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Question 1 A = $A_3 A_2 A_1 A_0$ B = $B_3 B_2 B_1 B_0$

Decimal	Binary Sum K $Z_3 Z_2 Z_1 Z_0$	BCD Sum C $S_3 S_2 S_1 S_0$
0	0 0000	0 0000
1	0 0001	0 0001
2	0 0010	0 0010
3	0 0011	0 0011
4	0 0100	0 0100
5	0 0101	0 0101
6	0 0110	0 0110
7	0 0111	0 0111
8	0 1000	0 1000
9	0 1001	0 1001 ⇒ Max BCD 4 digits
10	0 1010	1 0000
11	0 1011	1 0001
12	0 1100	1 0010
13	0 1101	1 0011
14	0 1110	1 0100
15	0 1111	1 0101
16	1 0000	1 0110
17	1 0001	1 0111
18	1 0010	1 1000 ⇒ Max sum (9+9=18)
19	1 0011	1 1001

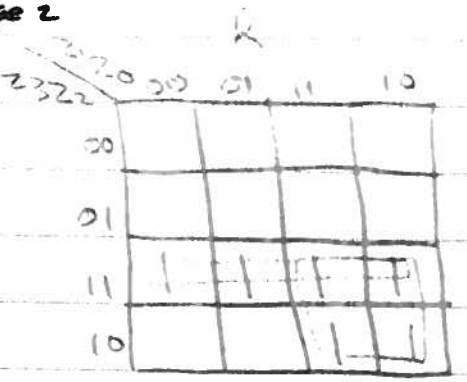
⇒ Add A and B with a 4bit binary adder

