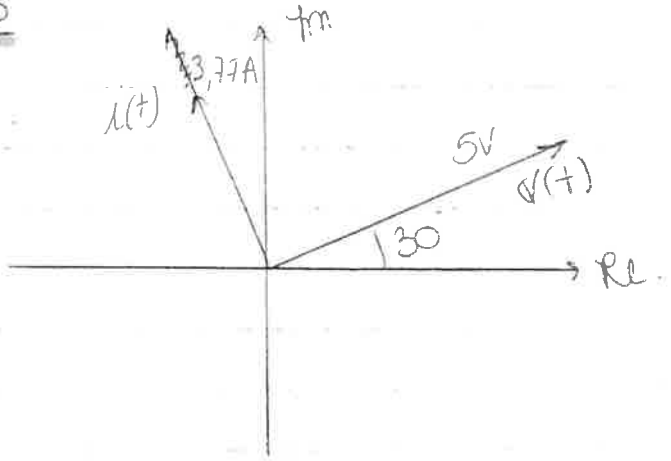
$f << f_{c2}$: $\left|\frac{V_2}{V_1}\right| \approx 1 \Rightarrow$ # dB $= 20 \cdot \log 1 = 0$ dB

* $f = f_{c2}$: $\left|\frac{V_2}{V_1}\right| = \frac{1}{\sqrt{2}} \Rightarrow \#dB = 20\log\frac{1}{\sqrt{2}} = -3dB$

* $f_{c1} << f << f_{c2}$: $\left|\frac{V_2}{V_1}\right| = \frac{f_{c2}}{f} \Rightarrow 20\log f_{c2} - 20\log f$

* $f = f_{c1}$: $\left|\frac{V_2}{V_1}\right| = \frac{\sqrt{2}}{f_{c1}/f} \Rightarrow$

Aufg 6



$+90° \Rightarrow$ kondensator

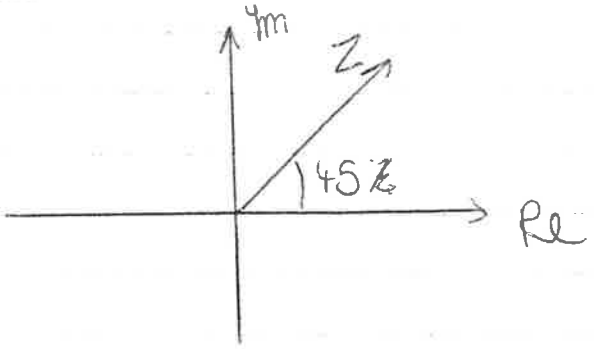
$$Z = \frac{5V}{3,77A} \cdot e^{j(-90°)} = j \cdot \frac{5V}{3,77A}$$

$$Z_C = \frac{V_C}{I} = \frac{1}{j\omega C}$$

$$C = \frac{1}{j\omega Z_C} = \frac{3,77A}{j^2 \cdot 2\pi f \cdot 5V} \qquad j^2 = -1$$

$$= 20\,\mu F$$

Aufg 7



* $Z = \frac{V}{i} = \frac{28V \cdot e^{j45°}}{9mA \cdot e^{j0°}} = \frac{28V}{9mA} \cdot e^{45}$

$\cos 45 = \frac{\sqrt{2}}{2}$

$= \frac{28V}{9mA} \cdot \frac{\sqrt{2}}{2} + j \cdot \frac{28V}{9mA} \cdot \frac{\sqrt{2}}{2}$

$= R + L$

$Z = 2{,}2k\Omega \cdot (1+j)$

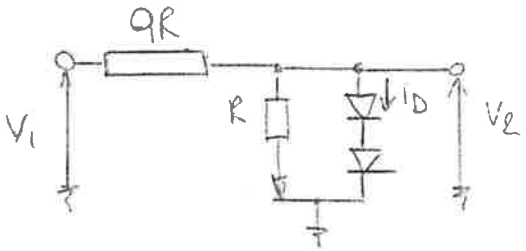
* $j2\pi f_1 \cdot L = j \cdot \frac{28V}{9mA} \cdot \frac{\sqrt{2}}{2}$

