Chapter 4 from "Mano" book
Combinational logic

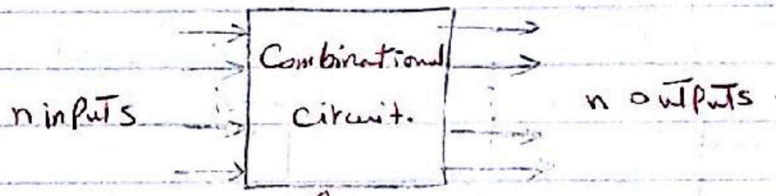
⇐ أخذنا الـ (logic gates) مثل : OR , AND , NAND , ...

والتي كانت تتكون من :

أكثر من (input) وفقط (output) واحد

⇐ أما الـ (Combinational logic) بتتكون من :

inputs , logic gates, outputs.



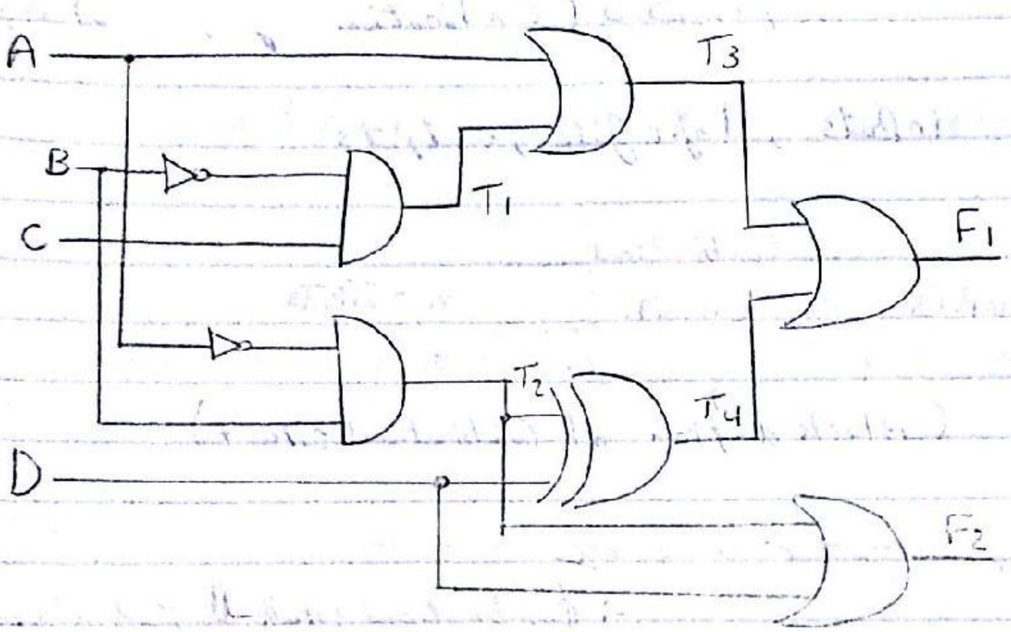
(Block diagram of Combinational circuit)

⇐ أمثلة للـ Combinational Circuits :

→ Adder
→ Subtractor
→ Comparator
→ Decoder
→ Encoder
→ Multiplexer
⋮

* Analysis of Combinational logic :-

Q 4.1 >> p.191



a) Derive the Boolean expressions for T_1, T_2, T_3, T_4, F_1 and F_2 and Evaluate the outputs F_1 and F_2 as functions of the inputs.

b) List the Truth Table (T.T) with 16 combinations of 4 input Variables Then list the binary values for T_1, T_2, T_3, T_4 and the outputs F_1 and F_2 in the Table.

c) Plot the Boolean output functions obtained in part (b) on Maps. and show that the simplified Boolean expressions are equivalent To the one's obtained in Part (a)..?!!

ANs

a)

لو نفرض أننا لحصل لها معادلات $T_1, T_2, T_3, T_4, F_1, F_2$ من الرسمة

$T_1 = \boxed{B'C}$

$T_2 = \boxed{A'B}$

$T_3 = A + T_1$
$\quad = \boxed{A + B'C}$

$T_4 = D \oplus T_2$
$\quad = D \oplus (A'B)$
$\quad = D'(A'B) + D(A'B)'$
$\quad = A'BD' + D(A+B')$
$\quad = \boxed{A'BD' + AD + DB'}$

$\oplus$ XOR

$a \oplus b$
$= a'b + ab'$

$F_1 = T_3 + T_4$
$\quad = (A + B'C) + (A'BD' + AD + DB')$ ⟸ مطلوب منا إننا نبسط المعادلة
$\quad =$
$\quad = A\underbrace{(\cancel{1+D})}_{1} + B'C + A'BD' + DB'$

$\quad = A + B'C + A'BD' + DB' \Longleftrightarrow = A + B'C + A'BD'$

توزيع جمع

$\quad = \underbrace{(\cancel{A+A'})}_{1}(A+BD') + B'C + DB'$

$\quad = \boxed{A + BD' + B'C + B'D}$

$F_2 = D + T_2$
$\quad = \boxed{D + A'B}$

b) $T_1 = B'C$, $T_2 = A'B$, $T_3 = A + T_1$, $T_4 = D \oplus T_2$, $F_1 = T_3 + T_4$, $F_2 = D + T_2$

