EE 101 Endsem Exam 24 Nov'14
Solutions

Q1 (a) $v_- = v_+ = 4V$ [Virtual ground]

On applying KCL,

$$\frac{v_o - v_-}{1k\Omega} + 1mA = 0 \Rightarrow v_o - 4 + 1 = 0$$

$$\therefore v_o = 3V$$

2 Marks for final answer.

(b) $v_i = R_i i_s$ and $i_o = \frac{A_V v_i}{R_o + R_L}$

Thus, $i_o = \frac{A_V R_i i_s}{R_o + R_L} \Rightarrow A_V = \frac{(i_o/i_s)(R_o + R_L)}{R_i}$

$$\therefore A_V = \frac{(120)(40\Omega + 20\Omega)}{2000\Omega} = 3.6 \text{ V/V}$$

2 Marks for final answer

(c)

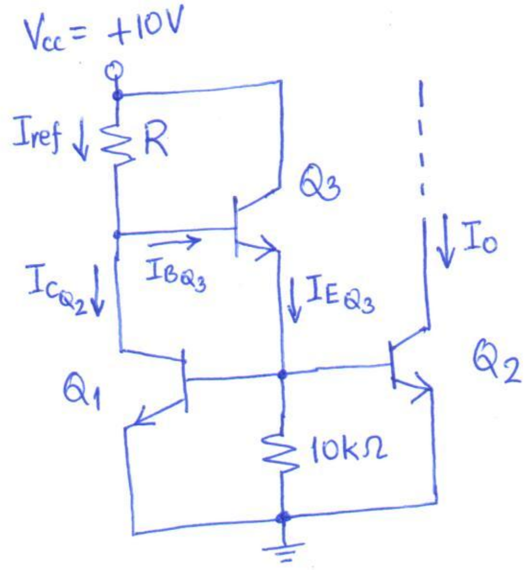
$$\begin{aligned} 127_8 &= (001010111)_2 \\ 5E_{16} &= (\ \ 01011110)_2 \\ \hline \text{Sum} &= (10110101)_2 \\ &= (11101111)_{Gray} \end{aligned}$$

Alternative way:

$$\begin{aligned} 127_8 &= 87_{10} \\ 5E_{16} &= 94_{10} \\ \hline \text{Sum} &= 181_{10} = 10110101_2 \\ &= 11101111_{Gray} \end{aligned}$$

2 Marks for obtaining the sum value in binary + 1 Mark for Gray conversion

Q 1 (d)



Q_1 and Q_2 are matched, and have same base-emitter voltage. Thus, they both have same collector current, namely $I_o = 0.7\,mA$. They also have the same base currents of I_o/β.

KCL equation:

$$I_{E_{Q_3}} = \frac{I_o}{\beta} + \frac{I_o}{\beta} + \frac{V_{BE}}{10k\Omega}$$

$$= \frac{2(0.7\times10^{-3})}{80} + \frac{0.7V}{10k\Omega} = 87.5\,\mu A$$

Then, $I_{B_{Q_3}} = I_{E_{Q_3}}/(1+\beta) = \dfrac{87.5\,\mu A}{1+80}$ 1

$= 1.08\,\mu A$

Now $I_{ref} = I_{B_{Q_3}} + I_{C_{Q_2}} = 1.08\,\mu A + 0.7\,mA$ +1

$= 0.7011\,mA$

$$\therefore R = \frac{V_{cc} - V_{BE_{Q_3}} - V_{BE_{Q_1}}}{I_{ref}}$$ +1

$$= \frac{(10 - 2\times0.7)V}{0.7011\times10^{-3}\,A} = 12.27\,k\Omega.$$

Alternate Solution:

$I_{ref} \approx I_o$ (Student should justify the base current $I_{B_{Q_3}}$ is neglected)

1 + 1 (for justification)

Q2. (a) Let 'x' be the fraction of the full range of the potentiometer. ~~There~~ w.r.t grounded end.