$\Rightarrow L = 700\mu H$

* $R = \frac{V}{I} \frac{\sqrt{2}}{2} = \frac{28V}{9mA} \cdot \frac{\sqrt{2}}{2} = 2{,}2k\Omega$

oefeningen H7

oef 1



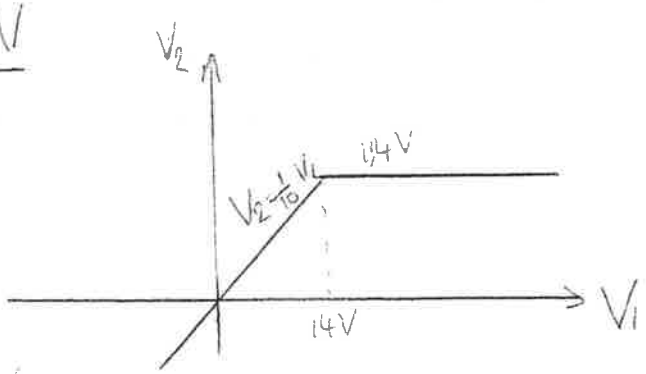
Diodes zijn in serie $\Rightarrow$ < de geleiden
de sperren $\Rightarrow I = 0$

a) geleiden: I_D moet pos zijn

- $V_2 = 0,7V + 0,7V = 1,4V$
- $I_D = \frac{V_1 - 1,4V}{9R} - \frac{1,4V}{R} > 0$

$$I_D = I_{tot} - I_R$$
$$= \frac{V_{9R}}{9R} - \frac{V_R}{R}$$
$$= \frac{V_1 - 1,4V}{9R} - \frac{1,4V}{R}$$

- $V_2 = 1,4V$
  $V_1 > 14V$



b) sperren: $V_D < 0,7V$

$V_2 = \frac{1}{10} V_1$

$V_1 < 14V \Rightarrow V_2 = \frac{1}{10} V_1$

Oef 3

1) beide geleiden:

$$V_1 - V_{R_1} - V_{D_1} - V_{D_2} = 0$$
$$V_1 - V_{R_1} = V_{D_1} + V_{D_2}$$
$$= 1,4V$$
$$V_1 - 1,4V = I_1 \cdot R_1$$
$$I_1 = \frac{V_1 - 1,4V}{R_1}$$

$$+ \quad \frac{V_1 - 1,4V}{R_1} > 0$$
$$V_1 > 1,4V$$

$$+ \quad I_1 - \frac{0,7V}{R} - I_2 = 0$$
$$\Rightarrow I_2 = \frac{V_1 - 1,4V - 0,7V}{R}$$
$$V_1 > 2,1V$$

2) D_1 geleidt, D_2 sperrt.

$$V_1 - V_{R_1} - V_{D_1} - V_{R_2} = 0$$
$$V_1 - V_{R_1} - V_{R_2} = 0,7V$$
$$V_1 - 0,7V = 2R \cdot I_1$$
$$I_1 = \frac{V_1 - 0,7V}{R_1} > 0$$
$$\Rightarrow V_1 > 0,7V$$

3) beide sperren: $I_1 = I_2 = 0$
$$\Leftrightarrow V_1 < 0,7V$$

Oef 4

a) Gesloten.

- $V_2 = 2,1V$
- $2,1V - V_R - 0,7V = 0$

$$1,4V = V_R$$
$$1,4V = R_1(I_1 - I_D)$$
$$R_1 I_D = R_1 I_1 - 1,4V$$
$$I_D = R_1 I_1 - \frac{1,4V}{R}$$

$$I_D > 0$$
$$I_1 > \frac{1,4V}{R}$$

b) D_1 gesloten, rest open

$$V_2 = V_R + 0,7V$$
$$\begin{cases} V_2 = I_R R + 0,7V \\ V_2 = V_{R1} + V_{R2} \end{cases}$$
$$0,7V + I_1 R = I_1 R + R(I - I_D)$$
$$I_D = I_1 - \frac{0,7V}{R}$$
$$I_D > 0 \Rightarrow I_1 > \frac{0,7V}{R}$$

