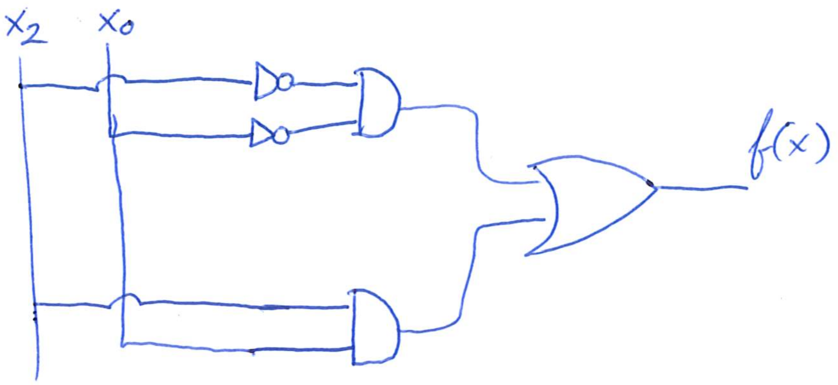
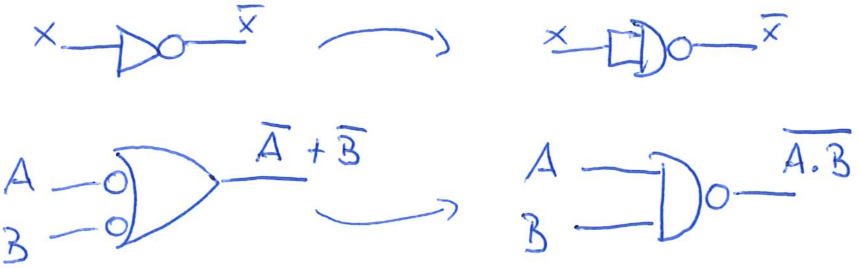
EXAM AUG 20, 2018

# A1

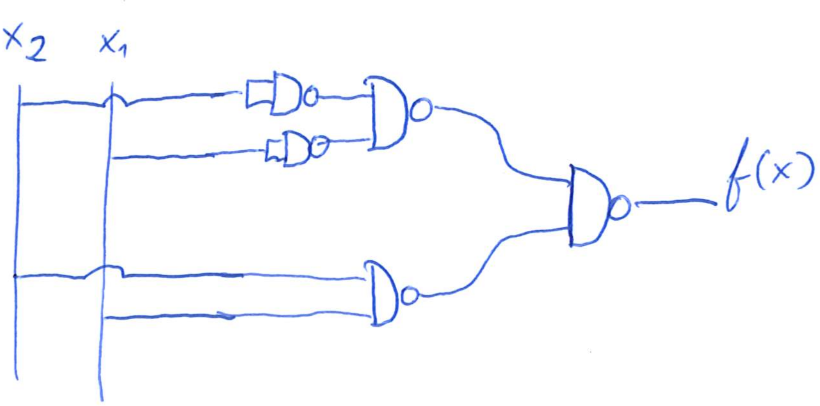
| $x_1x_0$ \ $x_3x_2$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | - | 1 |
| 01 | 0 | 1 | 1 | 0 |
| 11 | 0 | 1 | - | 0 |
| 10 | 1 | 0 | 0 | - |

$$f(x) = \overline{x_0} \cdot \overline{x_2} + x_0 \cdot x_2$$



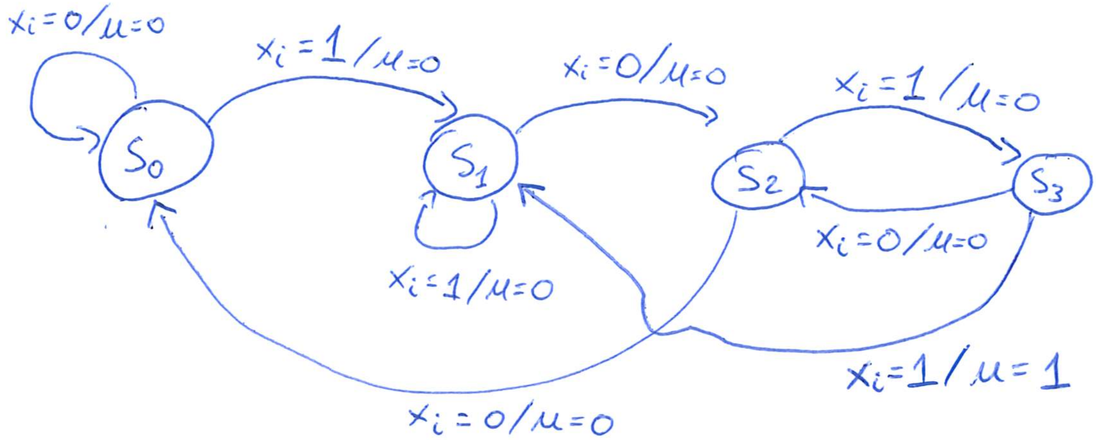







A2

## State diagram




State coding:

| | $q_1$ | $q_0$ |
|---|---|---|
| $S_0$ | 0 | 0 |
| $S_1$ | 0 | 1 |
| $S_2$ | 1 | 0 |
| $S_3$ | 1 | 1 |