If the sum > 9, add 6

⇒ When C = 1, Add 6 to the binary sum

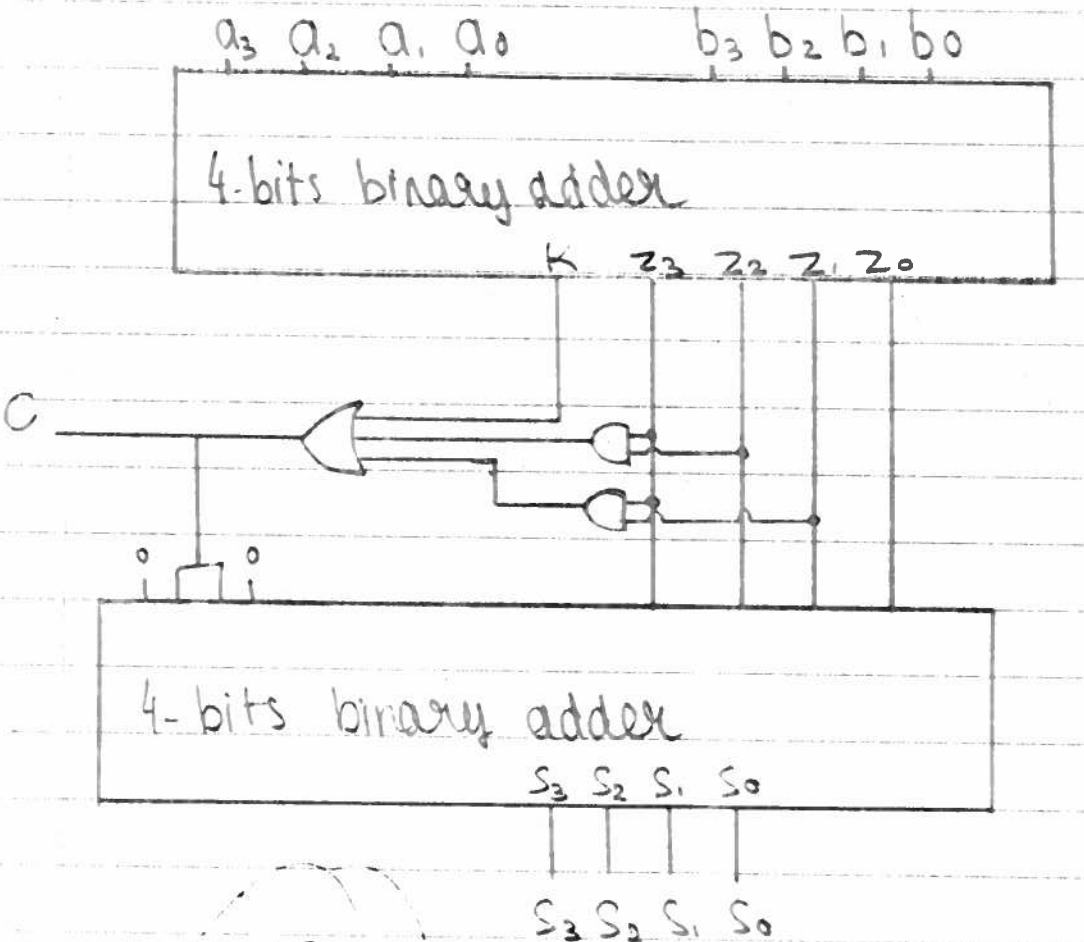
6 = 0110

Q1:



$$C = K + Z_3Z_2 + Z_3Z_1$$

BCD adder



10
10

↳ no carry needed in the 2nd adder

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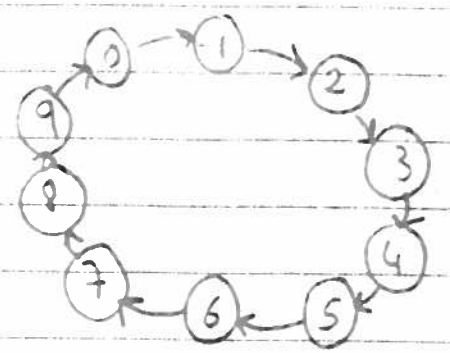
Question 2.



Present State		Next state	
	$y_3\ y_2\ y_1\ y_0$		$y_3^+\ y_2^+\ y_1^+\ y_0^+$
0	0 0 0 0	1	0 0 0 1
1	0 0 0 1	2	0 0 1 0
2	0 0 1 0	3	0 0 1 1
3	0 0 1 1	4	0 1 0 0
4	0 1 0 0	5	0 1 0 1
5	0 1 0 1	6	0 1 1 0
6	0 1 1 0	7	0 1 1 1
7	0 1 1 1	8	1 0 0 0
8	1 0 0 0	9	1 0 0 1
9	1 0 0 1	0	0 0 0 0

*NEXT: don't care

T Flip Flop:

	T_i
0 → 0	0
0 → 1	1
1 → 0	1
1 → 1	0

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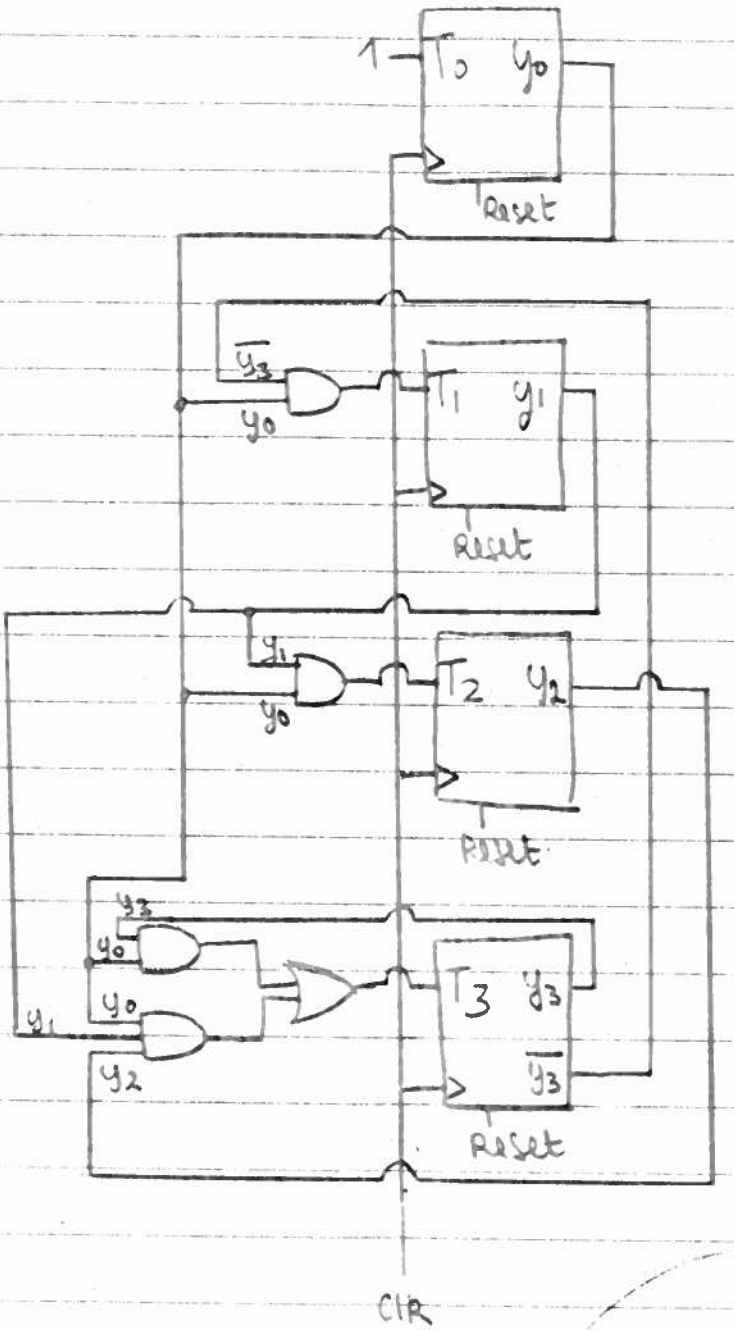
BCD counter



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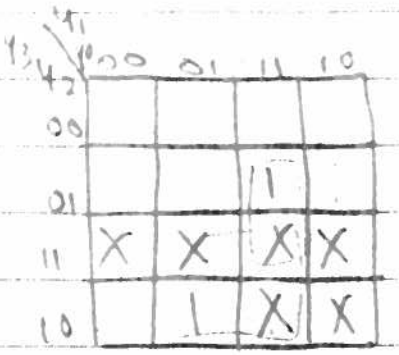
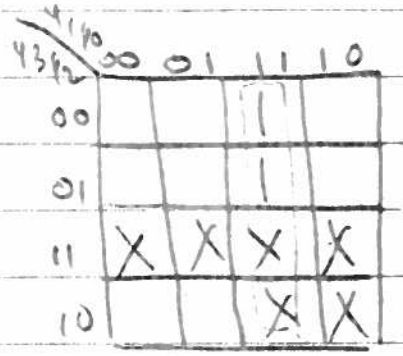
Y_3^+