c) allemaal ✗

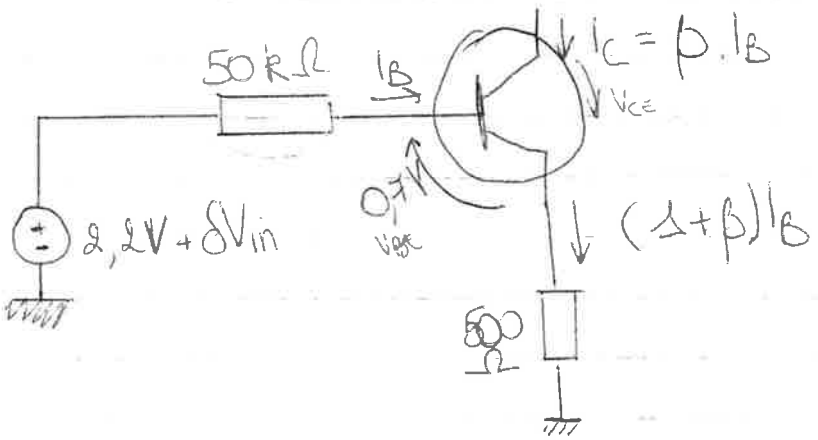
$$V_2 = 2R \cdot I_1$$
$$I_1 < \frac{0,7V}{R}$$

Opg 5

$V_{BE} = 0,7V$

$I_C = \beta . I_B$

+ wet v. Ohm en Kirchoff



Oplossing 1) $2,2V + \delta V_{in} = 50k\Omega . I_B + 0,7V + 500\,\Omega . 200 . I_B$

$\Rightarrow I_B = 10\mu A + \frac{\delta V_{in}}{150k\Omega}$

2) $I_C = \beta . I_B$

$= 2mA + \frac{4}{3} \frac{\delta V_{in}}{k\Omega}$

3) $V_{out} = 12V - 3k\Omega . I_C$

$= 12V - 6V - 4\delta V_{in}$

$= 6V - (4)\delta V_{in}$

↳ versterker v/d ingangs-

polarisatiespanning spanning

stijgende inputV ⇒ dalende Vout

oef 6

3 werkingsgebieden die complementair zijn.
V_2 ijv V_1 voor $0 \leq V_1 \leq 5V$

Opl.

3 gebieden → cut-off : $V_{BE} < 0,7V$
→ lineair : $V_{BE} = 0,7V$, $I_C = \beta . I_B$, $V_{CE} > 0$
→ saturatie : $V_{BE} = 0,7V$, $V_{CE} = 0V$, $I_C < \beta . I_B$

① Cut-off (transistor geleidt niet)

$I_B = I_C = I_E = 0A$
$V_{BE} < 0,7V$

→ geen stroom → qk spanningsval

$V_2 = 12V$; $V_1 < 0,7V$

② lineair : $V_{BE} = 0,7V$
$V_{CE} > 0$
$I_C = \beta . I_B$

$$I_E = \frac{V_1 - 0,7V}{100\Omega} \cong I_C$$

$$V_2 = 12V - 500\Omega . \frac{V_1 - 0,7V}{100\Omega}$$

$$= 15,5V - 5V_1$$

$$15{,}5V - 5V_1 > V_1 - 0{,}7V$$
$$\Leftrightarrow \quad 6V_1 < 16{,}2V$$
$$V_1 < 2{,}7V$$

③ Saturatie: transistor geleidt

$$V_{BE} = 0{,}7V$$
$$V_{CE} = 0V$$
$$I_C < \beta \cdot I_B$$

$$V_2 = V_1 - 0{,}7V$$
$$V_1 > 2{,}7V$$

Opg 4

* I_B: $2{,}7V + \delta V_{in} = V_{BE} + 600\Omega \cdot 200 \cdot I_B$
$= 0{,}7V + 120000\, I_B$

$$\Rightarrow I_B = \frac{1{,}0V}{60k\Omega} + \frac{\delta V_{in}}{120k\Omega}$$