A	B	C	D	T_1	T_2	T_3	T_4	F_1	F_2	m
0	0	0	0	0	0	0	0	0	0	m0
0	0	0	1	0	0	0	1	1	1	m1
0	0	1	0	1	0	1	0	1	0	m2
0	0	1	1	1	0	1	1	1	1	m3
0	1	0	0	0	1	0	1	1	1	m4
0	1	0	1	0	1	0	0	0	1	m5
0	1	1	0	0	1	0	1	1	1	m6
0	1	1	1	0	1	0	0	0	1	m7
1	0	0	0	0	0	1	0	1	0	m8
1	0	0	1	0	0	1	1	1	1	m9
1	0	1	0	1	0	1	0	1	0	m10
1	0	1	1	1	0	1	1	1	1	m11
1	1	0	0	0	0	1	0	1	0	m12
1	1	0	1	0	0	1	1	1	1	m13
1	1	1	0	0	0	1	0	1	0	m14
1	1	1	1	0	0	1	1	1	1	m15

From Trut table: $F_1 = \sum m(1, 2, 3, 4, 6, 8, 9, 10, 11, 12, \ldots, 15)$

$F_2 = \sum m(1, 3, 4, 5, 6, 7, 9, 11, 13, 15)$

c) for F_1

AB \ CD	C'D'	C'D	CD	CD'
A'B'		1	1	1
A'B	1			1
AB	1	1	1	1
AB'	1	1	1	1

$F_1 = A + BD' + CD' + B'D$

or $= A + BD' + B'C + B'D$ ← الحل جزئي Partial

لحل كامل

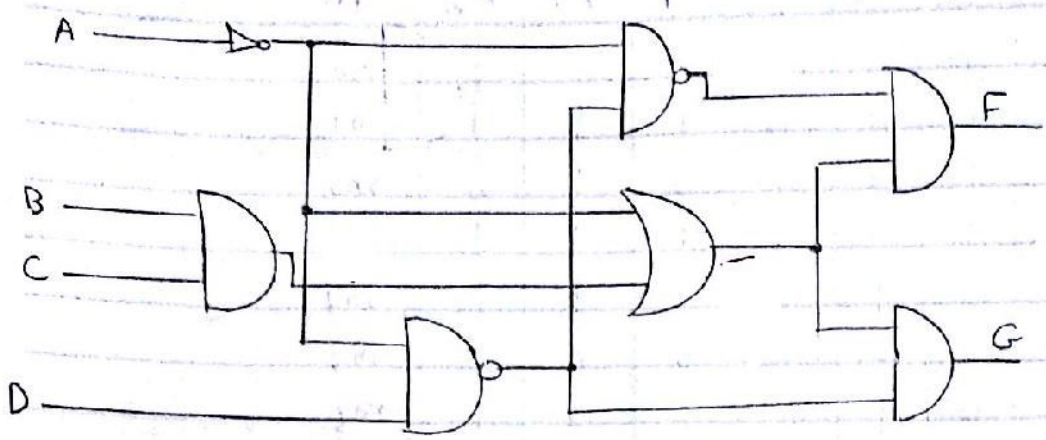
for F_2

AB \ CD	C'D'	C'D	CD	CD'
A'B'		1	1	
A'B	1	1	1	1
AB		1	1	
AB'		1	1	

$F_2 = D + A'B$ ✓✓

الحل جزئي Partial

In the book p. 191 Q4.2



* obtain the simplified Boolean expressions for outputs F & G in terms of the input variables in the circuit.

Ans:

$$F = (A' \cdot (A' D)')' (A' + BC)$$

للتسهيل نرجم كل (output لكل gate) برمز معين.

$\boxed{F = T_3 \cdot T_4}$, $\boxed{G = T_4 \cdot T_2}$

$\Rightarrow T_1 = \boxed{B \cdot C}$

$\Rightarrow T_2 = (A' D)'$

$= \boxed{A + D'}$

$\Rightarrow T_3 = (A' \cdot T_2)'$

$= A + T_2'$

$= A + (A' D)''$

$= \boxed{A + A' D}$

$\Rightarrow T_4 = A' + T_1$

$= \boxed{A' + BC}$

$\longrightarrow$

$F = T_3 \cdot T_4$

$$= (A + A'D)(A' + BC)$$

$$= \underset{0}{\cancel{A \cdot A'}} + ABC + A'A'D + A'BCD$$

$$= ABC + \underbrace{A'D + A'BCD}_{A'D}$$

$$= ABC + A'D(\underset{1}{\cancel{1 + BC}})$$

$$= \boxed{ABC + A'D}$$

$G = T_4 \cdot T_2$

$$= (A' + BC)(A + D')$$

$$= \underset{0}{\cancel{A'A}} + A'D' + ABC + BCD'$$

$$= \underbrace{A'D' + ABC}_{\substack{\not{C} \\ BCD'}} + \cancel{BCD'}$$

(Consensus Term) $= BCD'$

$$= \boxed{A'D' + ABC}$$

* Design of Combinational logic

To Design The Combinational Circuit :

1. Construct Truth Table.
2. obtain on The equations of The outputs in numeric form $\Sigma m = (\ldots)$
3. Put The function on the K-map & Simplify it/them.
4. Draw the Block diagram of each output function.

→

Examples

EX1: Q4.3 >> P.191

* Design a Combinational Circuit with 3 inputs and one output The output is 1, When the binary Value of the input is less Than 3 and 0 other wise.

ANS.

