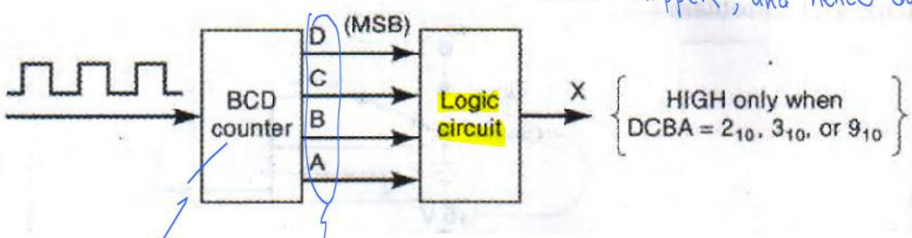
4-16. Figure 4-65 shows a *BCD counter* that produces a four-bit output representing the BCD code for the number of pulses that have been applied to the counter input. For example, after four pulses have occurred, the counter outputs are $DCBA = 0100_2 = 4_{10}$. The counter resets to 0000 on the tenth pulse and starts counting over again. In other words, the *DCBA* outputs will never represent a number greater than $1001_2 = 9_{10}$. Design the logic circuit that produces a HIGH output whenever the count is 2, 3, or 9. Use K mapping and take advantage of the don't-care conditions. ie the input combinations which will never happen, and hence don't need to care about them.



Ch. 6 (Sem. 2)

BCD (Binary Coded Decimal — ie using a 4-bit binary no. to represent a single decimal digit)

0000 (0), 0001 (1), 0010 (2), ... 1001 (9)

Step 1: Truth Table

MSB → inputs → o/p

	D	C	B	A	x
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	1
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	1
10	1	0	1	0	X
11	1	0	1	1	X
12	1	1	0	0	X
13	1	1	0	1	X
14	1	1	1	0	X
15	1	1	1	1	X

Standard (in binary seq.)

Don't care as BCD won't have 10 to 15

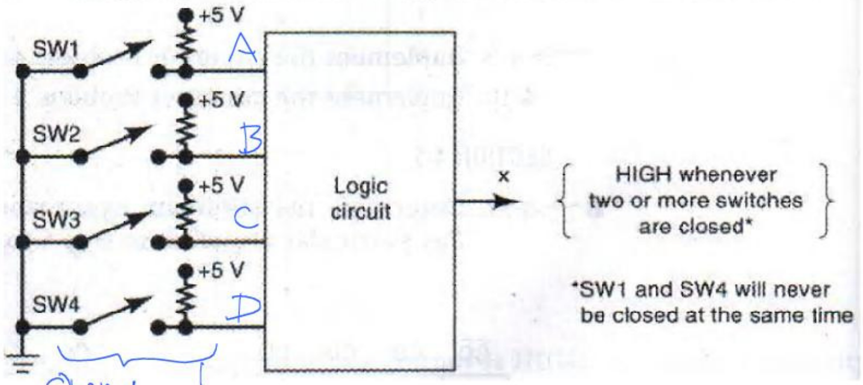
Step. 2

D.C \ BA	00	01	11	10
00	0	0	1	1
01	0	0	0	0
11	X	X	X	X
10	0	1	X	X

$x = D \cdot A + \bar{C} \cdot B$

Try to form biggest groups for the '1's by pretending each 'X' as either '1' or '0' as necessary.

4-17. Figure 4-66 shows four switches that are part of the control circuitry in a copy machine. The switches are at various points along the path of the copy paper as the paper passes through the machine. Each switch is normally open, and as the paper passes over a switch, the switch closes. It is impossible for switches SW1 and SW4 to be closed at the same time. Design the logic circuit to produce a HIGH output whenever *two or more* switches are closed at the same time. Use K mapping and take advantage of the don't-care conditions.



Open : 1
Closed : 0

	SW1 A	2 B	3 C	4 D	x
0	0	0	0	0	X
1	0	0	0	1	1
2	0	0	1	0	X
3	0	0	1	1	1
4	0	1	0	0	X
5	0	1	0	1	1
6	0	1	1	0	X
7	0	1	1	1	0
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	1
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	0

