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Laboratory 6

Karnaugh Map

1. Write the output logic equation according to the following given truth table;

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

A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

1.1 In m-notation of minterm expansion form:

$F(A,B,C) = \sum m(0,2,3,4,6)$

1.2 In m-notation of maxterm expansion form:

$F(A,B,C) = \prod M(1,5,7)$

1.3 In algebraic from:

$x = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}\bar{C} + AB\bar{C}$

$x = (\bar{B}+B)A\bar{C} + (\bar{B}+B)\bar{A}\bar{C} + \bar{A}BC$

$= A\bar{C} + \bar{A}\bar{C} + \bar{A}BC = (\bar{A}+A)\bar{C} + \bar{A}BC = \bar{A}BC + \bar{C} = \bar{A}B + \bar{C}$

$\bar{x} = (A+B+\bar{C})(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+\bar{C})$

Instructor's signature

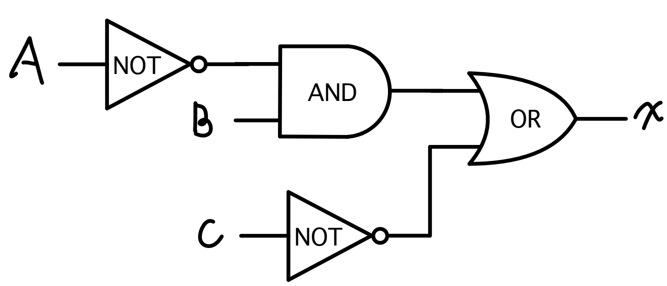
2. Draw a Karnaugh map from the truth table shown in 1. Demonstrate looping the 1's in the map in order to obtain the minimum solution.

A \ BC	00	01	11	10
0	1	0	1	1
1	1	0	0	1

$$x = \bar{A}BC + \bar{C}$$
$$= \bar{A}B + \bar{C} \quad \#$$

Instructor's signature

3. Draw a corresponding logic circuit diagram from the logic equation obtained from 2. Connect the circuit and record the results:



A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Instructor's signature

4. Write the output logic equation according to the following given truth table;

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	X
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	X

4.1 In m-notation of minterm expansion form:

$F(A,B,C,D) = \Sigma m(0,2,5,6,7,10,13) + d(4,15)$

4.2 In m-notation of maxterm expansion form:

$F(A,B,C,D) = \Pi M(1,3,8,9,11,12,14) + d(4,15)$

4.3 In algebraic from:

$X = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}C\bar{D} + \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD + A\bar{B}C\bar{D} + AB\bar{C}D$

$\bar{X} = (A+B+C+\bar{D})(A+B+\bar{C}+\bar{D})(\bar{A}+B+C+D)(\bar{A}+B+C+\bar{D})$
$(\bar{A}+B+\bar{C}+\bar{D}) + (\bar{A}+\bar{B}+C+D)(\bar{A}+\bar{B}+\bar{C}+D)$ #

Instructor's signature

5. Draw a Karnaugh map from the truth table shown in 4. Demonstrate looping the 1's in the map in order to obtain the minimum solution.