$$v_+ = \frac{xR_3}{R_3} v_i = x v_i = v^-, \qquad 0 \le x \le 1$$

On applying KCL at node between $R_1 - R_2$, we have

$$\frac{v_i - x v_i}{R_1} = \frac{x v_i - v_o}{R_2}$$

$\because R_1 = R_2, \quad \therefore v_o = (2x-1) v_i$

When $x = 1, \quad v_{o\,max} = v_i = +1V$ 1

When $x = 0, \quad v_{o\,min} = -v_i = -1V$ +1

(b) Now when switch is closed

$$\frac{v_i - x v_i}{R_1} = \frac{x v_i}{R_4} + \frac{x v_i - v_o}{R_2}$$

$$\frac{R_2}{R_1}(v_i - x v_i) = \frac{R_2}{R_4} \cdot x v_i + x v_i - v_o$$

$$\therefore v_o = \left[x + \frac{R_2}{R_4} x - \frac{R_2}{R_1}(1-x)\right] v_i$$ 1.5

When $x = 0, \quad v_{o\,min} = -\frac{R_2}{R_1} v_i = -1V$

When $x = 1, \quad v_{o\,max} = [1 + 4 + 0]\,1 = 5V$ +1.5

(c) From part (b), on setting absolute of $v_{o\,min}$ to 5

$$|v_{o\,min}| = \left| -\frac{R_2}{R_1} v_i \right| = 5$$

$$\Rightarrow \frac{R_2}{R_1} = 5 \quad \text{or} \quad R_1 = \frac{R_2}{5} = \frac{10k\Omega}{5} = 2\,k\Omega$$

2

Q3 (a)
(i)

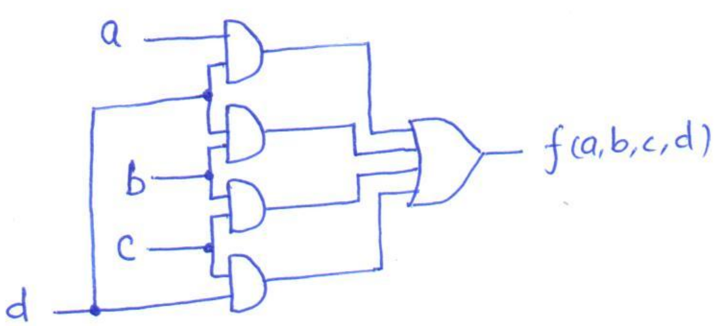
BCD Input				Output
a	b	c	d	f(a,b,c,d)
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	1
1	0	1	0	X
1	0	1	1	X
1	1	0	0	X
1	1	0	1	X
1	1	1	0	X
1	1	1	1	X

K-map

cd \ ab	00	01	11	10
00			X	
01		1	X	1
11	1	1	X	X
10		1	X	X

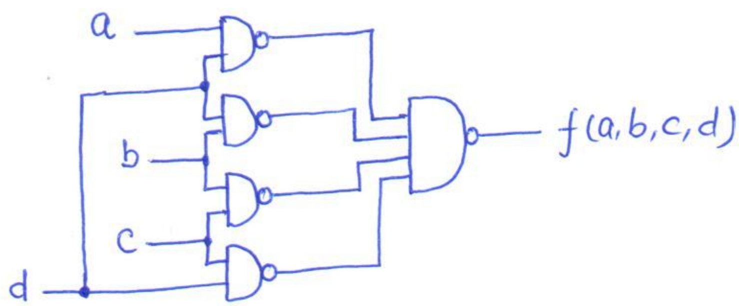
Minimized logic ckt → $f(a,b,c,d) = cd + bc + bd + ad$ 2

