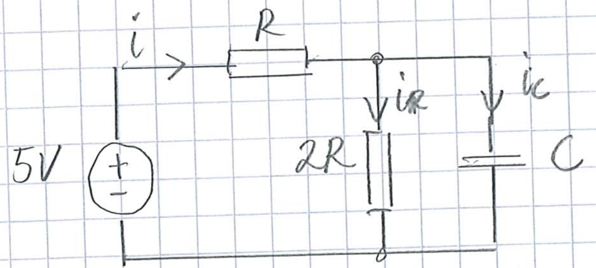
1 a) $u_a = \frac{R}{R+R} \cdot u_N = \underline{5/2 = 2{,}5\,[V]}$

b)



$i_c = C\,\frac{du_c}{dt}$

$$u_c = 5 - Ri = 5 - R(i_R + i_c) =$$

$$= 5 - R \cdot \frac{u_c}{2R} - RC\,\frac{du_c}{dt}$$

$$\frac{3u_c}{2} = 5 - RC\,\frac{du_c}{dt}$$

$$RC\,\frac{du_c}{dt} = 5 - \frac{3u_c}{2}$$

$$\frac{1}{5 - \frac{3u_c}{2}}\,du_c = \frac{1}{RC}\,dt$$

$$\frac{2/3}{\frac{10}{3} - u_c}\,du_c = \frac{1}{RC}\,dt$$

$$-\frac{2}{3}\int \frac{1}{u_c - \frac{10}{3}}\,du_c = \frac{1}{RC}\int dt + \beta$$

$$-\frac{2}{3}\ln\left(u_c - \frac{10}{3}\right) = t/RC + \beta$$

$$\ln\left(u_c - \frac{10}{3}\right) = -3t/2RC + \beta'$$

$$u_c - \frac{10}{3} = e^{-3t/2RC} \cdot \beta''$$

$*\quad t = 0 \mapsto u_c = 0 \rightarrow \beta'' = -10/3$

$$\underline{u_c = \frac{10}{3}\left(1 - e^{-3t/2RC}\right)}$$

Next, solve for C given $t = 10$ & $U_C = 5/2$.

$$\frac{5}{2} = \frac{10}{3}\left(1 - e^{-30/2RC}\right)$$

$$\frac{3}{4} = 1 - e^{-30/2RC}$$

$$e^{-30/2RC} = 1/4$$

$$-\frac{30}{2RC} = -\ln(4)$$

$$C = \frac{15}{R \cdot \ln(4)} \; [F]$$

c) $R_{led} = \frac{5 - 1{,}2}{10^{-2}} = 380 \, [\Omega]$

2a) From the datasheets it is given that

$U_Z \approx 5,1$ [V] at 50 [mA] (Zener-diode)

$U_f \approx 0,85$ [V] at 50 [mA] (Diode)

$\rightarrow U_a \approx 5,95$ [V]

b) Assuming that $U_{BE} \approx 0,7$ [V], then

$I \approx \frac{U_a - U_{BE}}{25} \approx \frac{5}{25} = \frac{1}{5}$ [A]

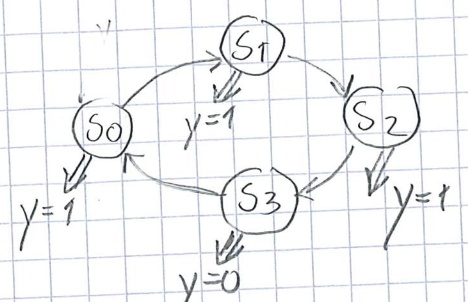
c) From the datasheet it is given at collector current of approx. 1/5 [A] then $h_{FE} \approx 50$.

$\rightarrow I_B = \frac{1}{1+h_{FE}} \cdot I_E \approx \frac{1}{50 \cdot 5} = \frac{1}{250}$ [A] = 4 [mA]

d) The dissipated power is $P = UI \approx (U_a - U_{BE}) \cdot I =$

$\approx 5 \cdot \frac{1}{5} = 1$ [W].