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

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

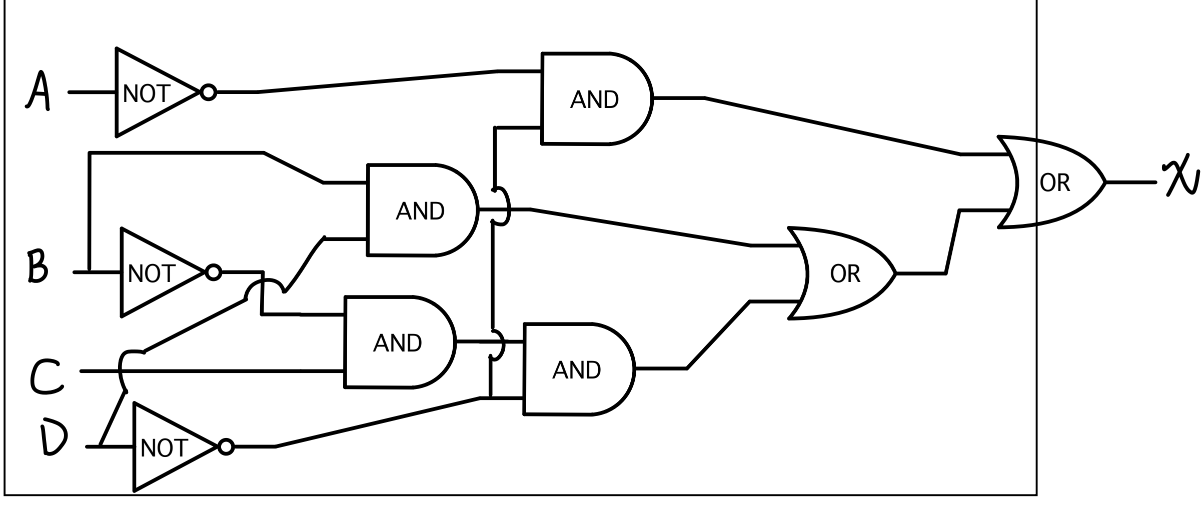
$$= (\bar{A} + A\bar{B}C)\bar{D} + BD$$

$$= (\bar{A} + \bar{B}C)\bar{D} + BD$$

$$= \bar{A}\bar{D} + \bar{B}C\bar{D} + BD$$

Instructor's signature

6. Draw a corresponding logic circuit diagram from the logic equation obtained from 5. Connect the circuit and record the results:



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

Instructor's signature

7. Give conclusion about the advantages of using Karnaough map to find the minimum solution.

Solving for result by using SOP, POS, and K-map will come out with the same result.

Instructor's signature

Mukse

8. **Assignments:**

8.1 The product package machine is built such that it loads the products into the package in the predefined number. If the desired number to be loaded is set to *n,* the machine is expected to load the products into the package in the range of *[n-3,n+3]*. From the detailed study, an engineer finds that, the machine will only load the products in the range of *[n-8,n+7]*. Design a logic circuit for this machine such that it outputs the alarm if the number of loaded products to the package is out of range.

a) Construct a truth table
b) Construct a Karnaugh map
c) Give the corresponding logic equation
d) Build the corresponding circuit to show the result

Instructor's signature

8.2 A simple floodgate has a sensor to measure incoming water level, which can be classified into 10 levels, (0-9). The opening height of the floodgate depends on this incoming water level. For water level of 0-3, the floodgate will be at its upper level. For water level 0f 4-6, the floodgate will be at its middle level, otherwise it will be at its lower level. Construct a logic circuit, which give the alarm signal when the floodgate is at its lower level.

Instructor's signature

8.3 Construct a minimum circuit which receives BCD inputs indicating the number of month in a year (for example, January is 1, February is 2, and so on). The circuit shall have the following functions:

- If the input month has 31 days, only D0 is ON
- If the month input has 30 days, only D1 is ON
- Otherwise, both D0 and D1 are ON.

(Credit: Applied from Mr. Kornkitt P. SE06)

