2011-2012 Answer

1. (10%) Find the minimum POS form for the following expression

$$Y = \overline{(A \oplus B)\overline{\overline{B}(\overline{A}B\overline{C}\overline{D} + \overline{A}C\overline{D})}}$$

Solution.

$$Y = \overline{(A\oplus B)\left(B + \overline{(\overline{A}B\overline{C}\overline{D} + \overline{A}C\overline{D})}\right)} = \overline{(A\oplus B)\left(B + (A+\overline{B}+C+D)(A+\overline{C}+D)\right)}$$

$$= \overline{(A\oplus B)\left(B + A + D + (\overline{B}+C)\overline{C}\right)} = \overline{(A\oplus B)\left(B+A+D+\overline{B}\overline{C}\right)}$$

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

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

+10

2. (10%) Use the minimum number of gates to implement a circuit that detects if a 4-bit binary number $A_3A_2A_1A_0$ is greater than 9. When the number is greater than 9, the output $Y=1$; otherwise $Y=0$.

>9

Solution.

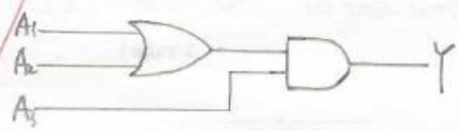
The Truth Table

Dec	A_3	A_2	A_1	A_0	Y
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	0
8	1	0	0	0	0
9	1	0	0	1	0
10	1	0	1	0	1
11	1	0	1	1	1
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	1

The Karnaugh Map.

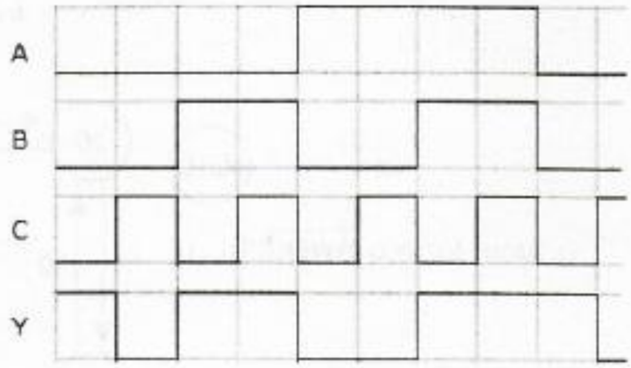
A_3A_2 \ A_1A_0	00	01	11	10	
00	0	0	0	0	
01	0	0	0	0	
11	1	1	1	1	A_3A_2
10	0	0	1	1	A_3A_1

$$Y = A_3A_2 + A_3A_1$$
$$= A_3(A_1+A_2)$$



3. (15%) Use one 3-line-to-8-line decoder 74LS138 and one NAND gate to implement a circuit whose output Y and inputs A, B, and C are related as shown in Figure 1.

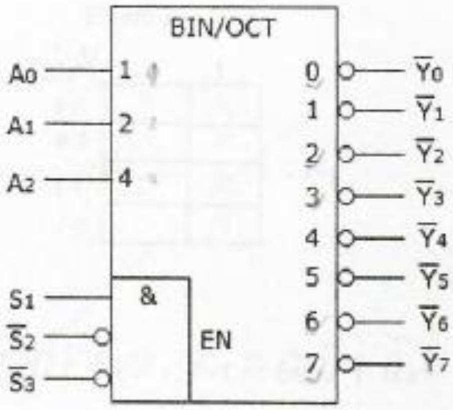
+15



(a) Waveforms for the desired circuit

INPUTS					OUTPUTS							
S_1	$\overline{S_2}+\overline{S_3}$	A_2	A_1	A_0	$\overline{Y_0}$	$\overline{Y_1}$	$\overline{Y_2}$	$\overline{Y_3}$	$\overline{Y_4}$	$\overline{Y_5}$	$\overline{Y_6}$	$\overline{Y_7}$
0	x	x	x	x	1	1	1	1	1	1	1	1
x	1	x	x	x	1	1	1	1	1	1	1	1
1	0	0	0	0	0	1	1	1	1	1	1	1
1	0	0	0	1	1	0	1	1	1	1	1	1
1	0	0	1	0	1	1	0	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1	1	1
1	0	1	0	0	1	1	1	1	0	1	1	1
1	0	1	0	1	1	1	1	1	1	0	1	1
1	0	1	1	0	1	1	1	1	1	1	0	1
1	0	1	1	1	1	1	1	1	1	1	1	0

(b) Function Table for 74LS138



(c) Logic symbol for 74LS138

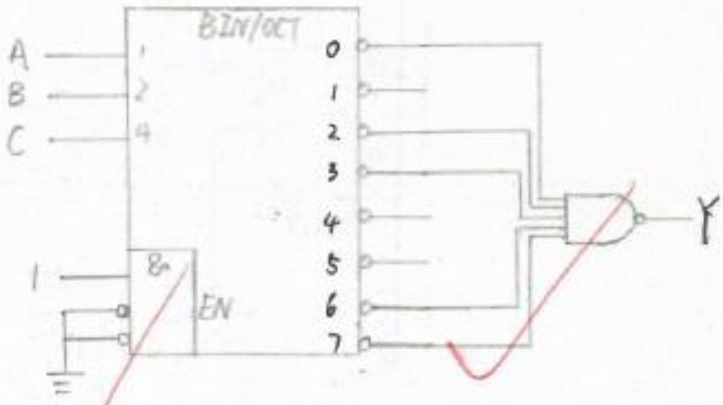
Figure 1

Truth Table.

A	B	C	Y
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

AB \ C	0	1
00	1	0
01	1	1
11	1	1
10	0	0

$\therefore Y = \cancel{A\bar{C}+B}\ \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + AB\bar{C} + ABC$.



4. (10%) Use 4-bit adders to implement a circuit which adds up two 11-bit numbers. Label all critical inputs and outputs.

