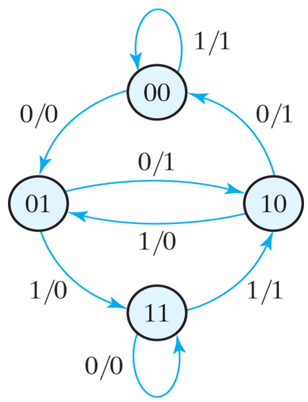
Department of Computer Science
National Chiao Tung University
Digital System Design
Final Exam 1/17/2013

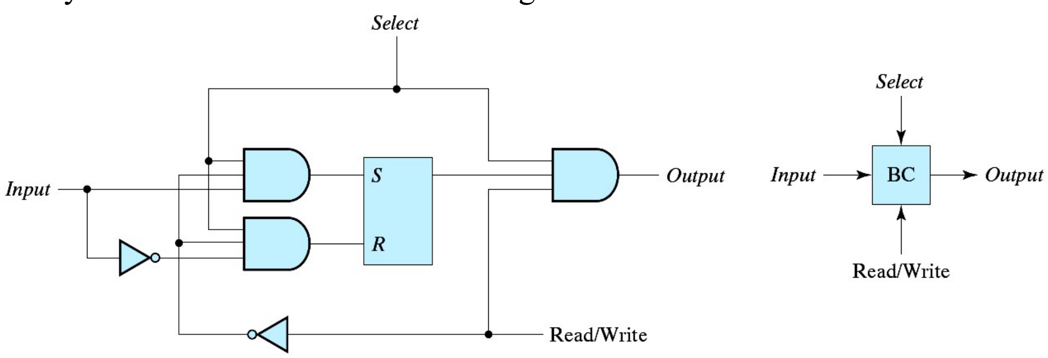
1. (10%) Design a *JK* flip-flop with a *T* flip-flop.

2. (10%) Derive the state diagram of a circuit that will generate a Gray code sequence for an input binary sequence. The circuit can be reset asynchronously to start and end the operation. (Note that for an m-bit binary sequence, $a_{m-1}, \cdots a_0$, its Gray code representation, $g_{m-1}, \cdots g_0$, can be determined by: $g_{m-1} = a_{m-1}$ and $g_i = a_i \oplus a_{i+1}$ for $i \leq m-2$.)

3. (12%) Consider the state diagram shown below. Design a sequential circuit with *D* flip-flops *A* and *B*, with one input *x* and one output *y*.



4. (10%) Consider the SRAM memory cell shown below. Show that we can connect four such cells to form a 4-bit shift register and describe how a 4-bit binary number can be store in such a register.



5. (8%) Include a clear input to the shift register discussed above.

6. (8%) Briefly explain advantages (and disadvantages) of using a ripple counter, versus a synchronous counter, as a binary counter.

7. (8%) Construct a mod-14 counter with a four-bit binary synchronous counter with parallel load, and a logic gate.

8. (8%) Briefly describe how 64K×8 RAM chips should be connected to provide a memory capacity of 256K bytes. You may use a block diagram to explain.

9. (8%) Derive the Hamming code word for the 12-bit data: 001110011011.

diff 10. (10%) Find different ways of using a PLA to implement the following functions if only four product terms (AND gates) are allowed. (There is no need to provide the PLA programming table.)

$$F_1(A,B,C) = \sum(0,2,3,6),$$

$$F_2(A,B,C) = \sum(2,4,5,7)$$

11. (8%) Specify the minimum size of a ROM that will accommodate the truth table for each of the following combinational circuit components. You may use an additional gate to reduce the ROM size.

(a) a code converter that converts a decimal digit from the 2421 code to the Excess-3 code, with $d(w,x,y,z) = \sum(5,6,7,8,9,10)$.

(b) a binary multiplier that multiplies two 8-bit binary words.

1.