3a) State-diagram



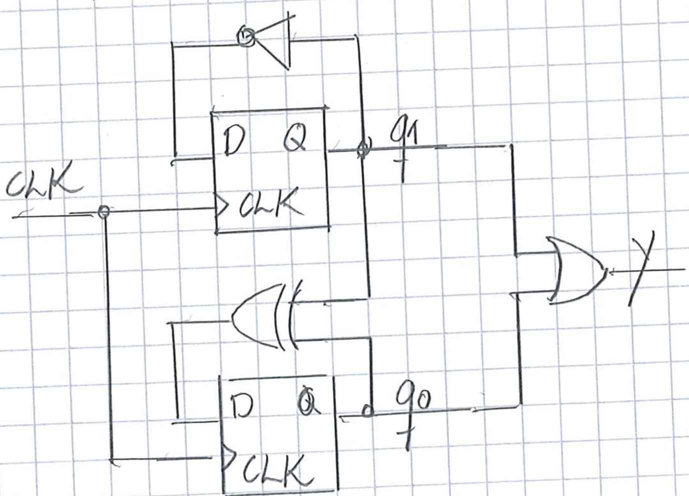
y = output
4 states → 2 flip-flops.

Old state	q_0	q_1	New state	q_0^+	q_1^+
S0	0	0	S1	0	1
S1	0	1	S2	1	0
S2	1	0	S3	1	1
S3	1	1	S0	0	0

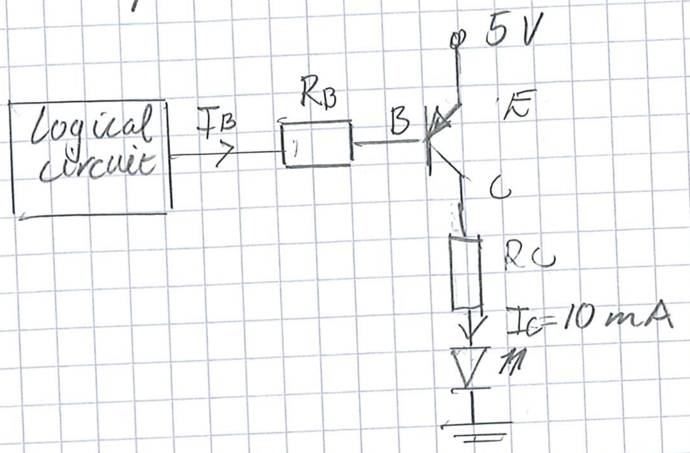
→ $q_0^+ = \overline{q_0} q_1 + q_0 \overline{q_1}$ (XOR)

→ $q_1^+ = \overline{q_1}$ (Inverter)

→ $y = q_0 + q_1$ (OR)



3b) One possible circuit is



Assume: $U_{EC} = 0{,}2$ [V] at saturation

$h_{FE} = 100$

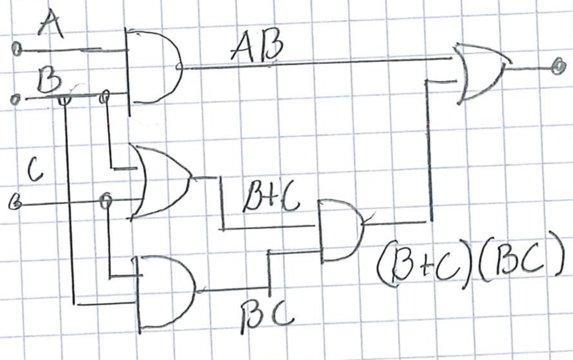
$$\longrightarrow \quad R_C = \frac{5 - U_{EC} - 1{,}2}{I_C} = \frac{3{,}6}{10^{-2}} = 360\ [\Omega]$$

$$\longrightarrow \quad \text{For saturation } I_B > I_C / h_{FE} = 10^{-2}/100 = 10^{-4}\ [A]$$

$$I_B = \frac{5 - U_{EB}}{R_B} \approx \frac{5 - 0{,}7}{R_B} > 10^{-4}$$

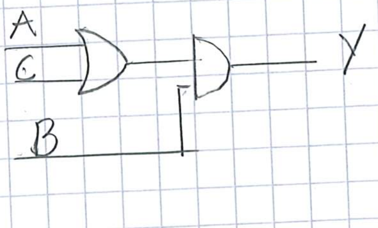
$$R_B < \frac{5 - 0{,}7}{10^{-4}} \approx 43\ [k\Omega]$$