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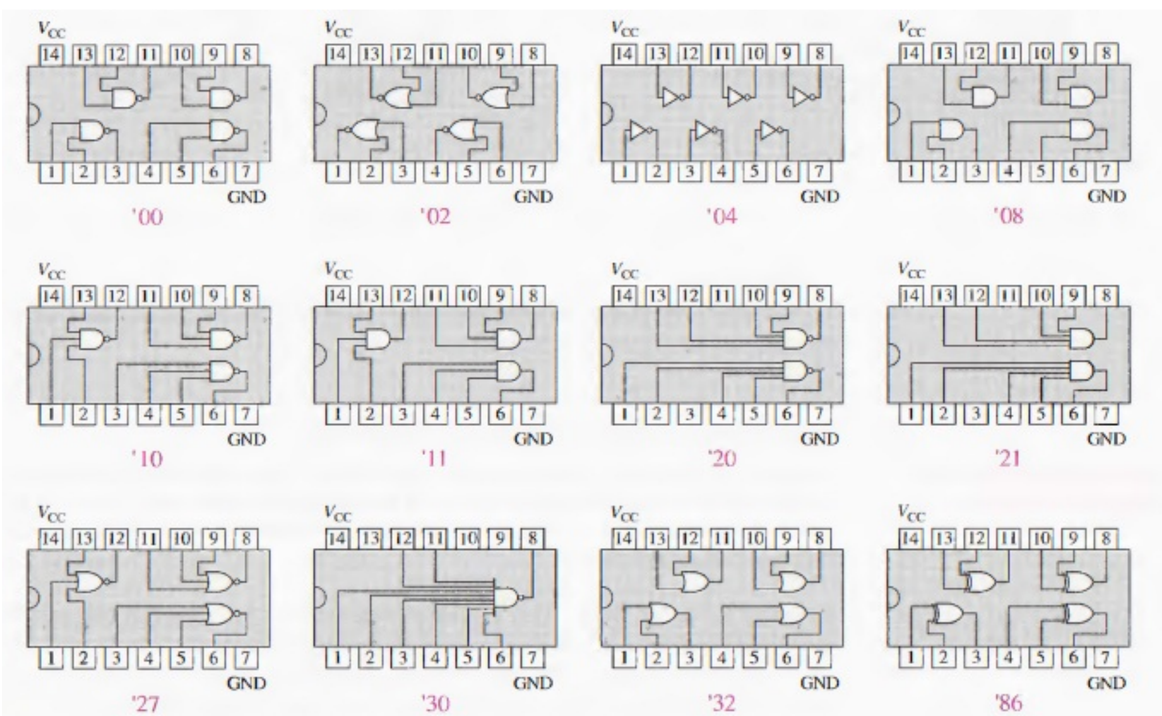
Logic Diagram of frequently used gates



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a) Construct a truth table

b) Construct a Karnaugh map

c) Give the corresponding logic equation

d) Build the corresponding circuit to show the result

x → 0 = No Alarm Signal

x → 1 = Give Alarm Signal.

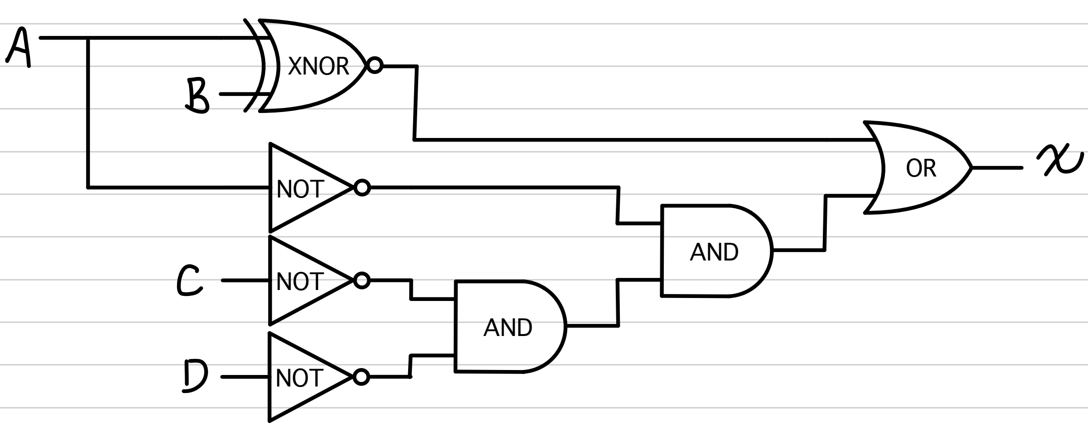
	A	B	C	D	x
0	0	0	0	0	1
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	1
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	0
$\boxed{8}$	1	0	0	0	0
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	1

Perfect number for being "n"

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1	1	1	1
$\bar{A}B$	1	0	0	0
AB	1	1	1	1
$A\bar{B}$	0	0	0	0