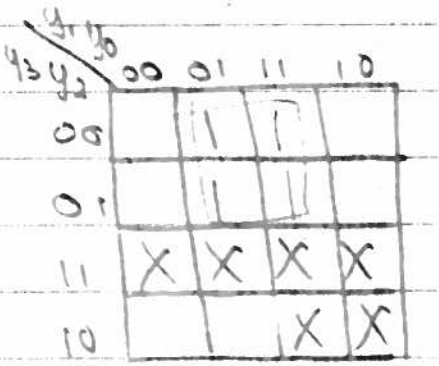
$T_3 = Y_3 Y_0 + Y_2 Y_1 Y_0$

Y_2^+



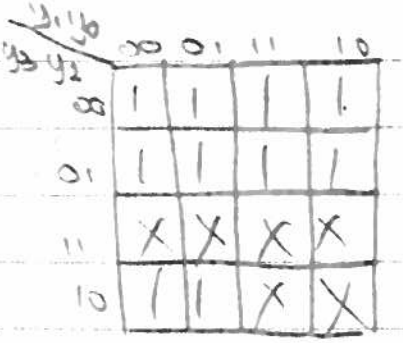
$T_2 = Y_1 Y_0$

Y_1^+



$T_1 = \overline{Y_3}\, Y_0$

Y_0^+



$T_0 = 1$

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Question 3

a) $N = N_2 N_1 N_0 \quad M = M_2 M_1 M_0$

	K	N_2	N_1	N_0		M_2	M_1	M_0
0	0	0	0	0	0	0	0	1
1	0	0	0	1	1	0	1	0
2	0	0	1	0	2	0	1	1
3	0	0	1	1	3	1	0	0
4	0	1	0	0	4	1	0	1
5	0	1	0	1	5	1	1	0
6	0	1	1	0	6	1	1	1
7	0	1	1	1	7	X	X	X
8	1	0	0	0	8	0	1	0
9	1	0	0	1	9	0	1	1
10	1	0	1	0	10	1	0	0
11	1	0	1	1	11	1	0	1
12	1	1	0	0	12	1	1	0
13	1	1	0	1	13	1	1	1
14	1	1	1	0	14	X	X	X
15	1	1	1	1	15	X	X	X

M_2

KN_2 \ N_1N_0	00	01	11	10
00			1	
01	1	1	X	1
11	1	1	X	X
10			1	1

$M_2 = N_2 + N_1N_0 + KN_0$

$= N_2 + N_0(K + N_1)$

M_1

KN_2 \ N_1N_0	00	01	11	10
00		1		1
01		1	X	1
11	1	1	X	X
10	1	1		

$M_1 = \overline{N_1}(K + N_0) + \overline{K} N_1 \overline{N_0}$

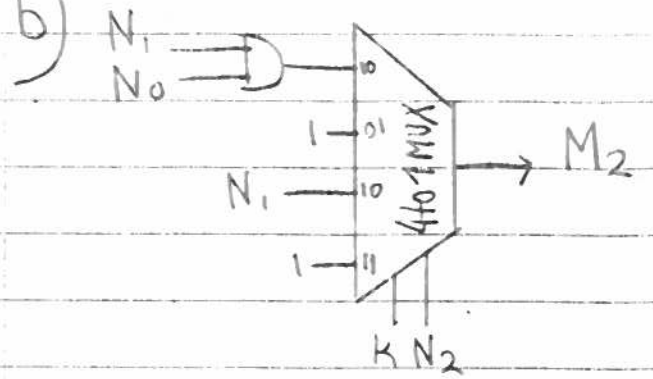
M_0

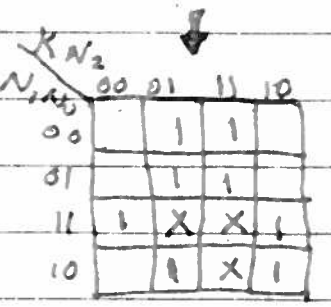
KN_2 \ N_1N_0	00	01	11	10
00	1			1
01	1			1
11		1	X	X
10		1	1	

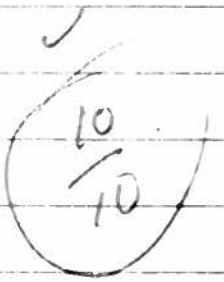
$M_0 = \overline{K}\,\overline{N_0} + KN_0$

$= K \odot N_0$

b)