T	Q	Q(t+1)	J	K
0	0	0	0	X
0	1	1	X	0
1	0	1	1	X
1	1	0	X	1

excitation table

Q	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

J (Q, T)

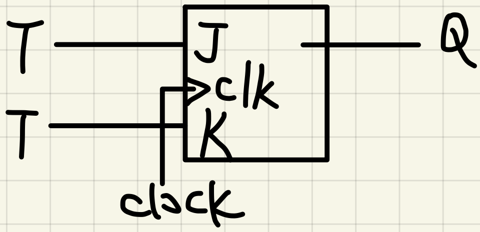
T'		X
T	1	X

$J = T$

K (Q, T)

T'	X	
T	X	1

$K = T$



3. present / Next

A	B	x	A	B	y
0	0	0	0	1	0
0	0	1	0	0	1
0	1	0	1	0	1
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	0	1	0
1	1	0	1	1	0
1	1	1	1	0	1

D_A (A, B, x)

A'			1	1
A			1	1

$\Rightarrow D_A = B$

D_B (A, B, x)

A'	1		1	
A		1		1

$D_B = A'B'x' + AB'x + A'Bx + ABx'$

y (A, B, x)

A'		1		1
A	1		1	

$y = AB'x' + A'B'x + ABx + A'Bx'$

9. $\lfloor \log_2 12 \rfloor = 3$

$2^k - 1 - k \geq 12$

5

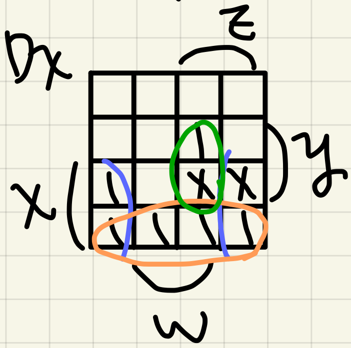
x	y	z	w	bit
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1

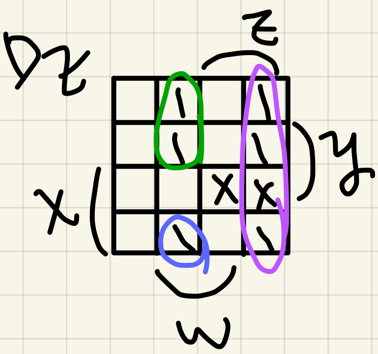
$P1 = 1$, $P_2 = 0$, $P_4 = 1$, $P_8 = 0$

Hamming code = 1000101100011011

7.

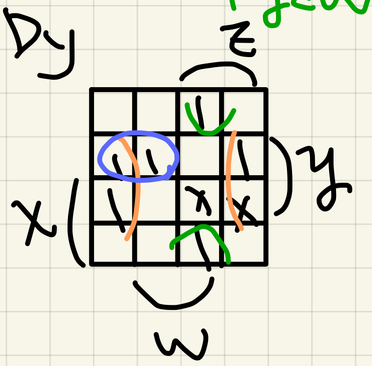
x	y	z	w	x(t+1)	y(t+1)	z(t+1)	w(t+1)
0	0	0	0	0	0	0	1
0	0	0	1	0	0	1	0
0	0	1	0	0	0	1	1
0	0	1	1	0	1	0	0
0	1	0	0	0	1	0	1
0	1	0	1	0	1	1	0
0	1	1	0	0	1	1	1
0	1	1	1	1	0	0	0
1	0	0	0	1	0	0	1
1	0	0	1	1	0	1	0
1	0	1	0	1	0	1	1
1	0	1	1	1	1	0	0
1	1	0	0	1	1	0	1
1	1	0	1	0	0	0	0