① TT → let: the 3 inputs are a, b, c
& The output : F

تعني أن الـ output
هيساوي "1" هيتحقق إذا كان
الـ (input) (يعني abc) هيكون
رقم binary أقل من (٣) وغير ذلك
تفقد هذا الشرط لتخرج الـ output
بصفر

	a	b	c	F
m0	0	0	0	1
m1	0	0	1	1
m2	0	1	0	1
m3	0	1	1	0
m4	1	0	0	0
m5	1	0	1	0
m6	1	1	0	0
m7	1	1	1	0

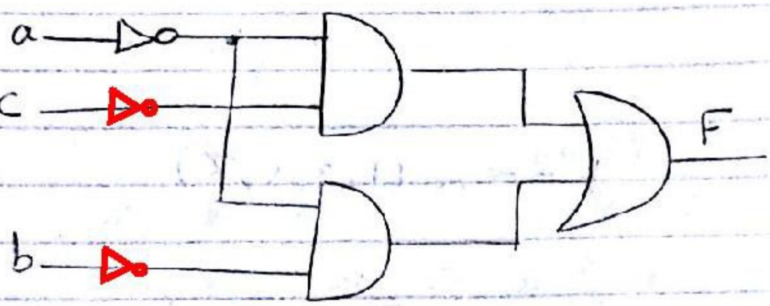
② $F = \Sigma m(0,1,2)$ →

③ K.map.

bc \ a	b'c'	b'c	bc	bc'
a'	0 1	1	3	2
a	4	5	7	6

F = a'c' + a'b'

④ The block diagram by AND, OR.



EX2: (From The book p.191 Q.4-3)

* Design a Combinational Circuit With 3 inputs & one output, The output is one When the binary Value of the inputs is an odd number.

Ans.

①

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

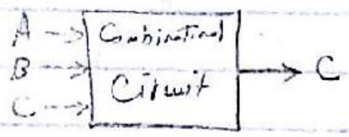
② $F = \sum m\ (1, 3, 5, 7)$

③

$A \backslash BC$	$B'C'$	$B'C$	BC	BC'
A'	0	1: 1	3: 1	2
A	4	5: 1	7: 1	6

$F = C$

④ the Block diagram



EX3, from the book P. 191 Q4.4

* Design a combinational circuit with 3 inputs X, Y & Z and three outputs A, B and C. When the binary input is 0, 1, 2 or 3 → The binary output is two greater than the input and when the binary input is 4, 5, 6 or 7 → The binary output is three less than the input.

ANS:

①

	inputs			outputs		
	X	y	Z	A	B	C
0	0	0	0	0	1	0
1	0	0	1	0	1	1
2	0	1	0	1	0	0
3	0	1	1	1	0	1
4	1	0	0	0	0	1
5	1	0	1	0	1	0
6	1	1	0	0	1	1
7	1	1	1	1	0	0