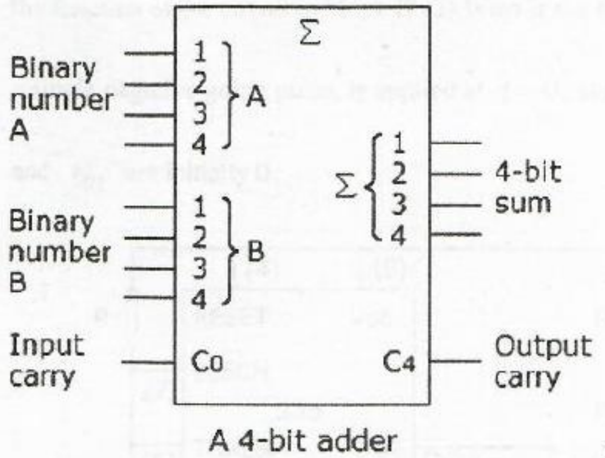
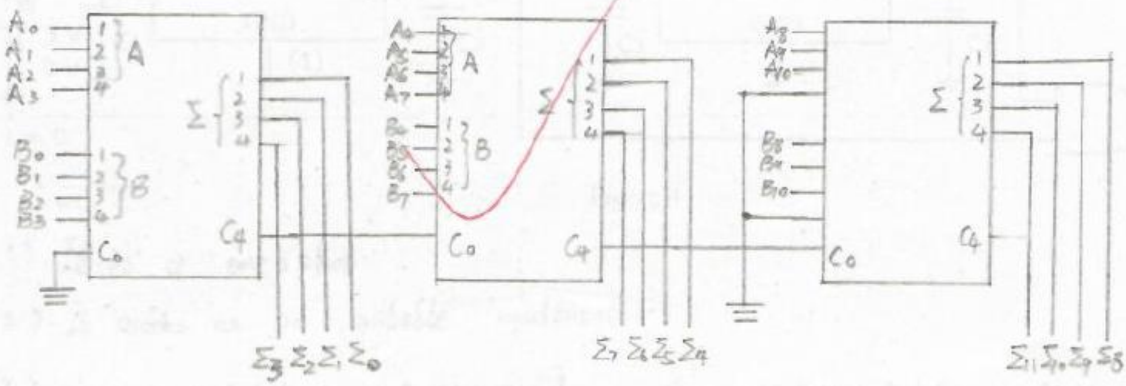
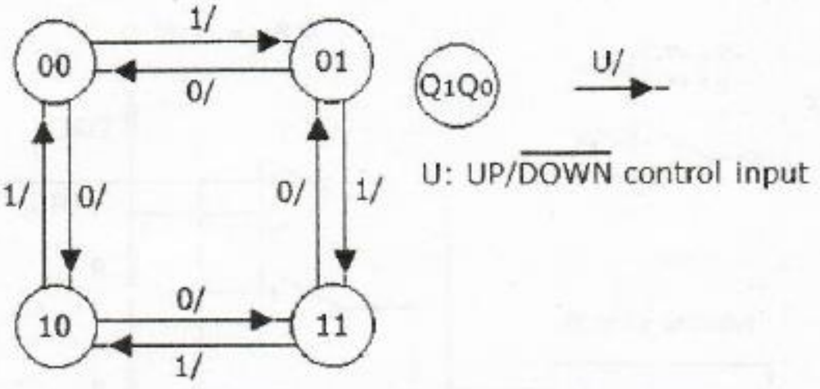


Figure 2



5. (15%) Use J-K flip-flops and the minimum number of gates to implement a synchronous 2-bit up/down counter with a Gray code sequence. The counter should count up when an $UP/\overline{DOWN}$ control input is 1 and count down when the control input is 0.

+15



State diagram for a 2-bit Gray code counter

Figure 3

state table.

$Q_1^n Q_0^n$	$Q_1^{n+1} Q_0^{n+1}$	
	$U=0$	$U=1$
0 0	10	01
0 1	00	11
1 1	01	10
1 0	11	00

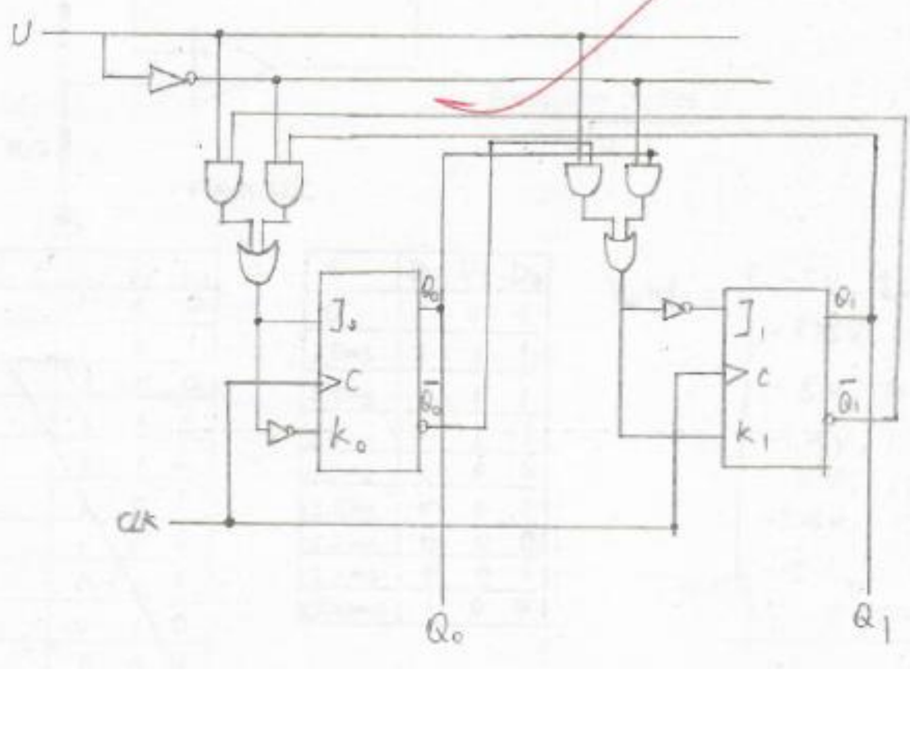
J-k :

$Q^n \to Q^{n+1}$	J	K
0 0	0	X
0 1	1	X
1 0	X	1
1 1	X	0

$Q_1Q_0 \backslash U$	0	1
00	X	X
01	X	X
11	1	0
10	0	1

k_1

$$J_0 = Q_1\bar{U} + \bar{Q}_1 U, \quad K_0 = \bar{Q}_1\bar{U} + Q_1 U, \quad J_1 = \bar{Q}_0\bar{U} + Q_0 U, \quad K_1 = Q_0\bar{U} + \bar{Q}_0 U$$



6. (15%) In Figure 4, $R_1 = 150\ \text{k}\Omega$, $R_2 = R_3 = 24\ \text{k}\Omega$, $C_1 = 0.033\ \mu\text{F}$, $C_2 = C_3 = C_4 = 0.01\ \mu\text{F}$. (1) What is the function of the circuit in block I? (2) What is the function of the circuit in block 2? (3) Suppose that the input v_{IN}, a single negative-going pulse, is applied at $t = 0$, sketch the waveforms v_{O1}, v_{O2}, and v_O. Suppose that both v_{O1} and v_{O2} are initially 0.