3c)

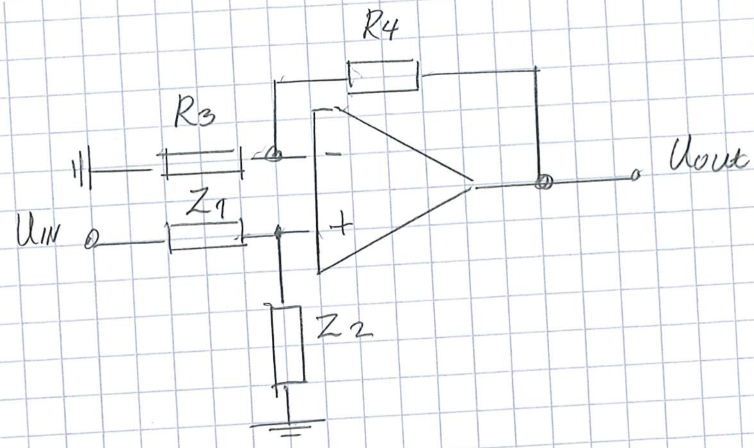


$Y = AB + (B+C)(BC)$

$$Y = AB + BBC + CBC = AB + BC = (A+C)B$$



4a)



Ideal OpAmp $\rightarrow u^- \approx u^+ \quad \rightarrow \frac{Z_2}{Z_1+Z_2} u_{IN} = \frac{R_3}{R_3+R_4} u_{out}$

$$\Rightarrow H(j\omega) = \frac{\frac{Z_2}{Z_1+Z_2}}{\frac{R_3}{R_3+R_4}} = \left(1+\frac{R_4}{R_3}\right)\left(\frac{1}{1+Z_1/Z_2}\right)$$

Case $H_{u_1u_2}$

$Z_1 = 1/j\omega C_1 \quad , Z_2 = R_1$

$$H_{u_1,u_2}(j\omega) = \left(1+\frac{R_4}{R_3}\right) \cdot \frac{1}{1+\frac{1}{j\omega R_1 C_1}} = \left(1+\frac{R_4}{R_3}\right) \cdot \frac{j\omega R_1 C_1}{1+j\omega R_1 C_1}$$

Case $H_{u_2u_3}$

$Z_1 = R_2 \quad , \quad Z_2 = 1/j\omega C_2$

$$H_{u_2,u_3}(j\omega) = \left(1+\frac{R_4}{R_3}\right) \cdot \frac{1}{1+j\omega R_2 C_2}$$

4b) $R_1 = 10k\Omega$, $C_1 = 100\mu F \rightarrow |H_{u_1,u_2}(0)| = 0$

$\lim_{\omega\to\infty} |H_{u_1,u_2}(j\omega)| = 11 \quad \Big\} \rightarrow$ HP-filt

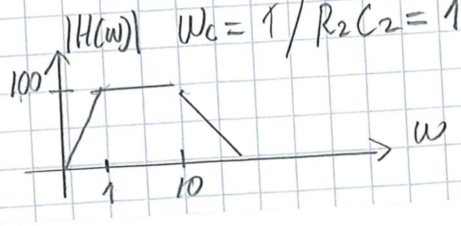
$\omega_c = 1/R_1C_1 = 1/(10^4 \cdot 10^{-4}) = 1$ [rac