②

outputs ٣

لدينا ٣ معادلات لل output

$A = \Sigma m(2, 3, 7)$

$B = \Sigma m(0, 1, 5, 6)$

$C = \Sigma m(1, 3, 4, 6)$

③ $A = x'y + yz$

x \ yz	y'z'	y'z	yz	yz'
x'			1	1
x			1	

B

x \ yz	y'z'	y'z	yz	yz'
x'	1	1		
x		1		1

$B = x'y' + y'z + xyz'$

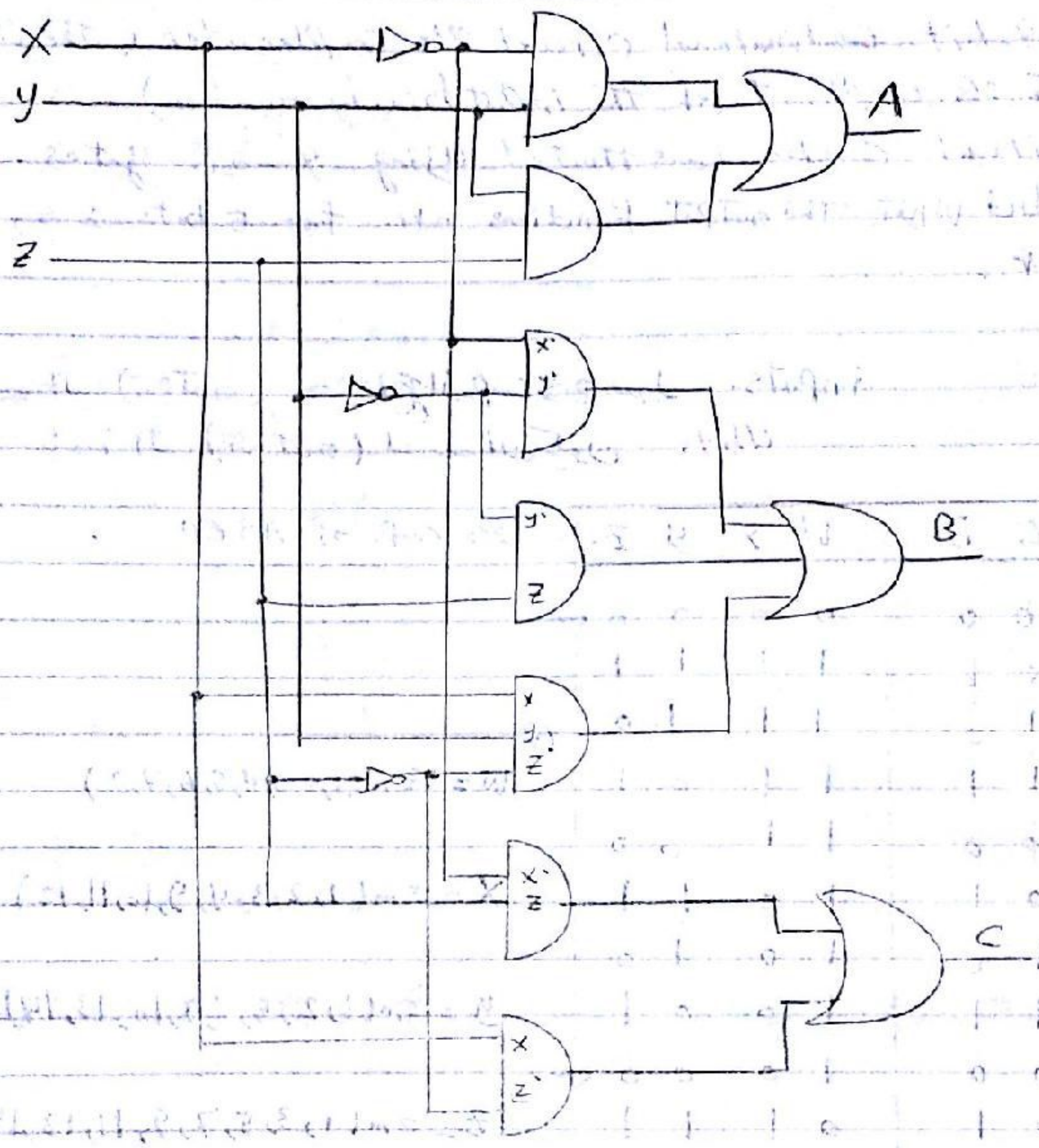
C

x \ yz	y'z'	y'z	yz	yz'
x'		1	1	
x	1			1

$C = x'z + xz'$

⟹

4



EX 4: Q4.7 >> P.192

* Design a 4-bit Combinational Circuit 2's Complementer (The output generates The 2's complement of the input binary number). Show That the circuit Can be Constructed using X-OR gates. Can you Predict What The output functions are for 5 bits 2's, 2's Complementer.

<u>ANS</u>

← ال (output) هو ناتج ال 2's Comp. مع ال inputs.

إذا ال (output) لابد ان يكون 4bits

①

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

← 2's comp. of ABCD

②

$W = \sum m(1,2,3,4,5,6,7,8)$

$X = \sum m(1,2,3,4,9,10,11,12)$

$y = \sum m(1,2,5,6,9,10,13,14)$

$Z = \sum m(1,3,5,7,9,11,13,15)$

$W = \sum m(1 \ldots 8)$

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0	1: 1	3: 1	2: 1
A'B	4: 1	5: 1	7: 1	6: 1
AB	12	13	15	14
AB'	8: 1	9	11	10

$W = A'B + A'D + A'C + AB'C'D'$

$= A'(B + D + C) + A(B'C'D')$

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

X

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0	1: 1	3: 1	2: 1
A'B	4: 1	5	7	6
AB	12: 1	13	15	14
AB'	8	9: 1	11: 1	10: 1

$X = B'D + B'C + BC'D'$

$= B'(D + C) + B(C'D')$

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

Y

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0	1: 1	3	2: 1
A'B	4	5: 1	7	6: 1
AB	12	13: 1	15	14: 1
AB'	8	9: 1	11	10: 1

$Y = C'D + CD'$

$= \boxed{C \oplus D}$

Z

AB \ CD	C'D'	C'D	CD	CD'
A'B'	0	1: 1	3: 1	2
A'B	4	5: 1	7: 1	6
AB	12	13: 1	15: 1	14
AB'	8	9: 1	11: 1	10

$Z = \boxed{D} \rightarrow D \oplus 0$

$\Rightarrow$ The equations of W, X, Y, Z show that the circuit can be constructed by X-OR gates.

$\Rightarrow$ if the inputs were 5 bits (E A B C D) & the outputs are the 2's complement of the inputs $\rightarrow$ if the outputs were (V W X Y Z)

$\hookrightarrow$ We predict that $V = E \oplus (A + B + C + D)$

According to the equations of 4 bits where:

$W = A \oplus (B + C + D)$

$X = B \oplus (C + D)$

$Y = C \oplus D$

$Z = D$

Q3: Design a code converter that converts from BCD_{8421} to Excess3
→ Build the truth table.
→ Minimize the functions by using k.map.

ANS:

	inputs				outputs			
Dec.	a	b	c	d	W	X	y	Z
0	0	0	0	0	0	0	1	1
1	0	0	0	1	0	1	0	0
2	0	0	1	0	0	1	0	1
3	0	0	1	1	0	1	1	0
4	0	1	0	0	0	1	1	1
5	0	1	0	1	1	0	0	0
6	0	1	1	0	1	0	0	1
7	0	1	1	1	1	0	1	0
8	1	0	0	0	1	0	1	1
9	1	0	0	1	1	1	0	0

$W(a,b,c,d) = a'bc'd + a'bcd' + a'bcd + ab'c'd' + ab'c'd$
$= \Sigma m(5,6,7,8,9) + \Sigma d(10,11,12,13,14,15)$

$X(a,b,c,d) = a'b'c'd + a'b'cd' + a'b'cd + a'bc'd' + ab'c'd$
$= \Sigma m(1,2,3,4,9) + \Sigma d(10,11,12,13,14,15)$

$y(a,b,c,d) = a'b'c'd' + a'b'cd + a'bc'd' + a'bcd + ab'c'd'$
$= \Sigma m(0,3,4,7,8) + \Sigma d(10,11,12,13,14,15)$

$Z(a,b,c,d) = a'b'c'd' + a'b'cd' + a'bc'd' + a'bcd' + ab'c'd'$
$= \Sigma m(0,2,4,6,8) + \Sigma d(10,11,12,13,14,15)$

⇒ Note → from (10 to 15) are don't cares on k.map.