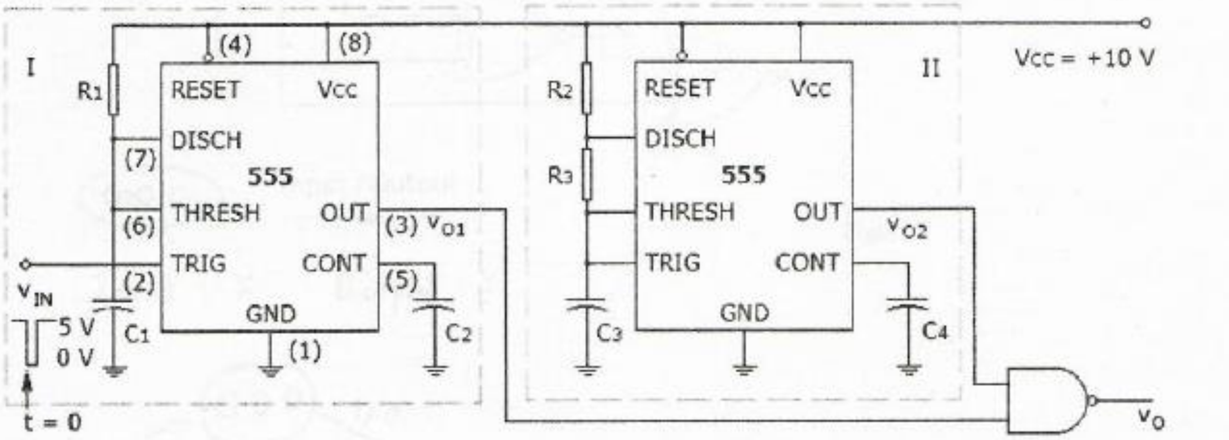
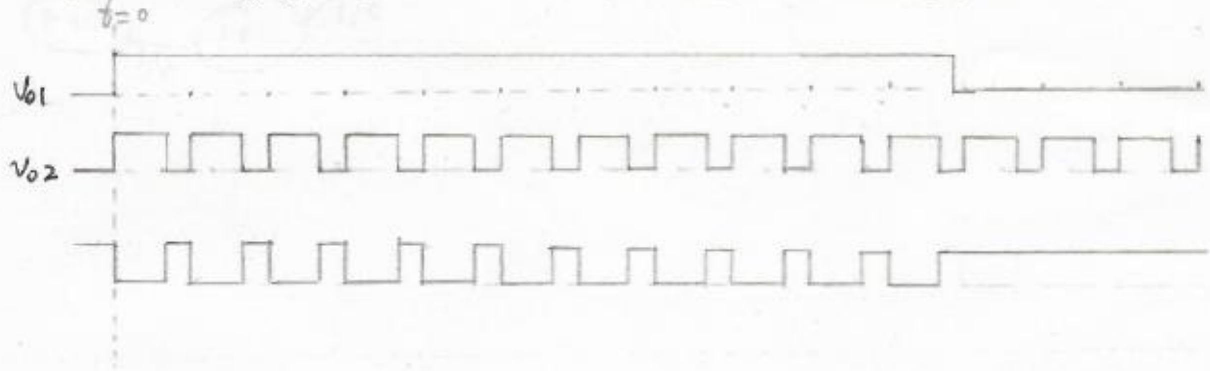


Figure 4

(1) It is a one-shot.

(2) It works as an astable multivibrator.

(3) $t_{w1} = 1.1 R_1 C_1 = 5.445 \times 10^{-3}\ \text{s}$. $t'_{w1} = 0.7(R_2+R_3)C_3 = 0.336 \times 10^{-3}\ \text{s}$.
$t'_{w2} = 0.7 R_3 C_3 = 0.168 \times 10^{-3}\ \text{s}$. $T = t'_{w1} + t'_{w2} = 0.504 \times 10^{-3}\ \text{s}$.



7. (15%) The input to the circuit in Figure 5 is $v_{IN}(t) = 4 + 4\sin(100\pi t)$ V, $0 \le t \le 20$ ms. The sampling signal has a frequency of 400 Hz. Determine the binary code sequence $D_2D_1D_0$ and the output $v_{OUT}(t)$ for $0 \le t \le 20$ ms.