* $I_C = \beta \cdot I_B = 200 \cdot \left(\frac{1{,}0V}{60k\Omega} + \frac{\delta V_{in}}{120k\Omega}\right)$
$= \frac{10}{3}mA + \frac{5}{3}\frac{\delta V_{in}}{k\Omega}$

* $V_{out} = 20V - 2k\Omega I_C - 3k\Omega \cdot I_C \rightarrow$ parallel?
$= 20V - \frac{20}{3}V - \frac{10}{3}\delta V_{in} = 10V - 5\delta V_{in}$

$$R_{tot} = \frac{6}{5}$$

Extra oef

* I_B: $2{,}1V + \delta V_{in} = 7k\Omega \cdot I_B + V_{BE}$ *

$= 7k\Omega \cdot I_B + 0{,}7V$

$\Rightarrow I_B = \frac{1{,}4V}{7k\Omega} + \frac{\delta V_{in}}{7k\Omega}$

$= 0{,}2mA + \frac{1}{7}\frac{\delta V_{in}}{k\Omega}$

* $I_C = 100 \cdot \left(2mA + \frac{1}{7}\frac{\delta V_{in}}{k\Omega}\right)$

$= 200mA + \frac{100}{700}\frac{\delta V_{in}}{k\Omega}$

$0{,}2A$

* $V_{out} = 24V - 700\Omega \cdot I_C - 700\Omega \cdot I_C$

$= 24V - 140V - 100\delta V_{in} - 140V$

$\frac{1}{R_{tot}} = \frac{1}{700} + \frac{1}{700} = \frac{2}{700}$

$\Rightarrow R_{tot} = 350\Omega$

$V_{out} = 24V - 350 I_C$

$= 24V - 350\left(200mA + \frac{1}{70}\frac{\delta V_{in}}{k\Omega}\right)$

$0{,}2A$

$= 24V - 7V - 5\delta V_{in}$

Oefeningen H8

Oef 1

$$Z = \bar{A}.\bar{B}.\bar{C} + BCD + (B\bar{C} + A\bar{B}).(B\bar{C} + CD) + BC\bar{D} + A(\bar{C} + BD)$$

$$= \bar{A}.\bar{B}.\bar{C} + BCD + B\bar{C} + A\bar{B}.CD + BC\bar{D} + A\bar{C} + ABD$$

$$= \bar{A}.\bar{B}.\bar{C} + BC(D + \bar{D}) + B\bar{C} + A\bar{B}CD + A\bar{C} + ABD$$

$$= \bar{A}.\bar{B}.\bar{C} + B(C + \bar{C}) + A\bar{B}CD + A\bar{C} + ABD$$

$$= \bar{A}.\bar{B}.\bar{C} + B + A\bar{B}CD + A\bar{C} + ABD$$

$$= \bar{C}(\bar{B}\bar{A} + A) + B + A\bar{B}CD + ABD$$

$$= \bar{C}(A + \bar{B}) + B + AD(\bar{B}C + B)$$

$$= \bar{C}(A + \bar{B}) + B + AD(B + C)$$

$$= A\bar{C} + C\bar{B} + B + ADB + ADC$$

$$= \bar{C} + B + A(\bar{C} + DC) + ADB$$

$$= B + \bar{C} + A(\bar{C} + D) + ADB$$

$$= B + \bar{C} + A\bar{C} + AD + ADB$$

$$= \cancel{B + AD +}$$

$$= B + \bar{C}(A + 1) + AD(B + 1)$$

$$= B + \bar{C} + AD$$

Oef 2

$$Z = \overline{(A\bar{B} + \overline{(A\bar{B}D + \bar{A}C)})} \;.\; \overline{((\overline{BC}).(A + C))}$$