AB \ CD	00	01	11	10
00	X	1	1	X
01	X	1	0	X
11	1	0	0	0
10	1	1	0	1

$\bar{A}\bar{C}$

$\bar{C}\bar{D}$

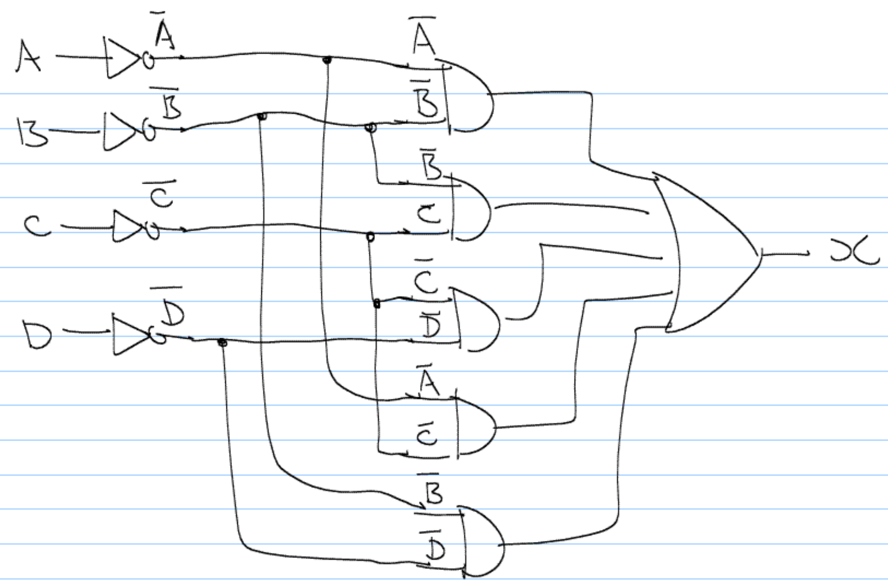
$\bar{B}\bar{C}$

AB \ CD	00	01	11	10
00	X	1	1	X
01	X	1	0	X
11	1	0	0	0
10	1	1	0	1

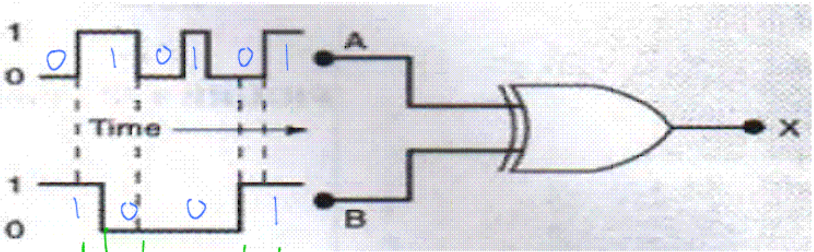
$\bar{A}\bar{B}$

$\bar{B}\bar{D}$

Hence $x = \bar{A}\bar{C} + \bar{C}\bar{D} + \bar{B}\bar{C} + \bar{A}\bar{B} + \bar{B}\bar{D}$

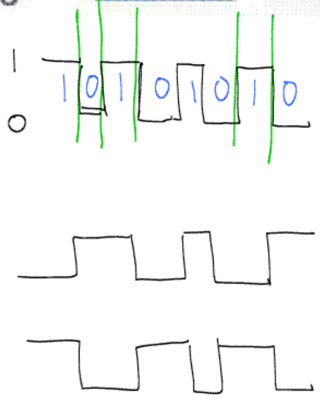


4-20. (a) Determine the output waveform for the circuit of Figure 4-67.
(b) Repeat with the *B* input held LOW.
(c) Repeat with *B* held HIGH.



XOR

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



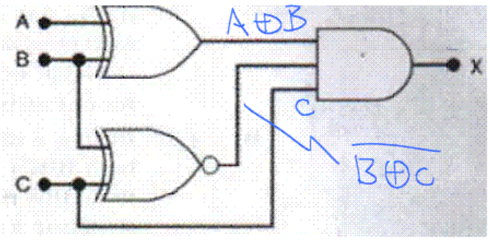
(a) $\begin{cases} x = 1 & \text{whenever } A \neq B \\ x = 0 & \text{" } A = B \end{cases}$

(b) $\leftarrow x = A$ when $B = 0$

(c) $\leftarrow x = \bar{A}$ when $B = 1$

	B	A	x
B=0	0	0	0
	0	1	1
B=1	1	0	1
	1	1	0

4-21. Determine the input conditions needed to produce $x = 1$ in Figure 4-68.