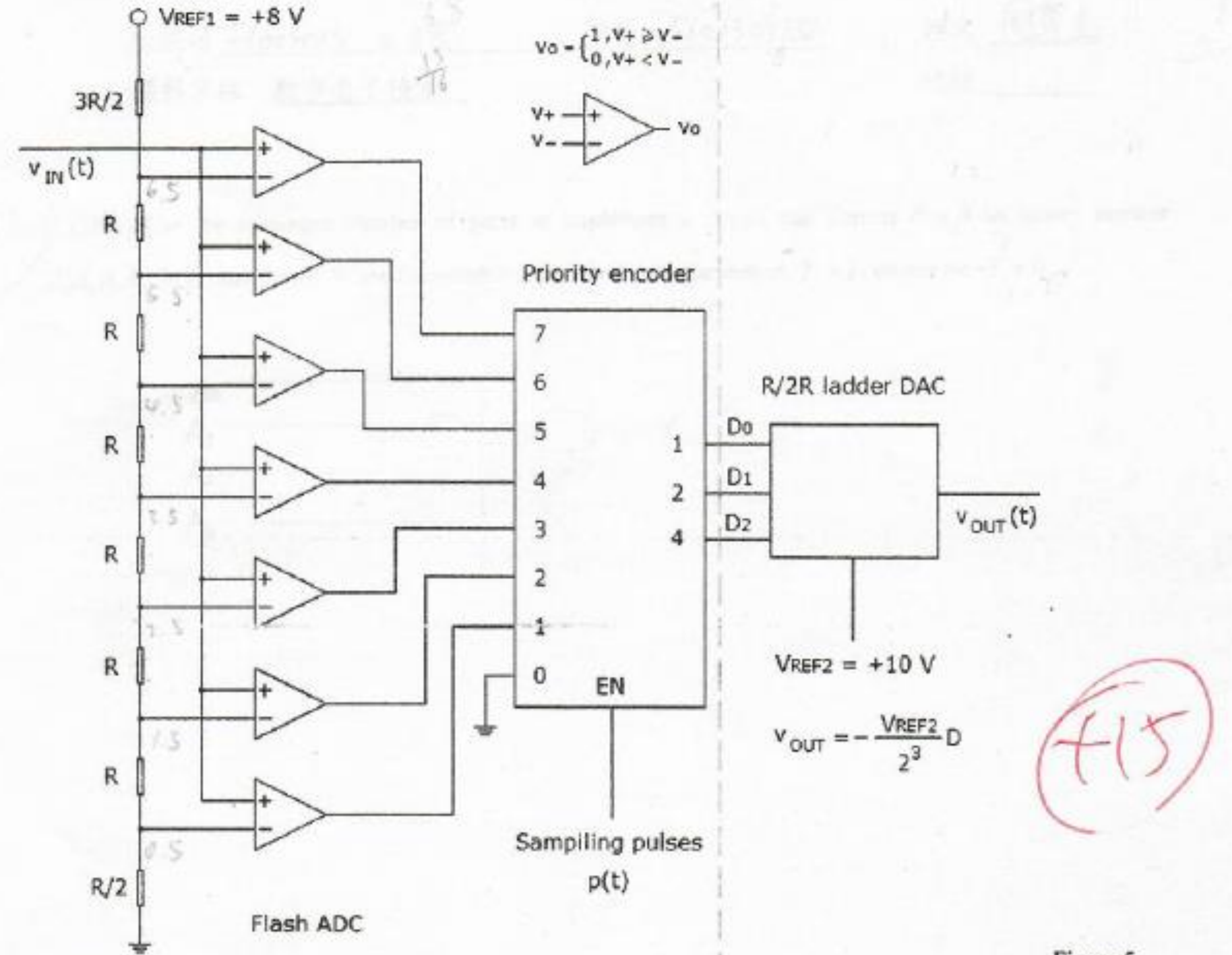


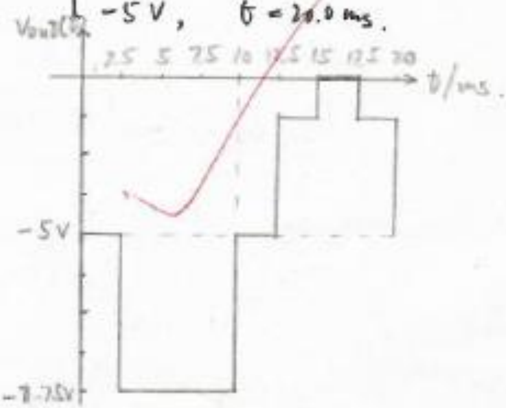
Figure 5

+15

t	D_2	D_1	D_0
0	1	0	0
	1	0	1
	1	1	0
	1	1	1
	1	1	0
	1	0	1
	1	0	0
	0	1	1
	0	1	0
	0	0	1
	0	0	0
	0	0	1
	0	1	0
	0	1	1
	1	0	0

t	D_2	D_1	D_0
0	1	0	0
2.5ms	1	1	1
5.0ms	1	1	1
7.5ms	1	1	1
10.0 ms	1	0	0
12.5ms	0	0	1
15.0 ms	0	0	0
17.5ms	0	0	1
20.0ms	1	0	0

$$V_{out}(t) = \begin{cases} -5\,V, & 0 \le t < 2.5\,ms \\ -8.75\,V, & 2.5\,ms \le t < 10.0\,ms \\ -5\,V, & 10.0\,ms \le t < 12.5\,ms \\ -1.25\,V, & 12.5\,ms \le t < 15\,ms \\ 0\,V, & 15\,ms \le t < 17.5\,ms \\ -1.25\,V, & 17.5\,ms \le t < 20.0\,ms \\ -5\,V, & t = 20.0\,ms \end{cases}$$



8. (10%) Draw the state diagram for the circuit in Figure 6. Y is the output of the circuit.

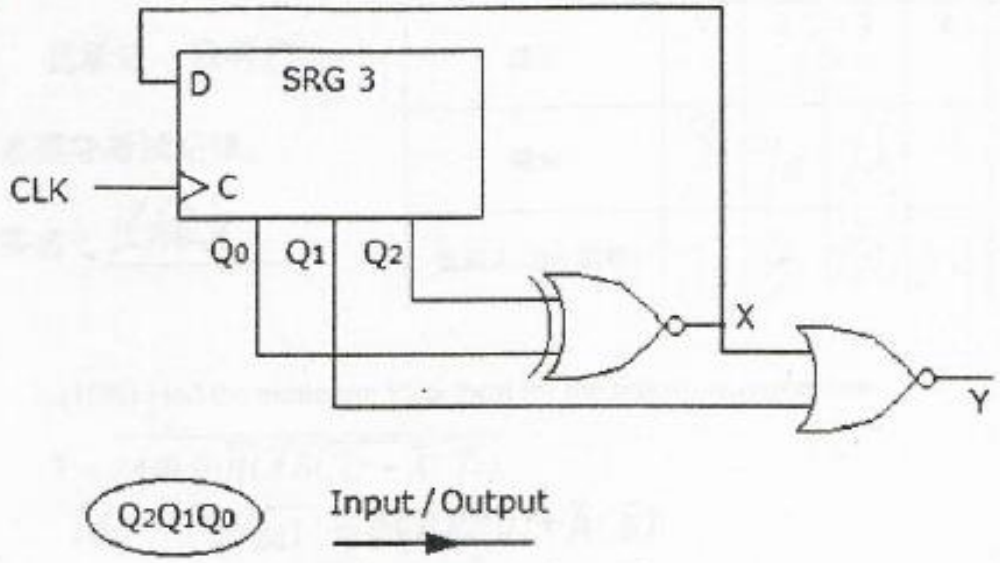
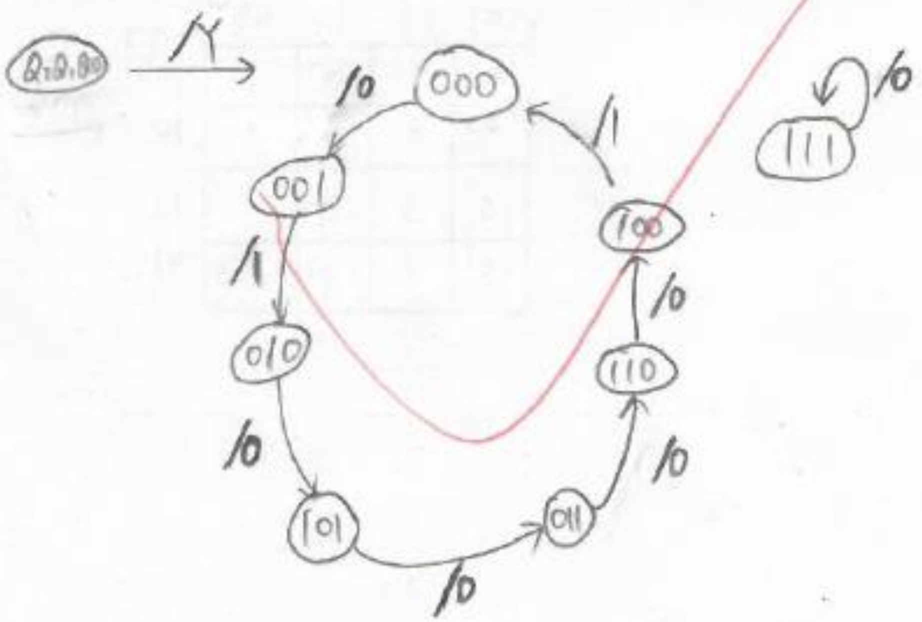


Figure 6

Sol:

Present state $Q_2(n)$	$Q_1(n)$	$Q_0(n)$	X	Y	next state $Q_2(n+1)$	$Q_1(n+1)$	$Q_0(n+1)$
0	0	0	1	0	0	0	1
0	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	0	1	1	0	0	1	1
0	1	1	0	0	1	1	0
1	1	0	0	0	1	0	0
1	0	0	0	1	0	0	0
1	1	1	1	0	1	1	1