① ②

① $$A\bar{B}.\overline{(A\bar{B}D + \bar{A}C)} = (\bar{A} + B).(A\bar{B}D + \bar{A}C)$$

$$= \bar{A}C + \bar{A}BC$$

$$= \bar{A}C(B + 1)$$

$$= \bar{A}C$$

② $$BC + \overline{(A + C)} = BC + \bar{A}.\bar{C}$$

$$\Rightarrow Z = \bar{A}C + (BC + \bar{A}\bar{C}) = \bar{A}BC$$

$A + \bar{A}B = A + B$

Oef 3

$$Z = \bar{A}.\bar{C} + \overline{(\bar{C}+A).(\bar{B}+\bar{D})} + (A.(D+B.\bar{C}))$$

$$= \bar{A}.\bar{C} + (\bar{C}+A) + (\bar{B}+\bar{D}) + (AD + AB\bar{C})$$

$$= \bar{A}.\bar{C} + \bar{A}C + B.D + AD + AB\bar{C}$$

$$= \bar{A} + BD + AD + AB\bar{C}$$

$$= \bar{A} + D(B+A) + AB\bar{C}$$

$$= $$

$$= (\bar{A} + AB\bar{C}) + AD + BD$$

$$= \boxed{\bar{A}} + B\bar{C} + \boxed{AD} + DD$$

$$= \bar{A} + D + B\bar{C} + BD$$

$$= \bar{A} + D\bar{C} + D(B+1)$$

$$= \bar{A} + D + B\bar{C}$$

Oef 4

$$Z = \bar{B} + \bar{A} + \bar{A}.C.D$$

$$= \bar{A}(\bar{B} + CD)$$

$$= \overline{\bar{A}(\bar{B}+CD)}$$

$$= \bar{A}.\overline{(\bar{B}+CD)}$$

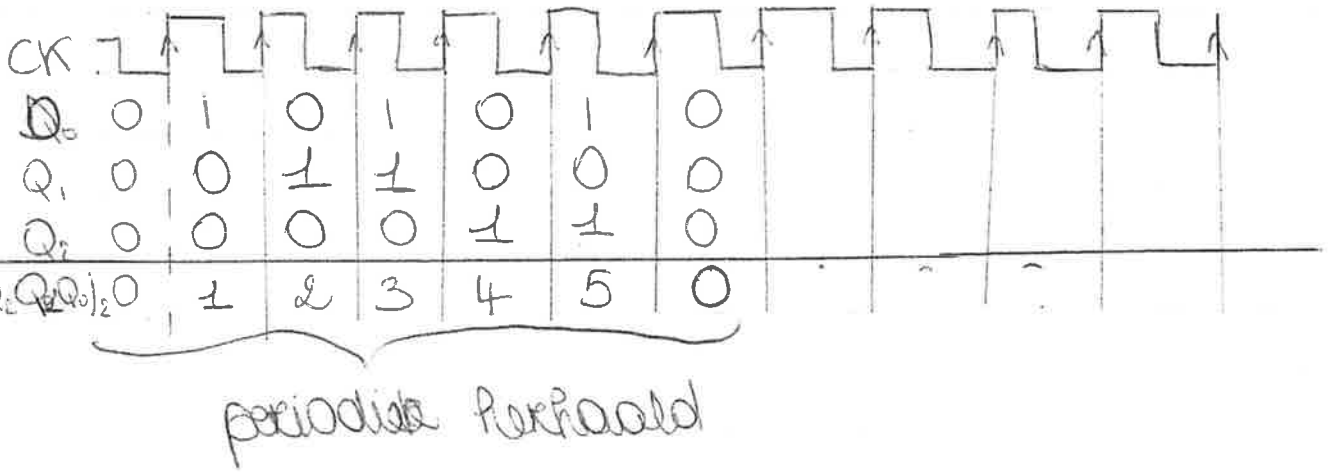
$$= \bar{A}.(B.\overline{CD})$$

Oef 5

$D_0 = \bar{Q}_0$

$D_1 = \bar{Q}_0 \cdot Q_1 + Q_0 \cdot \bar{Q}_2 \cdot \bar{Q}_1$

$D_2 = Q_1 \cdot Q_0 + Q_2 \bar{Q}_0$



CK							
Q_0	0	1	0	1	0	1	0
Q_1	0	0	1	1	0	0	0
Q_2	0	0	0	0	1	1	0
$(Q_2Q_1Q_0)_2$	0	1	2	3	4	5	0

periodisch herhaald

Oef 6 → niet tunnen.