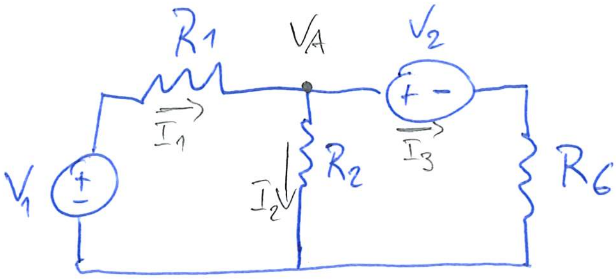
| $q_1$ | $q_0$ | $x_i$ | $q_1^+$ | $q_0^+$ | $u$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 | 1 | 1 |

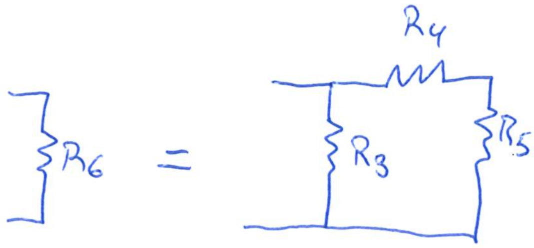
- 2 D flip-flops are used, 1 per

- This is a ~~Mo~~ Mealy circuit, Since the output $u$ depends on both the state and the input at each time.

# $A_3$

a)




$$R_6 = R_3 // (R_4 + R_5)$$

$$= \frac{R_3(R_4+R_5)}{R_3+R_4+R_5} = 10\Omega$$

$$I_1 = I_2 + I_3$$

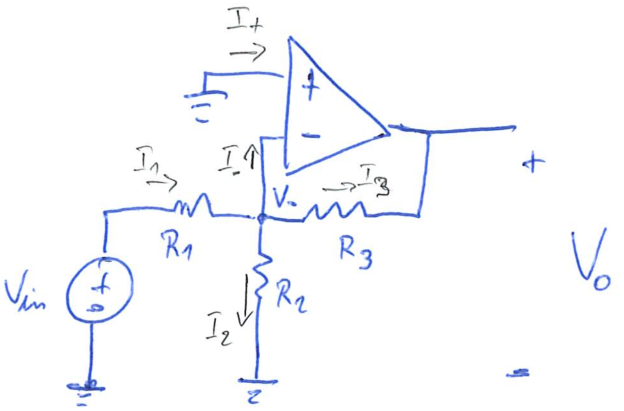
$$I_1 = \frac{V_1 - V_A}{R_1} \quad ; \quad I_2 = \frac{V_A}{R_2} \quad ; \quad I_3 = \frac{V_A - V_2}{R_6}$$

$$\Rightarrow \frac{V_1 - V_A}{R_1} = \frac{V_A}{R_2} + \frac{V_A - V_2}{R_6} \Leftrightarrow \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_6}\right)V_A = \frac{V_1}{R_1} + \frac{V_2}{R_6} \Leftrightarrow$$

$$\frac{1}{5} V_A = \frac{5}{20} + \frac{2}{10} \Leftrightarrow V_A = \frac{9}{4} \ V$$

$$I_2 = \frac{V_A}{R_2} = \frac{9}{4 \times 20} = \frac{9}{80} \ A = 0{,}1125 \ A$$

# A3.b)




Ideal OPAMP:

- $I_+ = I_- = 0$
- $V_+ = V_-$ (because of negative feedback)

$V_+ = 0 \Rightarrow V_- = V_+ = 0$

$I_1 = \frac{V_{in} - V_-}{R_1}$ ; $I_2 = \frac{V_-}{R_2}$ ; $I_3 = \frac{V_- - V_o}{R_3}$

$I_1 = I_2 + I_3 + \underbrace{\cancel{I_-}}_{=0} = I_2 + I_3$

$I_2 = \frac{V_-}{R_2} = \frac{0}{R_2} = 0 \Rightarrow I_1 = I_3$

$\Rightarrow I_1 = I_3 \Leftrightarrow \frac{V_{in} - \overset{=0}{\cancel{V_-}}}{R_1} = \frac{\overset{=0}{\cancel{V_-}} - V_o}{R_3} \Leftrightarrow V_o = -\frac{R_3}{R_1} V_{in}$

$\Rightarrow I_3 = I_1 = \frac{V_{in} - \overset{=0}{\cancel{V_-}}}{R_1} = \frac{3}{100} = 30\,mA$