2015-2016 Answer

(I)True/False

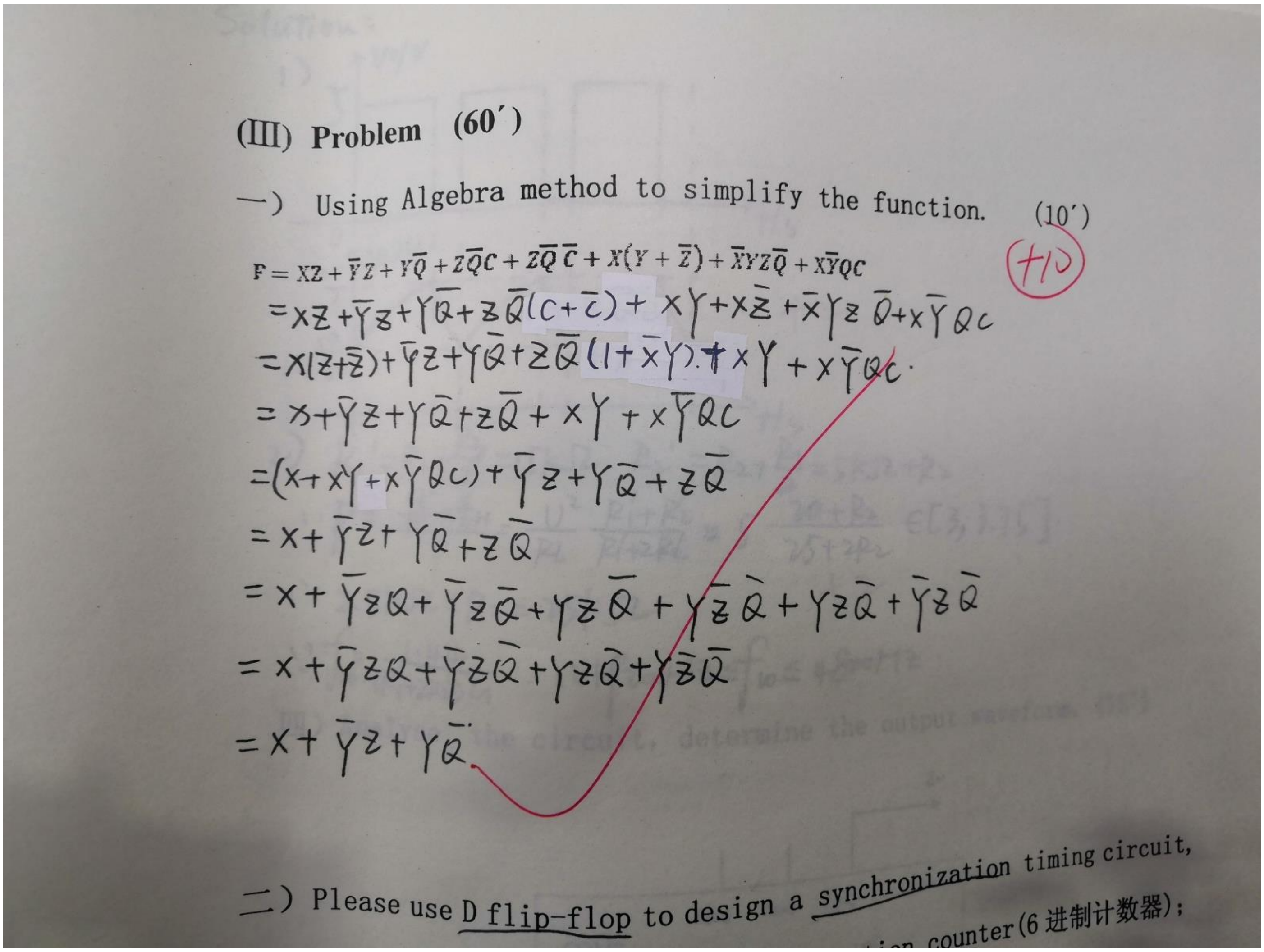
FFFTF   FFTTF

(II)Choice

BDEAB   AABBA

(III)Problem

一.



(III) Problem (60′)

一) Using Algebra method to simplify the function. (10′)

$F = XZ + \bar{Y}Z + Y\bar{Q} + Z\bar{Q}C + Z\bar{Q}\bar{C} + X(Y+\bar{Z}) + \bar{X}YZ\bar{Q} + X\bar{Y}QC$

$= XZ + \bar{Y}Z + Y\bar{Q} + Z\bar{Q}(C+\bar{C}) + XY + X\bar{Z} + \bar{X}YZ\bar{Q} + X\bar{Y}QC$

$= X(Z+\bar{Z}) + \bar{Y}Z + Y\bar{Q} + Z\bar{Q}(1+\bar{X}Y) + XY + X\bar{Y}QC$

$= X + \bar{Y}Z + Y\bar{Q} + Z\bar{Q} + XY + X\bar{Y}QC$

$= (X + XY + X\bar{Y}QC) + \bar{Y}Z + Y\bar{Q} + Z\bar{Q}$

$= X + \bar{Y}Z + Y\bar{Q} + Z\bar{Q}$

$= X + \bar{Y}ZQ + \bar{Y}Z\bar{Q} + YZ\bar{Q} + Y\bar{Z}\bar{Q} + YZ\bar{Q} + \bar{Y}Z\bar{Q}$

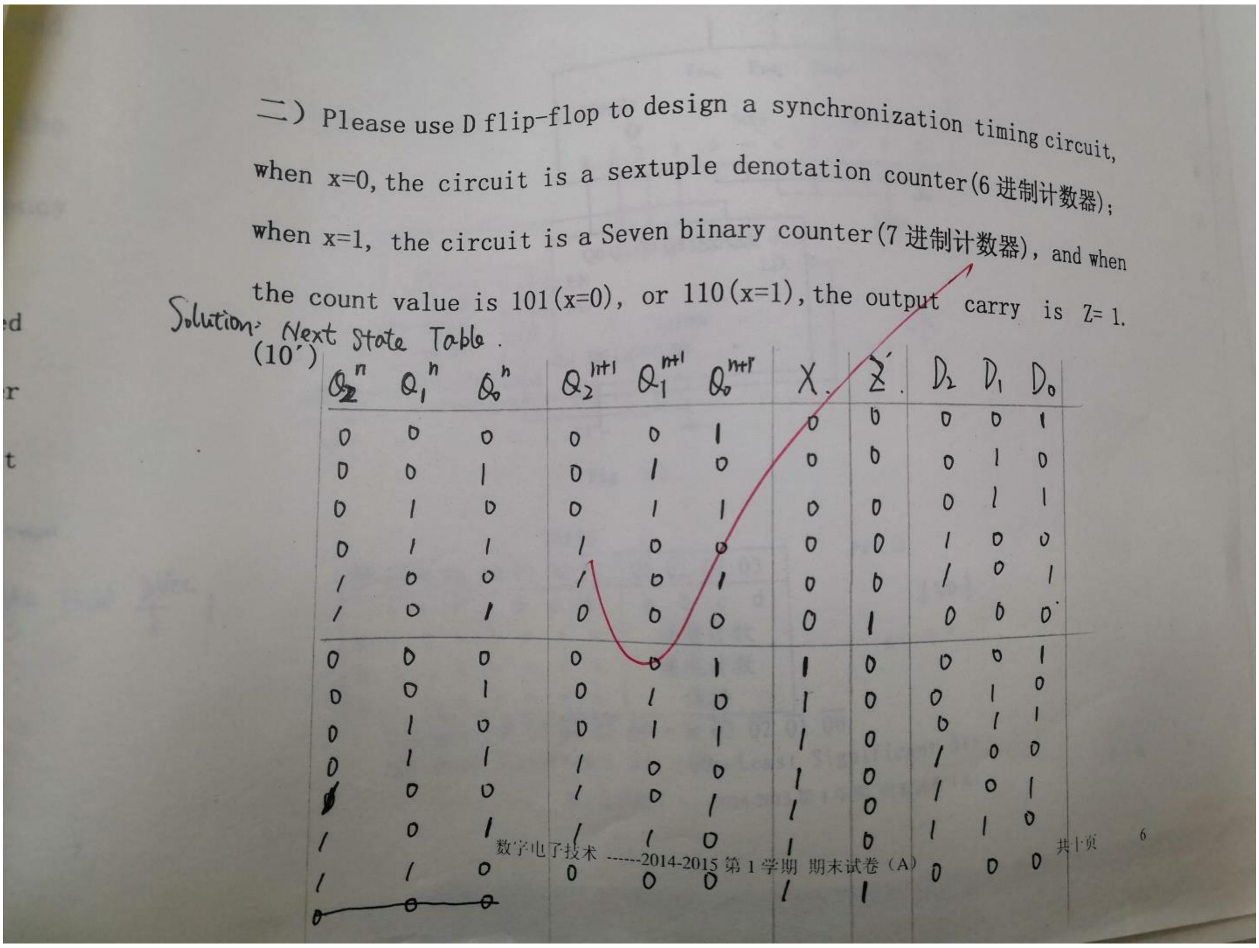
$= X + \bar{Y}ZQ + \bar{Y}Z\bar{Q} + YZ\bar{Q} + Y\bar{Z}\bar{Q}$