K-maps:

cd \ ab	a'b'	a'b	ab	ab'
c'd'	0	4	12 X	8 1
c'd	1	5 1	13 X	9 1
cd	3	7 1	15 X	11 X
cd'	2	6 1	14 X	10 X

W

$$W = a + bd + bc$$

cd \ ab	a'b'	a'b	ab	ab'
c'd'		1	X	
c'd	1		X	1
cd	1		X	X
cd'	1		X	X

X

$$X = bc'd' + b'd + b'c$$

---

cd \ ab	a'b'	a'b	ab	ab'
c'd'	1	1	X	
c'd			X	
cd	1	1	X	X
cd'			X	X

y

$$y = c'd' + cd$$

cd \ ab	a'b'	a'b	ab	ab'
c'd'	1	1	X	1
c'd			X	
cd			X	X
cd'	1	1	X	X

Z

$$Z = c'd' + cd'$$

$$Z = 0'$$

P. 16 sec 6

Q. Design a Combinational Circuit that converts a four bit binary Number to a four bit Gray Code.

(Implement the Circuit with exclusive OR gates)

XOR.

	Binary number				Gray Code.			
Dec	a	b	c	d	W	X	y	Z
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	1	0
5	0	1	0	1	0	1	1	1
6	0	1	1	0	0	1	0	1
7	0	1	1	1	0	1	0	0
8	1	0	0	0	1	1	0	0
9	1	0	0	1	1	1	0	1
10	1	0	1	0	1	1	1	1
11	1	0	1	1	1	1	1	0
12	1	1	0	0	1	0	1	0
13	1	1	0	1	1	0	1	1
14	1	1	1	0	1	0	0	1
15	1	1	1	1	1	0	0	0

$W = \Sigma m(8, 9, 10, 11, 12, 13, 14, 15)$

$X = \Sigma m(4, 5, 6, 7, 8, 9, 10, 11)$

$y = \Sigma m(2, 3, 4, 5, 10, 11, 12, 13)$

$Z = \Sigma m(1, 2, 5, 6, 9, 10, 13, 14)$

K-maps $\Longrightarrow$

K.maps

$W = \Sigma m(8, 9, 10, 11, 12, 13, 14, 15)$

cd \ ab	a'b'	a'b	ab	ab'
c'd'	0	4	12 1	8 1
c'd	1	5	13 1	9 1
cd	3	7	15 1	11 1
cd'	2	6	14 1	10 1

$W = a$

$X = \Sigma m(4, 5, 6, 7, 8, 9, 10, 11)$

cd \ ab	a'b'	a'b	ab	ab'
c'd'	0	4 1	12	8 1
c'd	1	5 1	13	9 1
cd	3	7 1	14	11 1
cd'	2	6 1	15	10 1

$X = a'b + ab'$
$= (a \oplus b)$

$y = \Sigma m(2, 3, 4, 5, 10, 11, 12, 13)$

cd \ ab	a'b'	a'b	ab	ab'
c'd'	0	4 1	12 1	8
c'd	1	5 1	13 1	9
cd	3 1	7	15	11 1
cd'	2 1	6	14	10 1

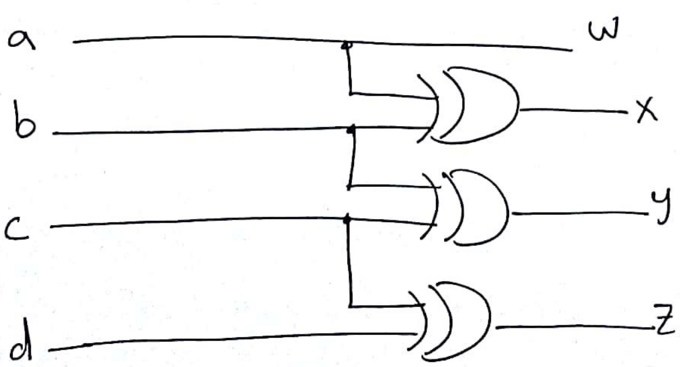
$y = b'c + bc'$
$= (b \oplus c)$

$Z = \Sigma m(1, 2, 5, 6, 9, 10, 13, 14)$

cd \ ab	a'b'	a'b	ab	ab'
c'd'	0	4	12	8
c'd	1 1	5 1	13 1	9 1
cd	3	7	15	11
cd'	2 1	6 1	14 1	10 1

$Z = c'd + cd'$
$= c \oplus d$

⇒ Implementing the output functions using XOR gates:



Q) Design a code converter that converts from BCD_{2421} to BCD_{84-2-1}

ANS:

	2	4	2	1		8	4	-2	-1
Dec	A	B	C	D		W	X	Y	Z
0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	0	1	1	1
2	0	0	1	0	2	0	1	1	0
3	0	0	1	1	3	0	1	0	1
4	0	1	0	0	4	0	1	0	0
5	1	0	1	1	11	1	0	1	1
6	1	1	0	0	12	1	0	1	0
7	1	1	0	1	13	1	0	0	1
8	1	1	1	0	14	1	0	0	0
9	1	1	1	1	15	1	1	1	1

W

CD \ AB	A'B'	A'B	AB	AB'
C'D'	0	4	12: 1	8: X
C'D	1	5: X	13: 1	9: X
CD	3	7: X	15: 1	11: 1
CD'	2	6: X	14: 1	10: X

W = A

X

CD \ AB	A'B'	A'B	AB	AB'
C'D'		1		X
C'D	1	X		X
CD	1	X		
CD'	1	X		X

X = A'B + A'C + A'D

Y

CD \ AB	A'B'	A'B	AB	AB'
C'D'			1	X
C'D	1	X		X
CD		X	1	1
CD'	1	X		X

Y = AC'D' + A'C'D + ACD + +A'CD'

Z

CD \ AB	A'B'	A'B	AB	AB'
C'D'				X
C'D	1	X	1	X
CD	1	X	1	1
CD'		X		X

Z = D

W = AB'CD + ABC'D' + ABC'D + ABCD' + ABC
  = Σm(11, 12, 13, 14, 15) + Σd(5, 6, 7, 8, 9, 10)

X = A'B'C'D + A'B'CD' + A'B'CD + A'BC'D'
  = Σm(1, 2, 3, 4) + Σd(5, 6, 7, 8, 9, 10)

Y = A'B'C'D + A'B'CD' + AB'CD + ABC'D' + ABCD
  = Σm(1, 2, 11, 12, 15) + Σd(5, 6, 7, 8, 9, 10)

Z = A'B'C'D + A'B'CD + AB'CD + ABC'D + ABCD
  = Σm(1, 3, 11, 13, 15) + Σd(5, 6, 7, 8, 9, 10)

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Q) Design a code converter that converts from BCD_{5421} to BCD_{2421}

ANS:

	5	4	2	1		2	4	2	1
Dec	A	B	C	D		W	X	Y	Z
0	0	0	0	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	1	0	0	0	8	1	0	1	1
6	1	0	0	1	9	1	1	0	0
7	1	0	1	0	10	1	1	0	1
8	1	0	1	1	11	1	1	1	0
9	1	1	0	0	12	1	1	1	1

$W = AB'C'D' + AB'C'D + AB'CD' + AB'CD$
$= \Sigma m(8,9,10,11,12) + \Sigma d(5,6,7,13,14,15)$

$X = A'BC'D' + AB'C'D + AB'CD' + AB'CD + ABC'D'$
$= \Sigma m(4,9,10,11,12) + \Sigma d(5,6,7,13,14,15)$

$Y = A'B'CD' + A'B'CD + AB'C'D' + AB'CD + ABC'D'$
$= \Sigma m(2,3,8,11,12) + \Sigma d(5,6,7,13,14,15)$

$Z = A'B'C'D + A'B'CD + AB'C'D' + AB'CD' + ABC'D'$
$= \Sigma m(1,3,8,10,12) + \Sigma d(5,6,7,13,14,15)$

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truth table (T T) :.

توعية الأسئلة

- Determine using truth table if these expressions are equal or no.

  f = ________

  g = ________

- ممكن تسؤال آخر يطلب إننا نكون الـ (Function) في الـ (Algebraic form)

  ↳ Write a Sum of minterms functions in algebraic form or in (Disjunctive Normal Form (DNF))

- أو يطلبها في الـ numeric form أو logic form :

  ↳ Write a sum of minterms in Numeric form.

  f = Σm(___ , ___ , ___ ---) ← من الـ (1's)

- أو يطلبها في (Product of maxterms)

  ↳ find a product of sums expressions in a product of maxterms form or in (Conjunctive Normal form) (CNF) ← From (0's)

- ممكن يطلب إننا نحل (Minimize) أو (Simplify) بإستخدام الـ Kmap of Rules

- أو إننا نحل (Design) أو (Block Diagram) بإستخدام (OR, AND, NOT)

  أو بـ or (NAND)

  أو بـ (NOR)

  أو بـ (2 input NAND)

أو يطلب إننا نحل expand للـ (Function) أو (Complement of f).

EX:

Determine, using truth tables, which expressions in the group functions (are equal):

$$f = a'c' + bc + ab'$$
$$g = b'c' + a'c' + ac$$
$$h = b'c' + ac + a'b$$

ANS.

a	b	c	$a'c'$	ac	bc	ab'	$a'b$	$b'c'$	f	g	h
0	0	0	1	0	0	0	0	1	1	1	1
0	0	1	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	1	0	1	1	1
0	1	1	0	0	1	0	1	0	1	0	1
1	0	0	0	0	0	1	0	1	1	1	1
1	0	1	0	1	0	1	0	0	1	1	1
1	1	0	0	0	0	0	0	0	0	0	0
1	1	1	0	1	1	0	0	0	1	1	1

$$(f = h) \neq g$$

EX.