N1
N0
0
1
01
N1
10
1
11
4to1 MUX
M2
K N2


K N2
N1 N0
00
01
11
10
00
01
11
10


10
10

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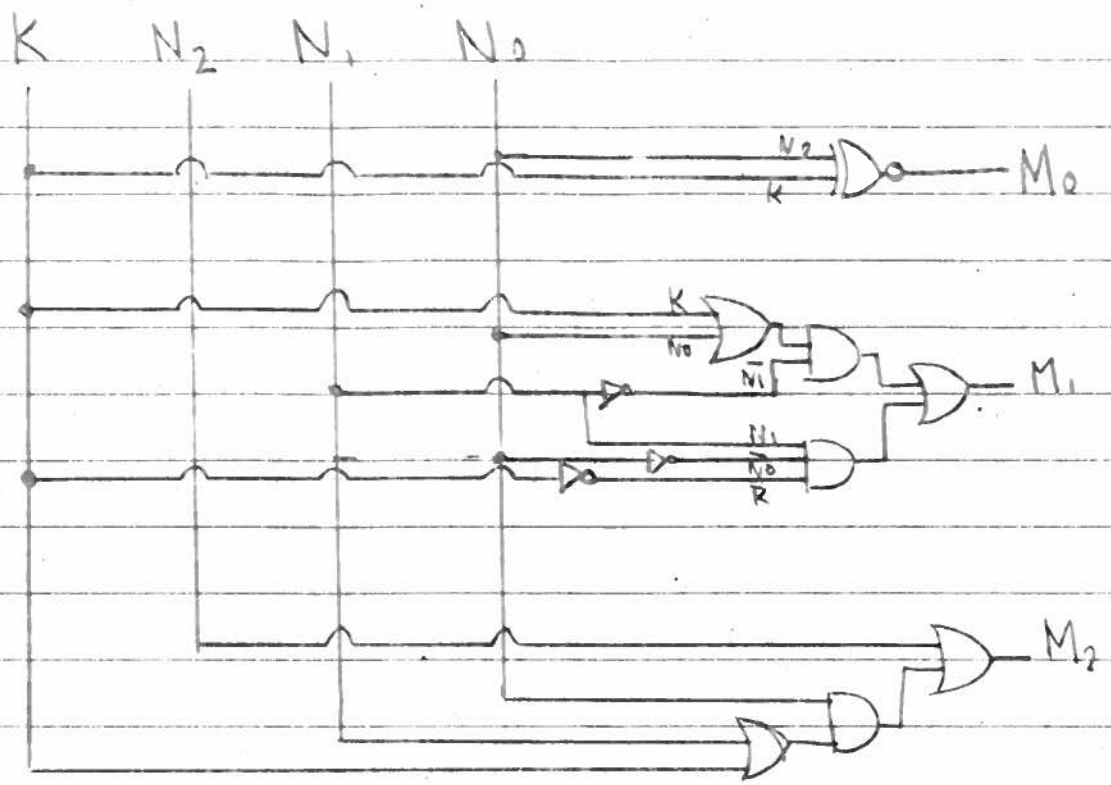

Question 4

a) $f_1(a,b,c) = \overline{a'c + b'c' + a'c}$

$= (a+c')(b+c)(a'+b')$

$= (ab + ac + bc')(a'+b')$

$= a'ba + a'ac + a'bc' + abb' + ab'c + b'bc'$

$= dbc' + a'b'c$

$f_2(a,b,c) = a'b' + bc + ac'$

$= (a'bc')(ab'c)$

$= \overline{a'b' + bc + ac'}$

$= (\overline{a'b'})(\overline{bc})(\overline{ac'})$

$= \overline{(a+b)(b+c')(a'+c)}$

$= \overline{(ab' + ac' + bc')(a'+c)}$

$= ab'a' + ab'c + ac'a' + ac'c + bc'a' + bc'c$

$= ab'c + a'bc'$

$= (a'b'c)(a'bc') = f_1(a,b,c)$

b) $f(a,b,c,d) = ac' + ab'd + a'b'c + a'cd' + b'c'd'$

$= ac'(b+b')(d+d') + ab'd(c+c') + a'b'c(d+d') + a'cd'(b+b') + b'c'd'(a+a')$

$= ab'c'd + ab'cd + abc'd' + ab'c'd' + ab'cd' + ab'c'd + a'b'cd + a'b'c'd$

$+ a'bcd' + a'b'cd' + ab'c'd' + a'b'c'd'$

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c)