$= X + \bar{Y}Z + Y\bar{Q}$

+10

二) Please use D flip-flop to design a synchronization timing circuit, ...ion counter(6 进制计数器);

二.



二） Please use D flip-flop to design a synchronization timing circuit, when x=0, the circuit is a sextuple denotation counter(6 进制计数器); when x=1, the circuit is a Seven binary counter(7 进制计数器), and when the count value is 101(x=0), or 110(x=1), the output carry is Z= 1.
(10′)

Solution: Next State Table.

Q_2^n	Q_1^n	Q_0^n	Q_2^{n+1}	Q_1^{n+1}	Q_0^{n+1}	X	Z	D_2	D_1	D_0
0	0	0	0	0	1	0	0	0	0	1
0	0	1	0	1	0	0	0	0	1	0
0	1	0	0	1	1	0	0	0	1	1
0	1	1	1	0	0	0	0	1	0	0
1	0	0	1	0	1	0	0	1	0	1
1	0	1	0	0	0	0	1	0	0	0
0	0	0	0	0	1	1	0	0	0	1
0	0	1	0	1	0	1	0	0	1	0
0	1	0	0	1	1	1	0	0	1	1
0	1	1	1	0	0	1	0	1	0	0
1	0	0	1	0	1	1	0	1	0	1
1	0	1	1	1	0	1	0	1	1	0
1	1	0	0	0	0	1	1	0	0	0
~~0~~	~~0~~	~~0~~								

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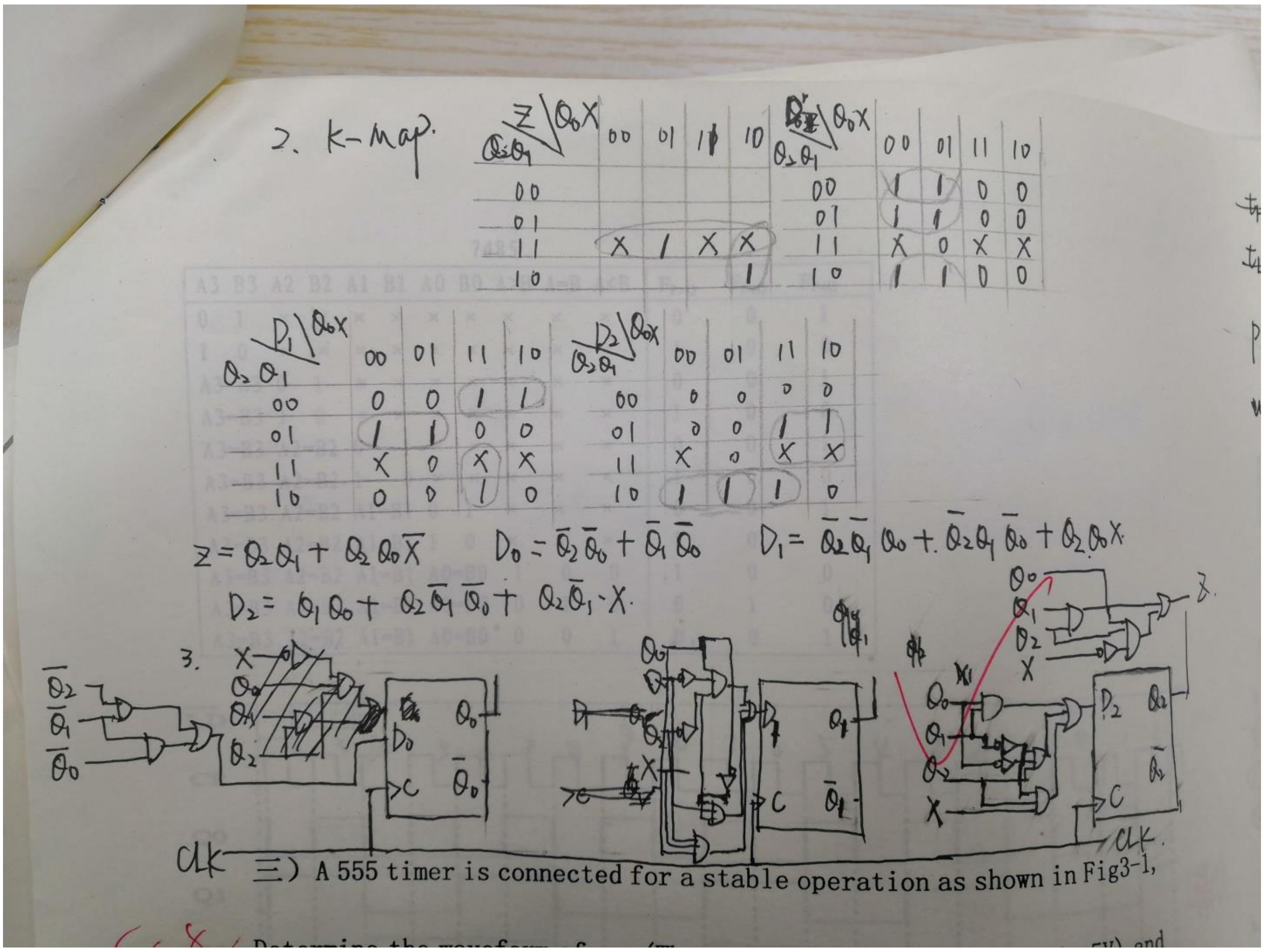