$R_2 = 1k\Omega$, $C_1 = 100\mu F \rightarrow |H_{u_2,u_3}(0)| = 11$

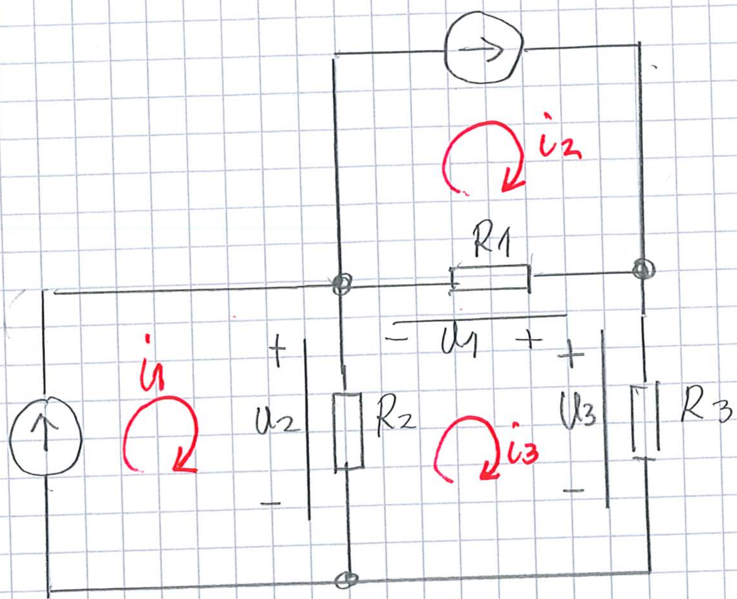
$\lim_{\omega\to\infty} |H_{u_2,u_3}(\omega)| = 0 \quad \Big\} \rightarrow$ LP-filte

$\omega_c = 1/R_2C_2 = 1/(10^3 \cdot 10^{-4}) = 10$ [rac

4c) Band-pass filter



5a)



$$u_2 = R_2(i_1 - i_3)$$
$$u_1 = R_1(i_2 - i_3)$$
$$u_1 + u_2 = u_3 = R_3 i_3$$

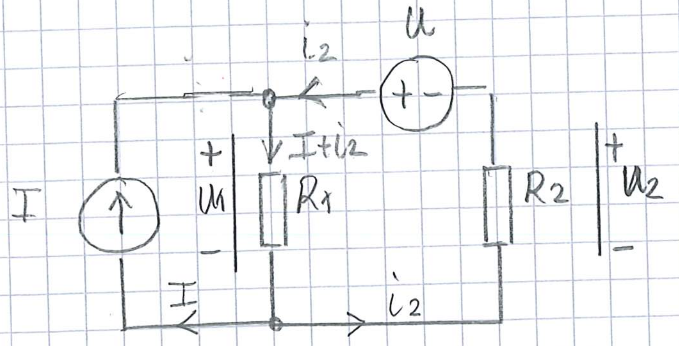
$$R_3 i_3 = R_2(i_1 - i_3) + R_1(i_2 - i_3)$$

$$(R_1 + R_2 + R_3) i_3 = R_2 i_1 + R_1 i_2$$

$$i_3 = \frac{R_2 i_1 + R_1 i_2}{R_1 + R_2 + R_3} = \frac{3 \cdot 0{,}7 + 7 \cdot 1{,}2}{15} = \frac{10{,}5}{15} = 0{,}7 \; [A]$$

$$\longrightarrow \; u_2 = R_2(i_1 - i_3) = 3 \cdot (0{,}7 - 0{,}7) = \underline{0 \; [V]}$$
$$u_3 = 5 \cdot 0{,}7 = \underline{3{,}5 \; [V]}$$

5b)



Equivalent resistance: $R_{equ} = |u/i_2|$

$$\begin{cases} u_1 = R_1(I + i_2) \\ u_1 = u + u_2 = u - R_2 i_2 \end{cases}$$

$$R_1(I + i_2) = u - R_2 i_2$$

$$(R_1 + R_2) i_2 = u - R_1 I$$

$$i_2 = \frac{u - R_1 I}{R_1 + R_2}$$

$$\longrightarrow R_{equ} = \left|\frac{u}{i_2}\right| = \left|\frac{(R_1+R_2)u}{u - R_1 I}\right| = \frac{(R_1+R_2)}{R_1} \cdot \left| \frac{u}{\frac{u}{R_1} - I} \right| \quad [\Omega]$$