$f = \prod M(0, 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 14)$

3/3

d) $A = (TE \times TI \times H)'$ → if H means 'it is not a holiday'

If H means 'it is a holiday'

then $A = (TE \cdot TI \cdot \overline{H})'$

2/2

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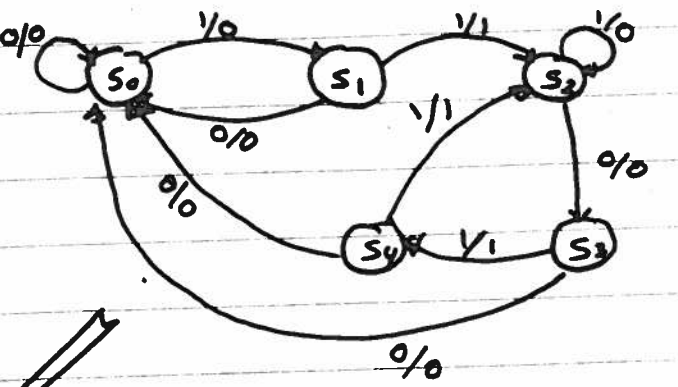
Question 5

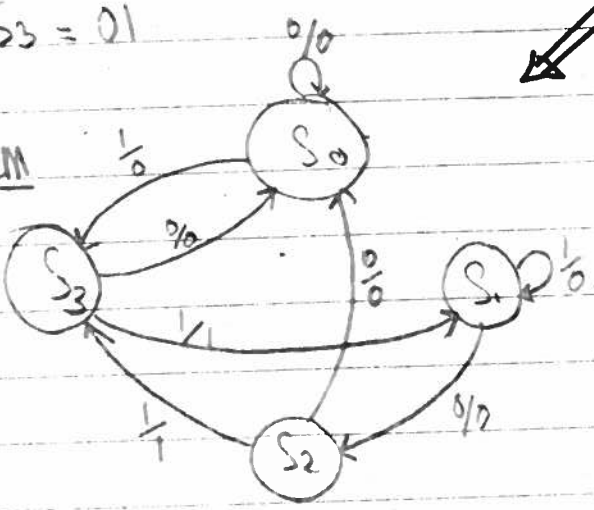
sequence detector
'1101' and '011' assuming no Reset state



$S_0 = 0$

$S_1 = 11$
$S_2 = 110$
$S_3 = 01$

State Diagram



S_0	S_0	0	S_1 0
→ S_1	S_0	0	S_2 1
S_2	S_3	0	S_2 0
S_3			
→ S_4	S_0	0	S_4 1
	S_0	0	S_2 1

S_1 & S_4 are equal &
S_4 is replaced by S_1

Transition table

Present State		Next State				Output z	
		$x=0$		$x=1$			
S	y_1 y_0	Y_1^+	Y_0^+	Y_1^+	Y_0^+	$x=0$	$x=1$
S_0	0 0	S_0	0 0	S_3	1 1	0	0
S_1	0 1	S_2	1 0	S_1	0 1	0	0
S_2	1 0	S_0	0 0	S_3	1 1	0	1
S_3	1 1	S_0	0 0	S_1	0 1	0	1