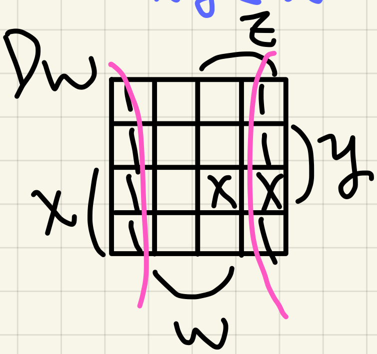




$D_x(t+1) = xw' + xy' + yzw$

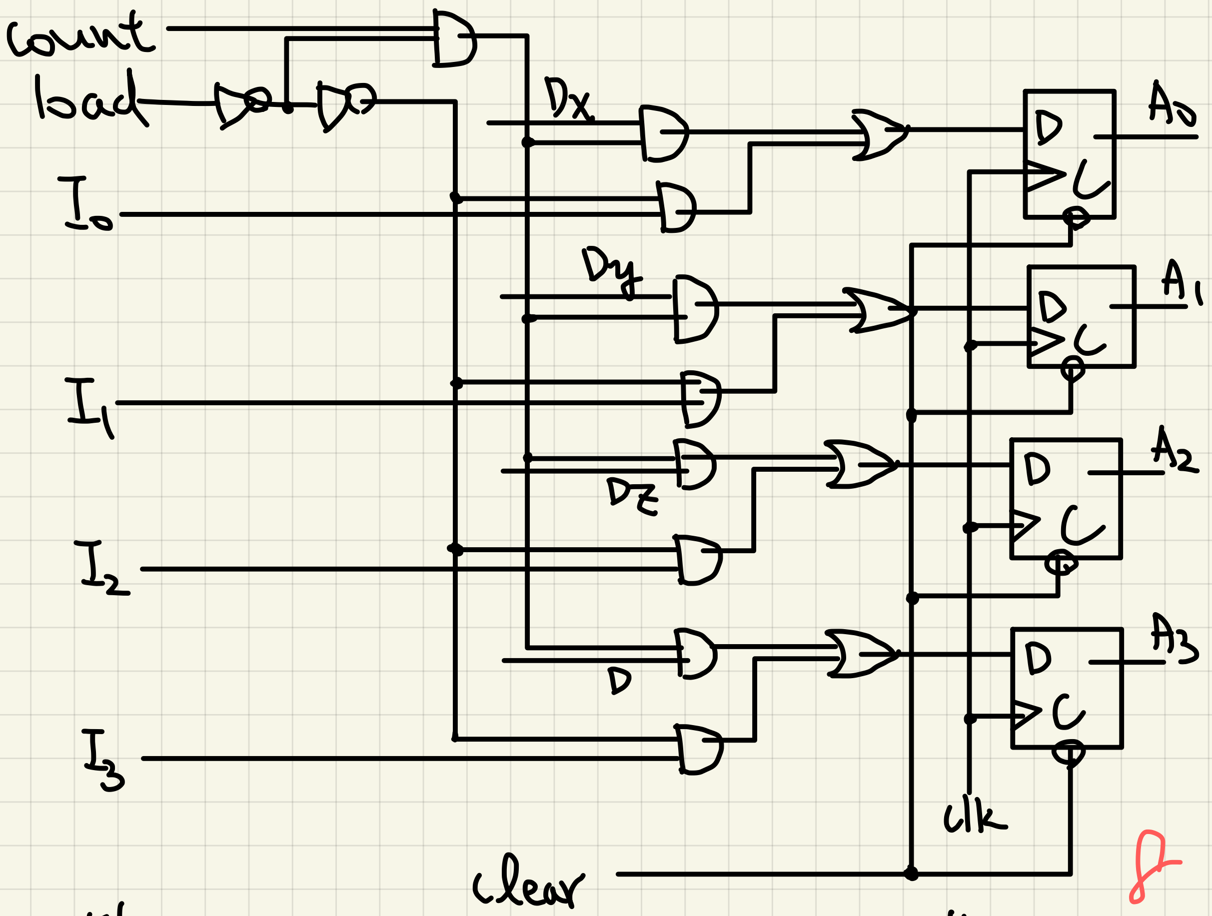
$D_z = zw' + x'z'w + xy'z'w$





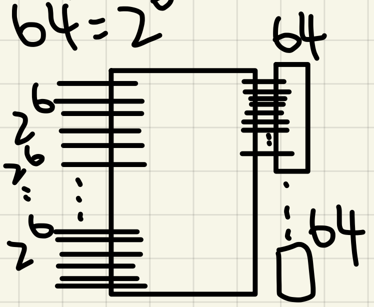
$D_y = yw' + y'zw + x'yz'$

$D_w = w'$



8. $\frac{256}{64} = 4$ (個)