2. K-Map.

Z: $Q_2Q_1 \backslash Q_0X$	00	01	11	10
00				
01				
11	X	1	X	X
10				1

D_0: $Q_2Q_1 \backslash Q_0X$	00	01	11	10
00	1	1	0	0
01	1	1	0	0
11	X	0	X	X
10	1	1	0	0

D_1: $Q_2Q_1 \backslash Q_0X$	00	01	11	10
00	0	0	1	1
01	1	1	0	0
11	X	0	X	X
10	0	0	1	0

D_2: $Q_2Q_1 \backslash Q_0X$	00	01	11	10
00	0	0	0	0
01	0	0	1	1
11	X	0	X	X
10	1	1	1	0

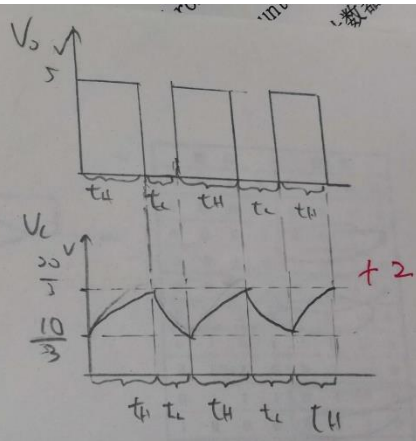
$Z = Q_2Q_1 + Q_2Q_0\bar{X}$ $D_0 = \bar{Q}_2\bar{Q}_0 + \bar{Q}_1\bar{Q}_0$ $D_1 = \bar{Q}_2\bar{Q}_1Q_0 + \bar{Q}_2Q_1\bar{Q}_0 + Q_2Q_0X$

$D_2 = Q_1Q_0 + Q_2\bar{Q}_1\bar{Q}_0 + Q_2\bar{Q}_1 \cdot X$

3.

三） A 555 timer is connected for a stable operation as shown in Fig3-1,

三.



$t_H = 0.7(R_1+R_2+R_3)C$

$t_L = 0.7(R_2+R_3)C$

$\because P = 3 \sim 3.75$

$\therefore \dfrac{R_1+R_2+R_3}{R_1+R_2+R_3+R_2+R_3} = \dfrac{3}{\frac{5^2}{5}}$

$\therefore R_2 = 10\,k\Omega$ +5

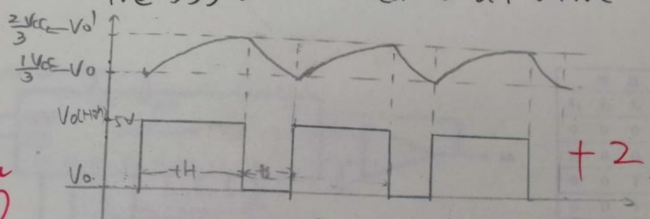
$\therefore t_\Sigma = t_H + t_L' = 0.21 + 0.14 = 0.35\,ms$

$t_\Sigma' = t_H + t_L' = 0.21 + 0.7 \times R_2 C = 0.28\,ms$

$\therefore 2857.1\,Hz < f_{V_o} < 3571.4\,Hz$ +3

四) Analyse the circuit, determine the output waveform. (15′)

The 555 timer is used as an astable multivibrator



+2

~~$t_H = 0.7(R_1+\frac{R_3}{3})C$~~

~~$t_L = 0.7(\frac{R_3}{3}+R_2)C$~~

$t_H = 0.7(R_1+R_{3x}+R_2)C$

$t_L = 0.7(R_2+R_{3x})C$

$P_{bulb} = \dfrac{V_o^2}{R_{bulb}} \cdot \dfrac{t_H}{t_H+t_L} = 5 \cdot \dfrac{t_H}{t_H+t_L}$

$\therefore \dfrac{3}{5} \le \dfrac{t_H}{t_H+t_L} \le \dfrac{3}{4}$

$\dfrac{t_H}{t_H+t_L} = \dfrac{R_1+R_3+R_2}{R_1+2R_2+R_3+R_{3x}} = \dfrac{20k+R_2}{20k+2R_2+R_{3x}}$

when $R_{3x}=0$: $\dfrac{20k+R_2}{20k+2R_2} = \dfrac{3}{4}$

when $R_{3x}=10$: $\dfrac{20k+R_2}{30k+2R_2} = \dfrac{3}{5}$

Then, $t_H = 0.7(30k)\cdot C = 2.1\times10^{-4}\,s$

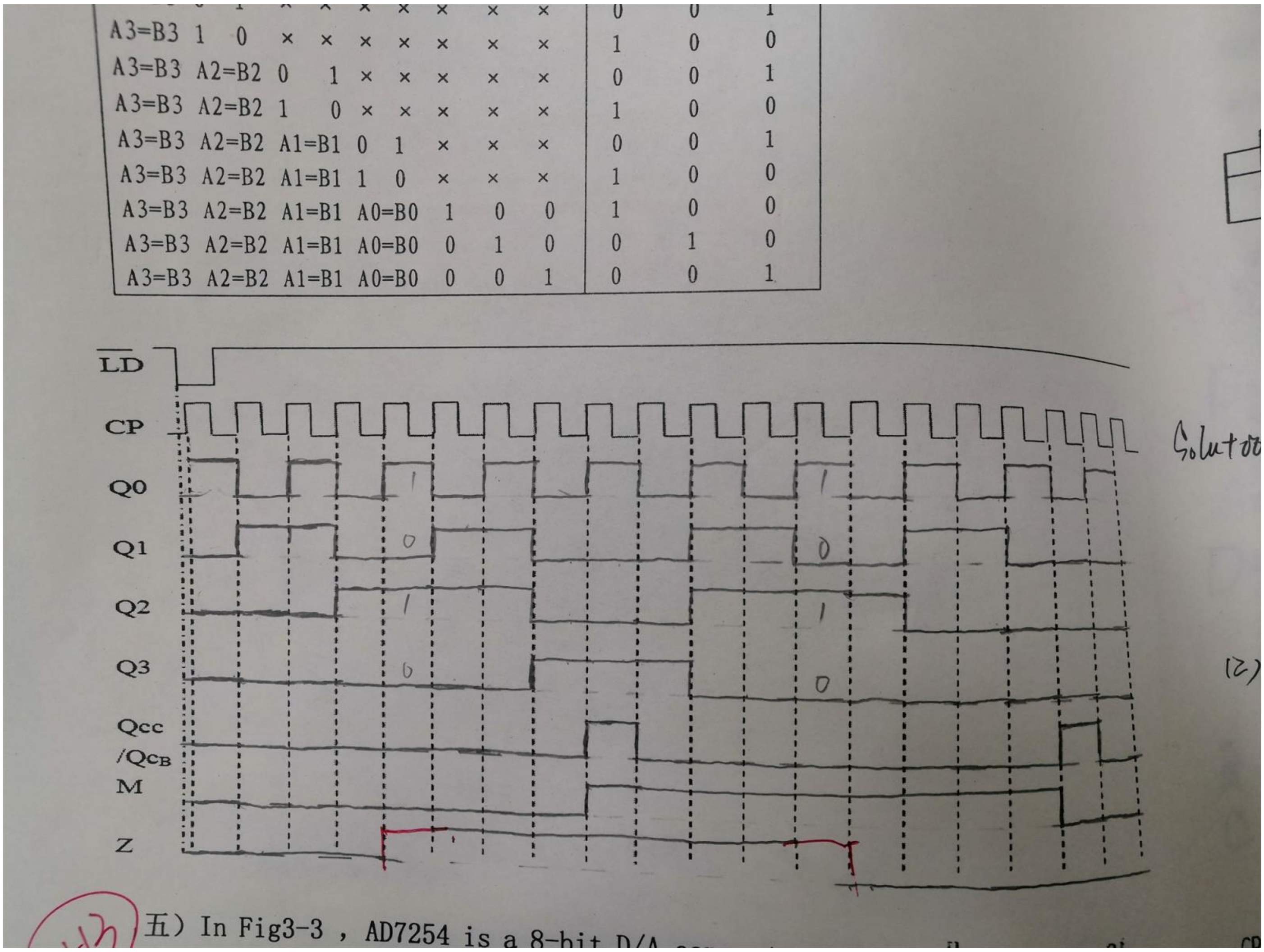
$t_L = 0.7(10k)\cdot C \sim 0.7(20k)\cdot C = 7\times10^{-5}\,s \sim 1.4\times10^{-4}\,s$