$Y_0^+ = x$

$Y_1^+ = \bar{x}\,\bar{y}_1 y_0 + x\bar{y}_0$

$z = x y_1$

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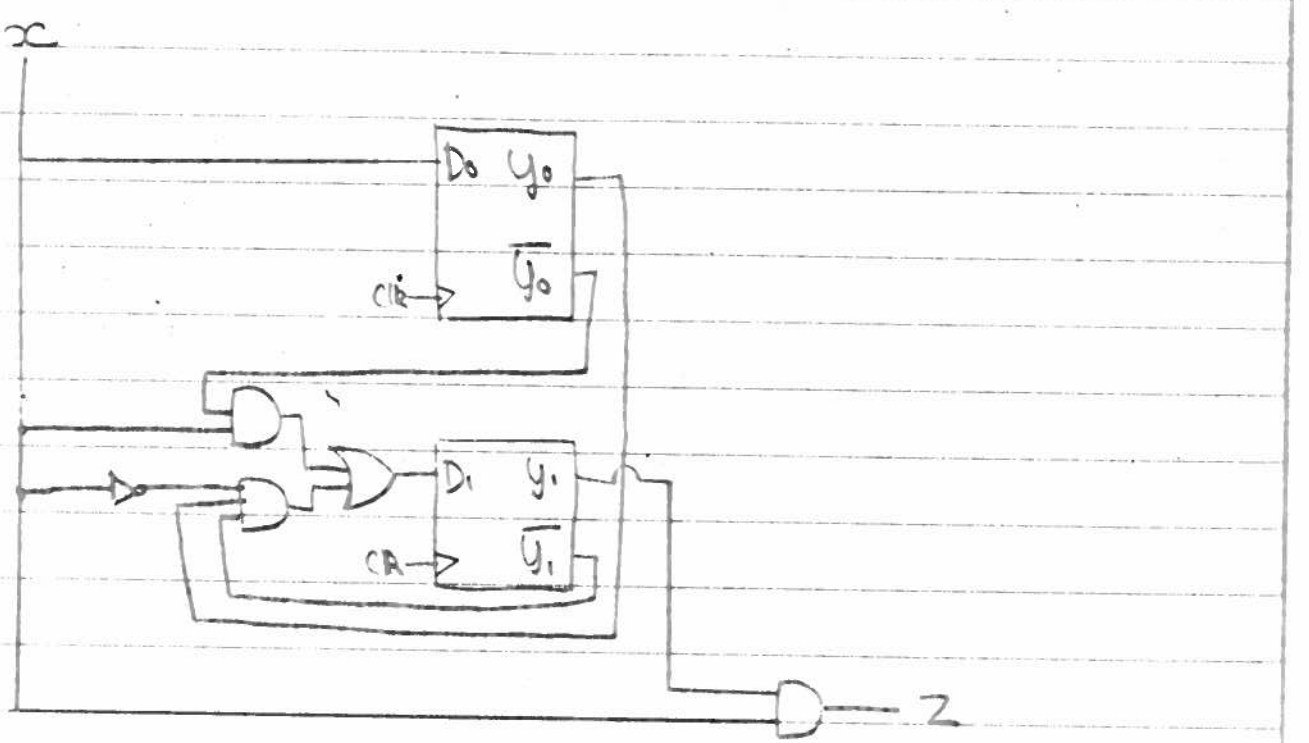
Using D Flip-Flops $D = y^+$

$D_0 = x$

$D_1 = \bar{x}\,\bar{y}_1 y_0 + x\bar{y}_0$



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Question 6:

$D = y^+$

$D_1 = y_2 \bar{A}$, $D_2 = A + B + y_1$,

$y_1^+ = y_2 \bar{A}$, $y_2^+ = A + B + y_1$,

Present State					Next State	
A	B	y_1	y_2		y_1^+	y_2^+
0	0	0	0	S_0	0	0
0	0	0	1	S_1	1	0
0	0	1	0	S_2	0	1
0	0	1	1	S_3	1	1
0	1	0	0		0	1
0	1	0	1		1	1
0	1	1	0		0	1
0	1	1	1		1	1
1	0	0	0		0	1
1	0	0	1		0	1
1	0	1	0		0	1
1	0	1	1		0	1
1	1	0	0		0	1
1	1	0	1		0	1
1	1	1	0		0	1
1	1	1	1		0	1

State Diagram