(ii) Realization using AND, OR gates



1

(iii) Realization using ONLY NAND gates



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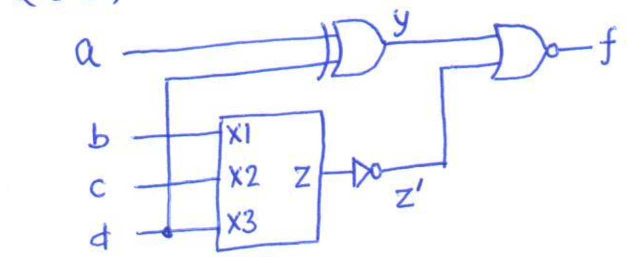
Q3(b)

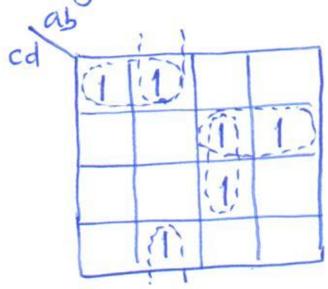


(i) Truth Table

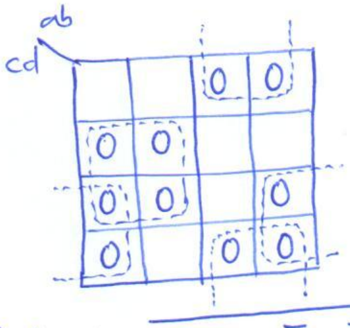
a	b	c	d	y	z'	f
0	0	0	0	0	0	1
0	0	0	1	1	0	0
0	0	1	0	0	1	0
0	0	1	1	1	1	0
0	1	0	0	0	0	1
0	1	0	1	1	0	0
0	1	1	0	0	0	1
0	1	1	1	1	0	0
1	0	0	0	1	0	0
1	0	0	1	0	0	1
1	0	1	0	1	1	0
1	0	1	1	0	1	0
1	1	0	0	1	0	0
1	1	0	1	0	0	1
1	1	1	0	1	0	0
1	1	1	1	0	0	1

2

(ii) The logic circuit contains 6 minterms or 10 maxterms. Thus on plotting in K-map, we can note that POS form of logic expression leads to better minimization