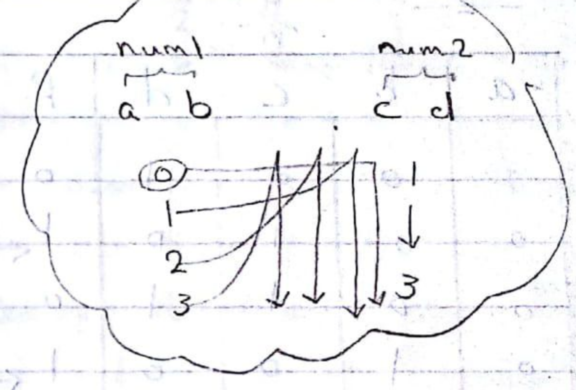
Show a truth table for a system that has four inputs a, b, c, d and one output (f), the first 2 inputs (a, b) represent one binary number (in the Range 0 to 3) and the last two (c, d) represent another number (in the Range 1 to 3).

⇒ The output (f) is one if the second number is at least two larger than the first.

(يعني أن (f=1) إذا كان الرقم الثاني أكبر من الرقم الأول بمقدار "2" أو أكثر).

ANS.

	inputs				output
	number1		number2		
m	a	b	c	d	f
1	0	0	0	1	0
2	0	0	1	0	1 ←
3	0	0	1	1	1 ←
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	1 ←
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	0
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	0



هناك نوعين من الـ (Function) :-

① Algebraic function :-
(sum of minterms) or
(sum of Products).

$$f = a'b'cd' + a'b'cd + a'bcd$$

② Numeric function or
(numeric form).

$$f = \sum m(2, 3, 7)$$

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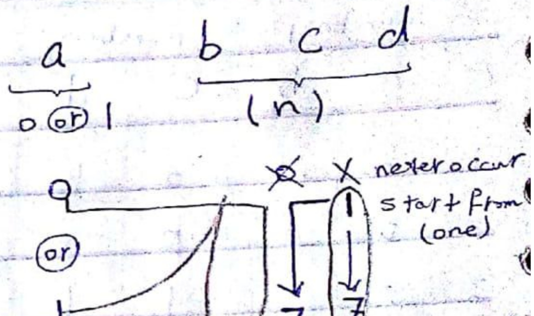
EX.

Show the truth table for:
The system has four inputs a, b, c, d and one output "f",
the last 3 inputs (b, c, d) represent a binary number "n"
in the Range 0 → 7 ; however, the input 0 never occurs,
the first input "a" specifies which of two computations
is made.

a = 0 : "f" is 1 if "n" is a multiple of 2
a = 1 : "f" is 1 if "n" is a multiple of 3

ANS.



m	a	b	c	d	f
1	0	0	0	1	0
2	0	0	1	0	1 ←
3	0	0	1	1	0
4	0	1	0	0	1 ←
5	0	1	0	1	0
6	0	1	1	0	1 ←
7	0	1	1	1	0
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	1 ←
12	1	1	0	0	0
13	1	1	0	1	0
14	1	1	1	0	1 ←
15	1	1	1	1	0

تأخذ احتمالات "n" من (1 وحتى 7)
عندما (a = 0)
وكذلك الاحتمالات عندما (a = 1)

- Algebraic function:-

$f = a'b'cd' + a'bc'd' + a'bcd' + ab'cd + abcd'$

- Numeric function:

$f = \sum m(2, 4, 6, 11, 14)$

EX.

Show a truth table for a system has four inputs A, B, C, D the first two inputs (A, B) represent a 2-bits unsigned binary number (in the range 0 to 3). the last two (C, D) represent a second unsigned binary number (in the same Range). The output "Y" is "1" if and only if the two numbers differ by two or more.

(يعني أن (Y=1) عندما الفرق بين الرقم الأول والثاني = 2 أو أكثر.)

ANS.

num1: A, B   num2: C, D

m	A	B	C	D	Y
	number 1		number 2		
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	1 ←
8	1	0	0	0	1 ←
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	0
15	1	1	1	1	0

- Algebraic function :-

$$Y = A'B'CD' + A'B'CD + A'BCD + AB'C'D + ABC'D' + ABC'D$$

- Numeric form :-

$$Y = \sum m(2, 3, 7, 8, 12, 13)$$

EX. (final 2012).

Show the truth table for a system that has four inputs a, b, c, d and two outputs, f & g. The first two inputs (a, b) represent one binary number (in the Range 0 to 3) & the last two (c, d) represent another number in the range 1 to 3. The output, f and g represent the magnitude of the difference of two binary numbers inputs (|ab - cd|)

ANS.

num1		num2		|ab - cd|	
a	b	c	d	f	g
0	0	0	1	0	1
0	0	1	0	1	0
0	0	1	1	1	1
0	1	0	1	0	0
0	1	1	0	0	1
0	1	1	1	1	0
1	0	0	1	0	1
1	0	1	0	0	0
1	0	1	1	0	1
1	1	0	1	1	0
1	1	1	0	0	1
1	1	1	1	0	0

$f = a'b'cd' + a'b'cd + a'bcd + abc'd$

$g = a'b'c'd + a'b'cd + a'bcd' + ab'c'd + ab'cd + abcd'$

* Show a truth table for a system that Convert from BCD Excess 3 to BCD 8421.

ANS.