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

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



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7-9

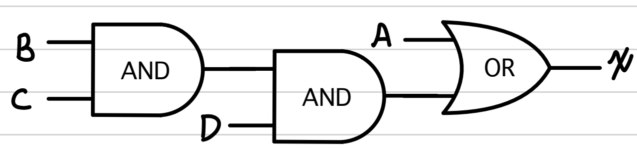
x: 0 = no alarm signal

1 = give alarm signal

	A	B	C	D	x
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	1
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	d
11	1	0	1	1	d
12	1	1	0	0	d
13	1	1	0	1	d
14	1	1	1	0	d
15	1	1	1	1	d

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0	0	0	0
$\bar{A}B$	0	0	1	0
AB	d	d	d	d
$A\bar{B}$	1	1	d	0

$x = A\bar{C} + BCD$



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- If the month input has 30 days, only D1 is ON
- Otherwise, both D0 and D1 are ON.

(Credit: Applied from Mr. Kornkitt P. SE06)

	A	B	Γ	Δ	w	x	y	z	D_0	D_1		
0	0	0	0	0	0	0	0	0	d	d	$z+\bar{z}d$	$\bar{z}+\bar{z}d$
1	0	0	0	0	0	0	0	1	1	0		
2	0	0	0	0	0	0	1	0	1	1	1	$\bar{z}$
3	0	0	0	0	0	0	1	1	1	0		
4	0	0	0	0	0	1	0	0	0	1	z	$\bar{z}$
5	0	0	0	0	0	1	0	1	1	0		
6	0	0	0	0	0	1	1	0	0	1	z	$\bar{z}$
7	0	0	0	0	0	1	1	1	1	0		
8	0	0	0	0	1	0	0	0	1	0	$\bar{z}$	z
9	0	0	0	0	1	0	0	1	0	1		
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	d	d		
									d	d		
									d	d		
10	0	0	0	1	0	0	0	0	1	0	$\bar{z}$	z
11	0	0	0	1	0	0	0	1	0	1		
12	0	0	0	1	0	0	1	0	1	0	$\bar{z}+zd$	$z+\bar{z}d$
	0	0	0	1	0	0	1	1	d	d		
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		

$D_0 = F(\Delta, w, x, y, z) = G(\Delta, W, x, y)$.

$\Delta W \backslash xy$	$\bar{x}\bar{y}$	$\bar{x}y$	xy	$x\bar{y}$
$\bar{\Delta}\bar{W}$	$z+\bar{z}d$	1	z	z
$\bar{\Delta}W$	$\bar{z}$	d	d	d
ΔW	d	d	d	d
$\Delta\bar{W}$	$\bar{z}$	$\bar{z}+zd$	d	d

$\therefore D_0 = \bar{x}z + \bar{\Delta}\bar{w}z + yz$

$= (\bar{\Delta}\bar{w} + x + y)z$

$D_1 = H(\Delta, W, x, y, z) = I(w, x, y, z)$.