(A) $f = \bar{a}\bar{c}\bar{d} + \bar{a}b\bar{d} + abd + a\bar{c}d$

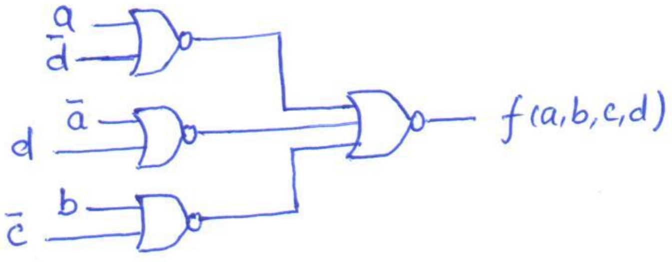


(B) $f = \overline{\bar{a}d + a\bar{d} + \bar{b}c}$

1 Mark for either (A) or (B)

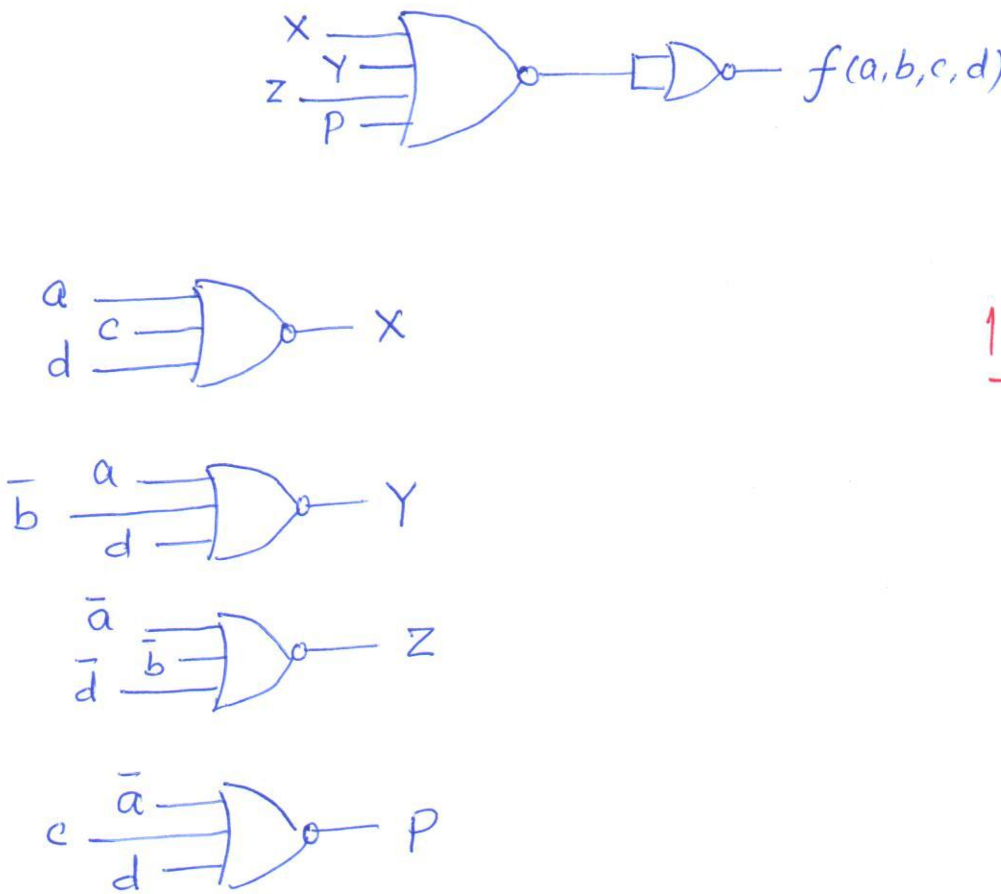
(iii) Realization of POS expression using only NOR gates with the assumption that complemented and uncomplemented logic variables are available.

1 Mark



Alternate non-minimum NOR only realization ⟶

NOR only realization for SOP, expression (A)



1 Mark

EE-101.

Q. 1

(a) $B = 1.5 \sin 377t$.

$A = 4 \times 4 \times 10^{-4}\ m^2$

$\therefore \varphi = 1.5 \times 16 \times 10^{-4} \sin 377t$. [1]

$\lambda = N\varphi = 200 \times 1.5 \times 16 \times 10^{-4} \sin 377t$. [1]

$\therefore e = \frac{d\lambda}{dt} = 4800 \times 10^{-4}\ 377 \cos 377t$.

$= 0.48 \times 377 \cos 377t$ [1]

$= \underline{\underline{181 \cos 377t}}$.

(b) Peak value of the flux $= \frac{1.5 \times 1.6 \times 10^{-3}}{\sqrt{2}} = Wb$

$= \underline{\underline{1.70\ mWb}}$.

Reluctance $= \frac{l}{\mu A} = \frac{0.80}{4\pi \times 10^{-7} \times 3000 \times 16 \times \cancel{10^{-4}}}$

$= \frac{0.8}{4\pi \times 3 \times 16} \times 10^{7}\ H^{-1} = 13262.9\ H^{-1}$ [1]

$N I_{m} = 1.70 \times 10^{-3} \times 13262.9$.

$\therefore I_{max} = \frac{1.70 \times 13.2629}{200} = \underline{\underline{0.113\ A}}$. [2].

(c) $L = \frac{N^2}{\mathcal{R}} = \frac{200^2}{13262.9} = 3.016\ H$. [1]

$W_f = \frac{1}{2} i_m^2 L = \frac{1}{2} 0.113^2 \times 3.016\ J$

$= 0.0192\ (J)$. [1].