Inputs				outputs			
Excess 3				8	4	2	1
A	B	C	D	W	X	y	Z
0	0	1	1 ← 3	0	0	0	0
0	1	0	0 ← 4	0	0	0	1
0	1	0	1 ← 5	0	0	1	0
0	1	1	0 ← 6	0	0	1	1
0	1	1	1 ← 7	0	1	0	0
1	0	0	0 ← 8	0	1	0	1
1	0	0	1 ← 9	0	1	1	0
1	0	1	0 ← 10	0	1	1	1
1	0	1	1 ← 11	1	0	0	0
1	1	0	0 ← 12	1	0	0	1

$W = \Sigma m(11, 12) + \Sigma d(0, 1, 2, 13, 14, 15)$

$X = \Sigma m(7, 8, 9, 10) + \Sigma d(0, 1, 2, 13, 14, 15)$

$y = \Sigma m(5, 6, 9, 10) + \Sigma d(0, 1, 2, 13, 14, 15)$

$Z = \Sigma m(4, 6, 8, 10, 12) + \Sigma d(0, 1, 2, 13, 14, 15)$

* Show a truth table for a system that convert from BCD 84-2-1 to BCD Excess-3, then show the switching algebra for the output functions.

↓ Algebraic form

ANS.

Inputs				outputs			
8	4	-2	-1	Excess 3			
A	B	C	D	W	X	Y	Z
0	0	0	0 ← 0	0	0	1	1
0	1	1	1 ← 7	0	1	0	0
0	1	1	0 ← 6	0	1	0	1
0	1	0	1 ← 5	0	1	1	0
0	1	0	0 ← 4	0	1	1	1
1	0	1	1 ← 11	1	0	0	0
1	0	1	0 ← 10	1	0	0	1
1	0	0	1 ← 9	1	0	1	0
1	0	0	0 ← 8	1	0	1	1
1	1	1	1 ← 15	1	1	0	0

$W = \sum m(8, 9, 10, 11, 15) + \sum d(1, 2, 3, 12, 13, 14)$

$=$

$X = \sum m(4, 5, 6, 7, 15) + \sum d(1, 2, 3, 12, 13, 14)$

$Y = \sum m(0, 4, 5, 8, 9) + \sum d(1, 2, 3, 12, 13, 14)$

$Z = \sum m(0, 4, 6, 8, 10) + \sum d(1, 2, 3, 12, 13, 14)$

* You simplify them on the K.map.

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Q2:

Develop a truth table for a system with 3 inputs a, b, c and four outputs W, X, y and Z. The output is a binary number equal to the largest integer that meets the input conditions:-

a = 0	: odd	a = 1	: even.
b = 0	: Prime	b = 1	: not Prime.
c = 0	: less than 8	c = 1	: greater Than 8

(The output is never all 0's)

ANS:

← عندنا ٣ مدخلات a, b, c

← و ٤ مخرجات (W, X, y, Z) بيمثلوا أكبر رقم الذى يحقق الشروط المكتوبة

الـ (output) هيكون من (0 ← 15) لأنهم 4 bits.

مثال :- لو : a=0 S b=1 S c=1

a	b	c
0	1	1

معناه أن الرقم odd, not prime, (n > 8)

وعندنا الأرقام من (0 : 15) فقط واللى أكبر من 8 هم (9, 10, 11, 12, 13, 14, 15) نختار منهم

الـ (odd) والـ (prime) ⇐ (11, 13, 15) وأكبر واحد فيهم 15

نضعه (binary) 4 bits ←

W	X	y	Z
1	1	1	1

a	b	c	W	X	y	Z
odd 0	Prime 0	<8 0	0	1	1	1
odd 0	Prime 0	>8 1	1	1	0	1
odd 0	not Prime 1	<8 0	X	X	X	X
odd 0	N.P 1	>8 1	1	1	1	1
1	0	0	0	0	1	0
1	0	1	X	X	X	X
1	1	0	0	1	1	0
1	1	1	1	1	1	0

هنا كان ممكن نختار: 1 or 3 or 5 or 7 لكن أخذنا 7 لأنه قال أكبر رقم يحقق الشرط

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

(Q2 - final 2010) (12 Points)

Q: The months of the year are coded in four variables a, b, c & d such that January is 0001, February is 0010, ---, and December is 1100. Febrauary of a leap year (in which, February is 29 days) is coded as 0000).

Remember: April, June, september and November has 30 days) all other months except february has 31 days)

a) Show the truth table with five variables V, W, X, Y, Z, that indicates the number of days in the selected month.

b) Write the switching formula for each of V, W, X, Y & Z

c) Minimize V, W, X, Y & Z, applying switching Rules.

ANS.

⟹

a)

Months & Days.	a	b	c	d	v	w	x	y	z
Feb (29)	0	0	0	0	1	1	1	0	1
Jan (31)	0	0	0	1	1	1	1	1	1
Feb. (28)	0	0	1	0	1	1	1	0	0
Mar. (31)	0	0	1	1	1	1	1	1	1
April (30)	0	1	0	0	1	1	1	1	0
May (31)	0	1	0	1	1	1	1	1	1
June (30)	0	1	1	0	1	1	1	1	0
July (31)	0	1	1	1	1	1	1	1	1
Aug. (31)	1	0	0	0	1	1	1	1	1
Sep. (30)	1	0	0	1	1	1	1	1	0
Oct. (31)	1	0	1	0	1	1	1	1	1
Nov. (30)	1	0	1	1	1	1	1	1	0
Dec. (31)	1	1	0	0	1	1	1	1	1
x	1	1	0	1					
x	1	1	1	0					
x	1	1	1	1					

$(29)_{10} \Rightarrow (11101)_2$, $(28)_{10} = (11100)_2$, $(30)_{10} = (11110)_2$; $(31)_{10} = (11111)_2$