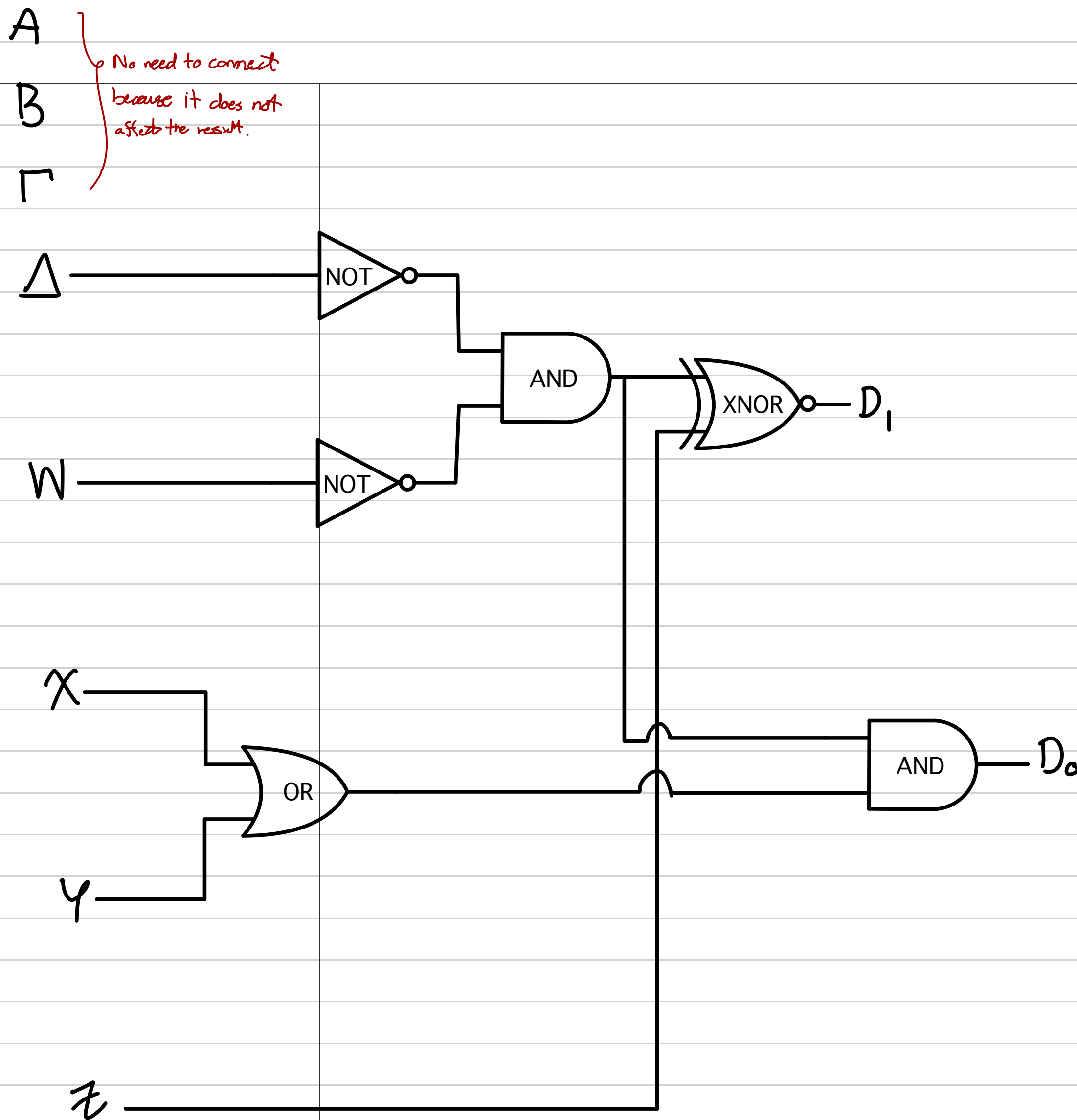
$\Delta W \backslash yz$	$\bar{x}\bar{y}$	$\bar{x}y$	xy	$x\bar{y}$
$\bar{\Delta}\bar{W}$	$\bar{z}+\bar{z}d$	$\bar{z}$	$\bar{z}$	$\bar{z}$
$\bar{\Delta}W$	z	d	d	d
ΔW	d	d	d	d
$\Delta\bar{W}$	z	$z+\bar{z}d$	d	d

$D_1 = \bar{\Delta}\bar{W}\bar{Z} + Wz + \Delta z$

$= \bar{\Delta}\bar{W}\bar{z} + (w+\Delta)z$

$= \bar{\Delta}\bar{W}\bar{z} + \overline{\bar{w}\bar{\Delta}}\,z$

$= (\overline{\bar{\Delta}\bar{W} \oplus z})$



A
B
Γ
No need to connect because it does not affect the result.
Δ
NOT
W
NOT
AND
XNOR
D_1
X
Y
OR
Z
AND
D_0