$x = 1$ if $A \oplus B = 1$ and $\overline{B \oplus C} = 1$ and $C = 1$ — ①

$A \oplus B = 1$ if $A \neq B$ ie $A, B = 0, 1$ or $1, 0$ — ②

$\overline{B \oplus C} = 1$ if $B = C$ ie $B, C = 0, 0$ or $1, 1$ — ③

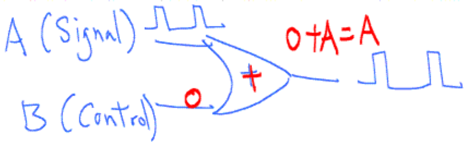
From ① : $C = 1$ → ③ : $B = 1$ → ② : $A = 0$

Hence, $x = 1$ if $A, B, C = 0, 1, 1$

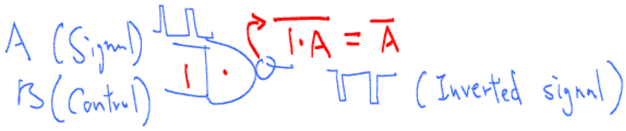
Alt. way — using truth-table :

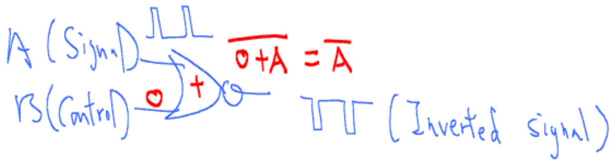
	A	B	C	$A \oplus B$	$\overline{B \oplus C}$	$x = A \oplus B \cdot \overline{B \oplus C} \cdot C$
0	0	0	0	0	1	0
1	0	0	1	0	0	0
2	0	1	0	1	0	0
3	0	1	1	1	1	1 — when $A, B, C = 0, 1, 1$
4	1	0	0	1	1	0
5	1	0	1	1	0	0
6	1	1	0	0	0	0
7	1	1	1	0	1	0

4-32. (a) Under what conditions will an OR gate allow a logic signal to pass through to its output unchanged?
(b) Repeat (a) for an AND gate.
(c) Repeat for a NAND gate.
(d) Repeat for a NOR gate.

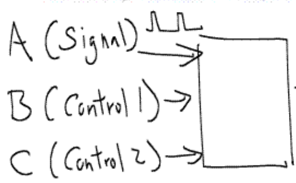
(a)


(b)


(c)


(d)


4-34. Design a logic circuit that will allow input signal *A* to pass through to the output only when control input *B* is LOW while control input *C* is HIGH; otherwise, the output is LOW.



$\rightarrow x = A$ only when $\overbrace{B=0 \text{ and } C=1}^{B,C=0,1}$

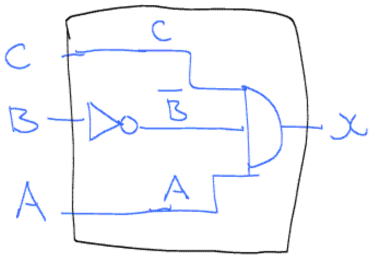
(signal) (Otherwise $x=0$)

	C	B	A	x
0	0	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	1	1	0
4	1	0	0	0
5	1	0	1	1
6	1	1	0	0
7	1	1	1	0

$x = A$ when $C,B = 1,0$

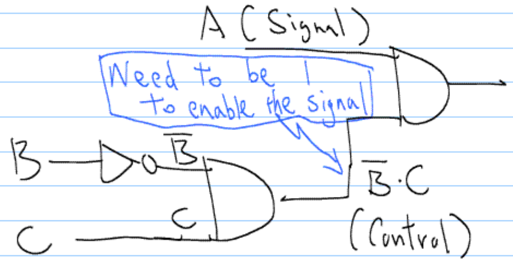
From the truth-table:

$x = C \cdot \overline{B} \cdot A$



Alternatively:

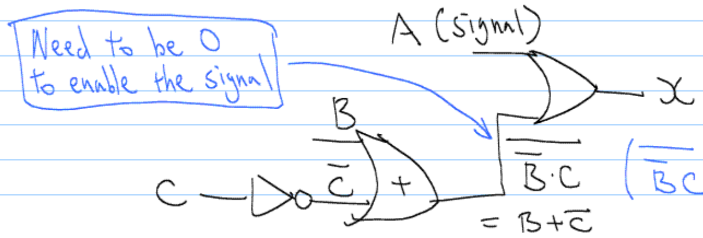
$x = A$ when $\overbrace{B=0,\ C=1}^{\bar{B}\cdot C}$



$x = \underbrace{A}_{\text{Signal}}$ when $\underbrace{\bar{B}\cdot C}_{\text{Control}} = 1$

(Otherwise $x = 0$)

How about : $x = A$ when $\bar{B}\cdot C = 1$, otherwise $x = 1$



$(\overline{\bar{B}C} = 0 \Rightarrow \bar{B}C = 1)$