$D_0 = \bar{Q}_0$

$D_1 = \bar{Q}_1 \cdot \bar{Q}_2$

$D_2 = Q_1$

CK				
Q_0	0	1	0	1
Q_1	0	0	1	
Q_2	0	0	0	1
$(Q_2Q_1Q_0)_2$	0	1	2	

Oef 8

$N_1 =$

$N_2 =$

$N_3 =$

$N_4 =$

$N_5 = \frac{1}{200ns} \cdot 4096 =$

Entrega ej H8

ej 1

$Z = (\bar{A}E + (\overline{A.(\overline{AB})})).(\bar{A}C + \bar{C} + \bar{C}\bar{E}).(\overline{A\bar{D}})$ → opción 3 usar más fácil

$= (\bar{A}E + (\bar{A} + AB)).(\bar{A}C + \bar{C} + \bar{C}\bar{E}).(\bar{A} + D)$

$= (\bar{A}E + \bar{A} + AB)(\bar{A}C + \bar{C}(\bar{E}+1))(\bar{A} + D)$

$= (\bar{A}(E+1) + AB)(\bar{A}C + \bar{C})(\bar{A} + D)$

$= (\bar{A} + B)(\bar{C} + \bar{A})(\bar{A} + D)$

$= (\bar{A} + B)(\bar{A}\bar{C} + \bar{A} + \bar{C}D + \bar{A}D)$

$= (\bar{A} + B)(\bar{A}(\bar{C}+1) + \bar{C}D + \bar{A}D)$

$= (\bar{A} + B)(\bar{A} + \bar{C}D)$

$= \bar{A} + \bar{A}\bar{C}D + \bar{A}B + B\bar{C}D$

$= \bar{A} + \bar{C}D$

$= \bar{A}(B+1) + \bar{C}D(A+B) \bar{A}\bar{C}D + B\bar{C}D$

$= \bar{A} + \bar{A}\bar{C}D + B\bar{C}D$

$= \bar{A} + B\bar{C}D$

ej 1

$D_0 = Q_0 \bar{Q}_1 + (Q_1 \oplus Q_2)$

$D_1 = \bar{Q}_0 + Q_2$

$D_2 = Q_1$

Extra Ej #8

Ej 1

$$Z = (\bar{A}E + \overline{(A.(\bar{A}B))}).(\bar{A}C + \bar{C} + C\bar{E})(\bar{A}\bar{D})$$

① $= \bar{A}E + \bar{A} + AB$

$= \bar{A}(E+1) + AB$

$= \bar{A} + AB$

$= \bar{A} + B$

② $= \bar{A}C + \bar{C}(\bar{E}+1)$

$= \bar{A}C + \bar{C}$

$= \bar{C} + \bar{A}$

③ $= \bar{A} + D$

$\Rightarrow (\bar{A}+B)(\bar{C}+\bar{A})(\bar{A}+D)$

$= \bar{A}\bar{A}\bar{C} + \bar{A} + \bar{A}B\bar{C} + B\bar{A} + \bar{A}\bar{C}D + \bar{A}D + B\bar{C}D + \bar{A}BD$

$= \bar{A}(C+1) + \bar{A}B(C+1) + \bar{A}D(\bar{C}+1) + B\bar{C}D + \bar{A}BD$

$= \bar{A}(B+1) + \bar{A}D + B\bar{C}D + \bar{A}BD$

$= \bar{A} + B\bar{C}D + \bar{A}BD$

$= \bar{A} + B\bar{C}D$

Opg 1

$D_0 = \overline{Q_0 + Q_2}\ \overline{Q}_1 + (Q_1 \oplus Q_2)$

$D_1 = \overline{Q}_0 + Q_2$

$D_2 = \overline{Q}_1 + (\overline{Q}_0 + Q_2)$