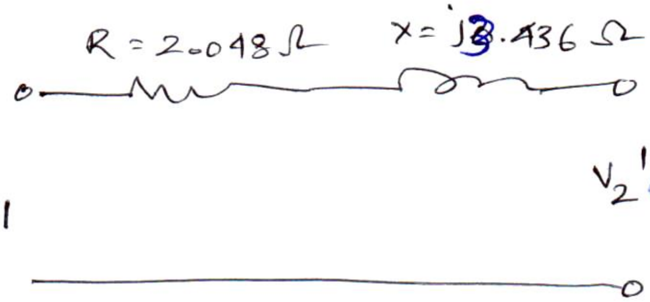
(2)

(a). $Z = \frac{100}{25} = 4\,\Omega$

$i^2R = 1280 \rightarrow R = \frac{1280}{25^2} = 2.048\,\Omega$. [1]

$\therefore X = \sqrt{Z^2 - r^2} = 3.436\,\Omega$. [1]

Referred to the hv side.



[1]

(b) At 40kW load at 0.8 pf. lag, $V_2' = 2400$ V.

$S = 40\times10^3 \angle 36.87°$

$I_2' = \frac{40\times10^3}{0.8\times2400} \angle -36.87°$

$= 20.83 \angle -36.87°$ A. [2]

Copper loss $= 20.83^2 \times 2.048 = 888.6$ W. [1]

$\therefore \eta = \frac{40}{40+0.8+0.8886} = 0.9595 = 95.95\%$ [1]

Input voltage $= V_2'\angle 0° + I_2'(R+jX)$.

$= 2400\angle 0° + 20.83\angle -36.87° \times \underbrace{(2.048 + j3.436)}_{4\angle 59.20°}$.

$\doteq 2400\angle 0° + 83.32\angle 22.33°$

$= 2400 + 77.03 + j31.65$

$= 2477.03 + j31.65$

$= 2477.2\angle 0.73°$ [2]

③ ⓐ ~~P~~ < $N_s = \frac{120f}{P} \gtrsim N_m = 1470$

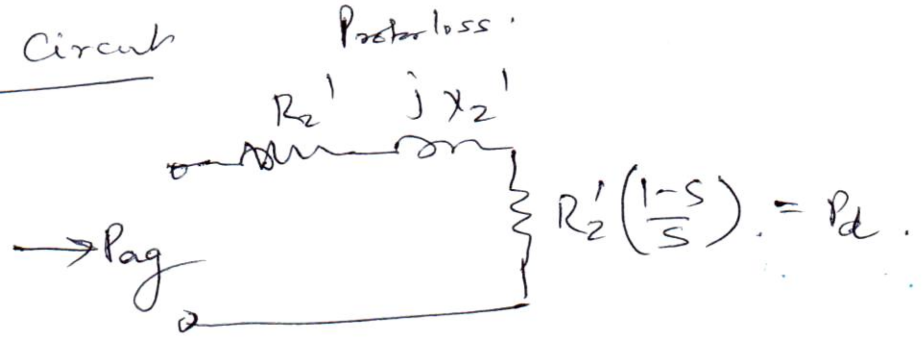
$$P \lesssim \frac{120\times 50}{1470} = 4.08 .$$

$\therefore P = 4$ poles [1]

and $N_s = \frac{120f}{P} = \frac{120\times 50}{4} = 1500$ rpm.

and $s = \frac{N_s - N_m}{N_s} = \frac{1500-1470}{1500} = 0.02$ pu. [1]

Rotor Circuit



[3]

ⓑ Frequency of the rotor current [1]

$f_r = sf = 0.02\times 50 = 1$ Hz

Speed of the rotor flux wrt rotor

$= \frac{120 f_r}{P} = \frac{120\times 1}{4} = 30$ rpm. [1]

ⓒ $P_d = 50$ kW $= 50\times 10^3$ W

$= 3\, I_2'^2 r_2' \left(\frac{1-s}{s}\right)$ [1]

$\therefore$ Rotor Copper loss $= 3\, I_2'^2 r_2' = \frac{P_d \times s}{1-s}$ [3]

$= \frac{5\times 0.02}{0.98} = 0.102$ kW.

Air gap power $= 3\frac{I_2'^2 r_2}{s} = \frac{P_d}{1-s} = \frac{5}{0.98}$ kW $= 5.102$ kW [1]