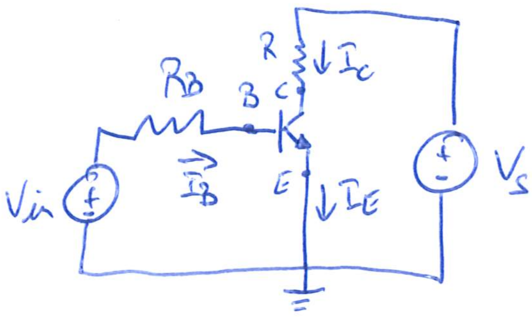
A4

a) $R_B = 10\,k\Omega$ $\quad V_{CE} = ?$ $\quad I_E = ?$ $\quad I_C = ?$

$R = 200\,\Omega$ $\quad V_{in} = 5V$ $\quad V_s = 12V$

$V_{BE} = 0.6V$

$\beta = 100$




- $V_{BE} = V_B - \underbrace{\cancel{V_E}}_{=0} = 0.6 \iff V_B = 0.6V$

- $I_B = \dfrac{V_{in} - V_B}{R_B} = \dfrac{5 - 0.6}{10K} = \dfrac{4.4}{10^4} = 0.44\ mA$

- $I_C = \beta I_B = 44\,mA$ ; $V_C = V_S - R\,I_C = 12 - 8.8 = 3.2V$

$V_{CE} = V_C - \overset{=0}{\cancel{V_E}} = V_C = 3.2\ V$

- $I_E = I_C + I_B = 44.44\,mA$

A4. b) Saturation mode : $V_B > V_E$ and $V_{CE} < V_{CE,sat}$

$R_B = ?$

From a): $V_{CE} = V_C - \cancel{V_E} = V_C$ ; $V_C = V_S - R\,I_C =$

$= 12 - 200\,I_C$

$I_C = \beta I_B \Rightarrow V_{CE} = 12 - 200\beta I_B$

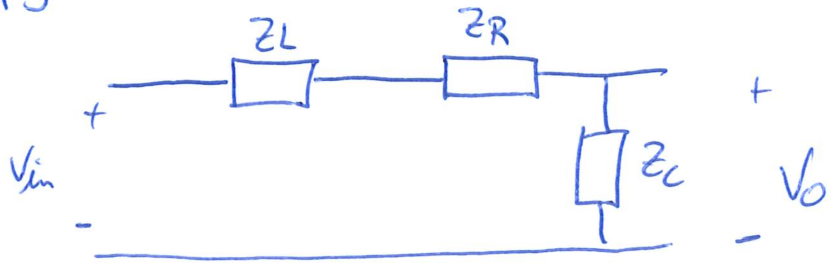
$I_B = \dfrac{V_{in} - V_{BE}}{R_B} = \dfrac{4.4}{R_B}$

$\Rightarrow V_{CE} = 12 - 2\times10^4 \times \dfrac{4.4}{R_B}$

$V_{CE} < V_{CE,sat} \Leftrightarrow V_{CE} < 0.2V \Leftrightarrow 12 - \dfrac{8.8\times10^4}{R_B} < 0.2 \Leftrightarrow$

$R_B < \dfrac{8.8\times10^4}{12}\ \Omega$

A5




$V_{in}$ and $V_o$ are phasors, where $V_{in}(t) = Im(V_{in} e^{j\omega t})$

$$V_{in} = 2 e^{j\frac{\pi}{3}} \quad ; \quad \omega = 2\pi f = 8000\pi \text{ rad/s}$$

$$V_o = H(j\omega) V_{in} \quad ; \quad H(j\omega) = ? \Rightarrow H(j\omega) = \frac{Z_C}{Z_L + Z_R + Z_C}$$

$$Z_R = R = \overset{50}{\cancel{2200}}\ \Omega \quad ; \quad Z_L = j\omega L = j\omega \text{ m}\Omega$$

$$Z_C = \frac{1}{j\omega C} = \frac{1}{j\omega \times 1.6} \times 10^6\ \Omega$$

$$H(j\omega) = \frac{\frac{1}{j\omega C}}{j\omega L + R + \frac{1}{j\omega C}} = \frac{1}{(j\omega)^2 LC + j\omega RC + 1} =$$

$$= \frac{1}{1 - \omega^2 LC + j\omega RC} = \frac{1}{1 - 64\pi^2 10^6 \times 1.6 \times 10^{-9} + j\, 8\pi \times 5 \times 1.6 \times 10^{-2}}$$

$$\underset{(\omega = 8000\pi)}{H(j\omega)} = \frac{1}{1 - 64\pi^2 \times 1.6 \times 10^{-3} + j\, 4\pi \times 1.6 \times 10^{-1}} = -0.0026 - j0.4973$$

$$V_o = H(j\omega) V_{in} = |H(j\omega)|\,|V_{in}|\, e^{j(\arg(H(j\omega)) + \arg(V_{in}))}$$

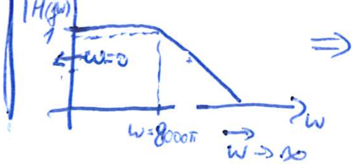
$$= 0.4974 \times 2\, e^{j\left(-1.58 + \frac{\pi}{3}\right)}$$

$$V_o(t) = 0.995 \times \sin\left(8000\pi t + \frac{\pi}{3} - 1.58\right)$$

$|H(j0)| = 1$

$|H(j8000\pi)| = 0.4974$

$|H(j\infty)| = 0$




$\Rightarrow$ Low-pass