$f(V_o) = \dfrac{1}{t_H+t_L} = 2857.14 \sim 3571.43\,Hz$ +3

Therefore, $R_2 = 10\,k\Omega$ +5

四) Analyse the circuit, determine the output waveform. (15′)

四.



		0	1	×	×	×	×	×	×	×	0	0	1
A3=B3		1	0	×	×	×	×	×	×	×	1	0	0
A3=B3		A2=B2		0	1	×	×	×	×	×	0	0	1
A3=B3		A2=B2		1	0	×	×	×	×	×	1	0	0
A3=B3		A2=B2		A1=B1		0	1	×	×	×	0	0	1
A3=B3		A2=B2		A1=B1		1	0	×	×	×	1	0	0
A3=B3		A2=B2		A1=B1		A0=B0		1	0	0	1	0	0
A3=B3		A2=B2		A1=B1		A0=B0		0	1	0	0	1	0
A3=B3		A2=B2		A1=B1		A0=B0		0	0	1	0	0	1

五）In Fig3-3 , AD7254 is a 8-bit D/A

五.

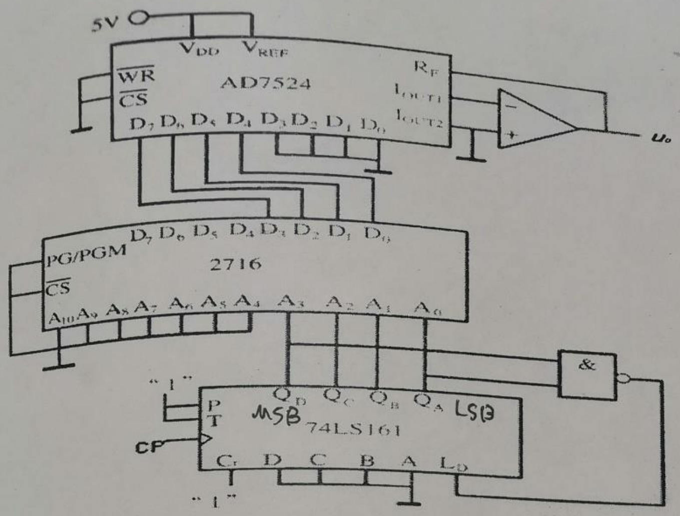
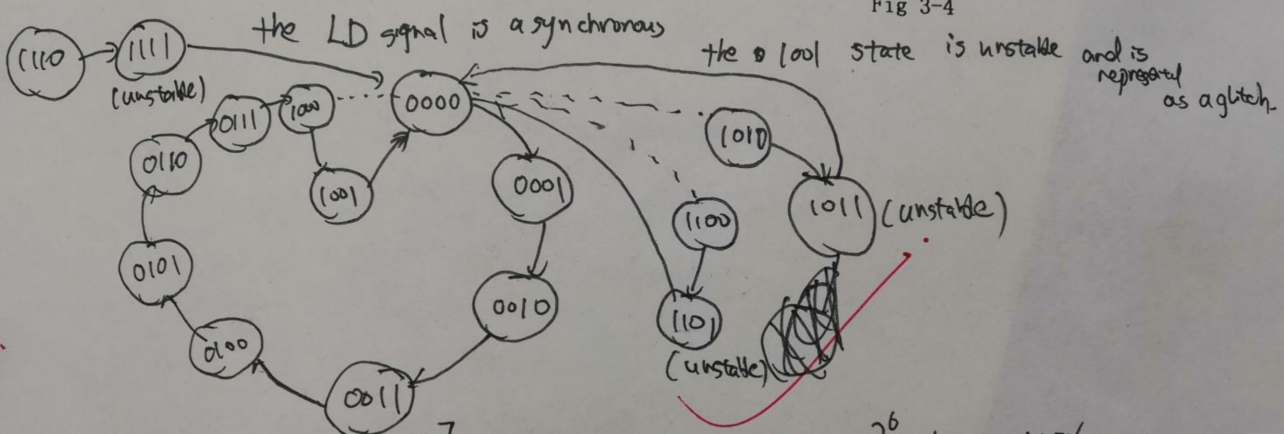


Fig 3-3

地址				数据			
A_3	A_2	A_1	A_0	D_3	D_2	D_1	D_0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	1	0
0	0	1	0	0	1	0	0
0	0	1	1	0	1	1	0
0	1	0	0	1	0	0	0
0	1	0	1	1	0	0	0
0	1	1	0	0	1	1	0
0	1	1	1	0	1	0	0
1	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0
1	0	1	0	1	0	0	0
1	0	1	1	0	1	1	0
1	1	0	0	0	0	1	0
1	1	0	1	0	1	0	0
1	1	1	0	0	0	1	0
1	1	1	1	0	1	0	0

Fig 3-4



Weight of D_7: $-\frac{2^7}{2^8}\cdot V_{REF} = -2.5V$ D_6: $-\frac{2^6}{2^8}\cdot V_{REF} = -1.25V$

D_5: $-\frac{2^5}{2^8} V_{REF} = -0.625V$ D_4: $-\frac{2^4}{2^8}\cdot V_{REF} = -0.3125V$