$64 = 2^6$



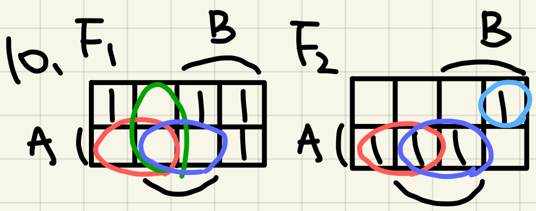
$64 \times 4 = 256$ #

11. (a) $2^4 \times 4 = \cancel{64}$ 8 bits

(b) $2^{8+8} \times (8+8)$

$= 2^{16} \times 16 = 2^{20}$ #

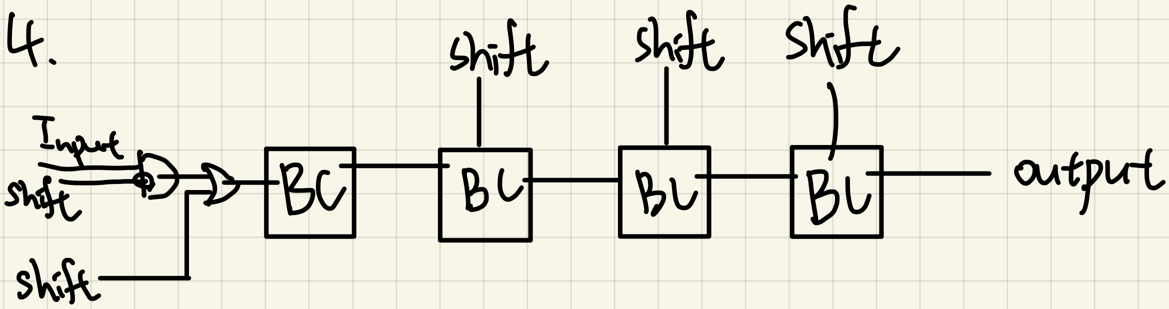
10.



$F_1 = (AB' + B'C + AC)'$

$F_2 = AB' + AC + A'BC'$

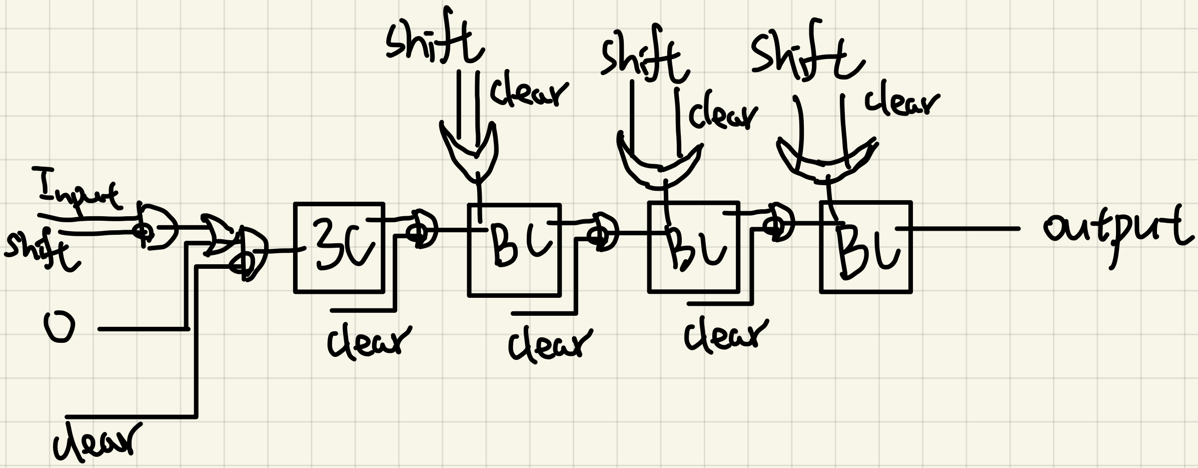
4.



假設我們要存1011,

Input=1 shift=0 ⇒ Input=0 shift=1 ⇒ Input=0 shift=1 ⇒ Input=1 shift=0 ⇒ Input=0 shift=1 ⇒ Input=1 shift=0

5.



6.

	pros	cons
ripple	成本低	無共同時脈/delay大
synchronous	有共同時脈	設計複雜成本高
binary	設計簡單	無共同時脈