EICoM
ELECTRICAL COMPUTER MECHATRONICS

تلخيص
منطق رقمي ميكاترونكس

للطالب المبدع
محمود المجدلاني

إرادة - ثقة - تغيير

Numbers system

- Decimal {1,...,9}
- Binary {0,1}
- Octal {0,...,7}
- Hexadecimal {0,...,9,A,...,F}

1's complement

1 ↔ 0 (فقط حول من)

Conversions between systems

- Decimal ⇌ Binary / Octal / Hexa.
  - ÷ Base
  - * Base
  - ↓ fraction
  - ↑ Integer
- Octal ⇌ Binary ⇌ Hexa

BCD	DECIMAL
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9

BINARY	OCTAL
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

BINARY	HEXA
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

2nd complement

2nd compl. = 1'st compl. + 1

GRAY	DECIMAL
0000	0
0001	1
0011	2
0010	3
0110	4
0111	5
0101	6
0100	7
1100	8
1101	9
1111	10
1110	11
1010	12
1011	13
1001	14
1000	15

$$\begin{array}{r} 0_{(2)} \\ +\ 0_{(2)} \\ \hline 0_{(2)} \end{array} \qquad \begin{array}{r} 0_{(2)} \\ +\ 1_{(2)} \\ \hline 1_{(2)} \end{array}$$

$$\begin{array}{r} (1)\ 1_{(2)} \\ +\ 1_{(2)} \\ \hline 1\ 0_{(2)} \end{array}$$

$$\begin{array}{r} 1_{(2)} \\ 1_{(2)} \\ +\ 1_{(2)} \\ \hline 1\ 1_{(2)} \end{array}$$

Basic Binary Gates

OR
⊕ (blue)

$A\ B \to F$

A	B	F
0	0	0
1	0	1
0	1	1
1	1	1

بتحب ال 1
لمميزها من رمزها
⊕ → 1 +

AND
⊙ (blue) — نقطة الفاصلة

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

بتحب ال 0
وبنميزها من رمزها نقطة (•) ويعني بالعربي رقم صفر

NOT
1^{st} compl.

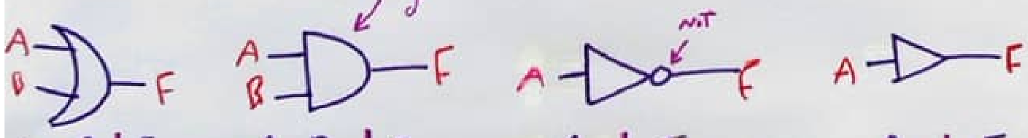
A	F
0	1
1	0

$F = \bar{A}$

Buffer
No change

A	F
0	0
1	1

$F = A$



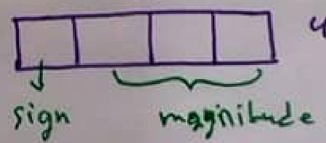
* Not Gate ⟹ 1^{st} complement

- $X + \bar{X} = 1 \longrightarrow X + 0 = X \longrightarrow X + 1 = 1$
- $X \cdot \bar{X} = 0 \longrightarrow X \cdot X \cdot X \cdot X = X$

(+ve) → 0
(−ve) → 1

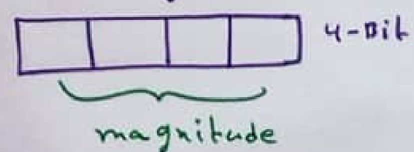
Number representation

Significal magnitude

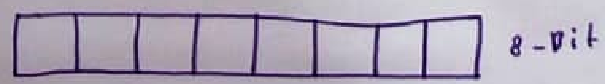


1^{st} complement representation
- (+ve) as is
- (−ve) 1^{st} compl.

2^{nd} complement representation
- (+ve) as is
- (−ve) 2^{nd} compl.



من بعد العدد 8 →



Logical Gate

OR

+

A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

AND

·

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

NOT

1's compl

A	F
0	1
1	0

Buffer

No change

A	F
0	1
1	0

NAND

$\overline{AB}$

A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

NOR

$\overline{A+B}$

A	B	F
0	0	1
0	1	0
1	0	0
1	1	0

Exclusive OR

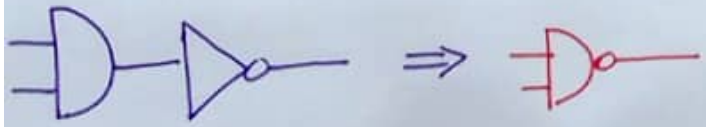
⊕

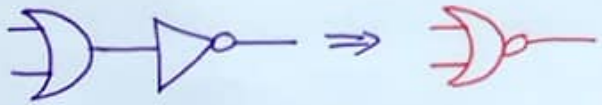
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

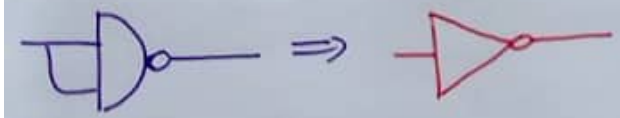
Exclusive NOR

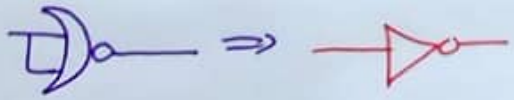
⊙

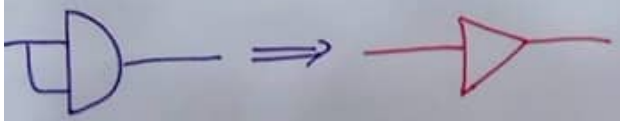
A	B	F
0	0	1
0	1	0
1	0	0
1	1	1

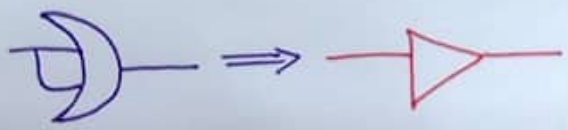












Range

sign-magnitude, 1's compl. rep. $\rightarrow -(2^{n-1}-1) : +(2^{n-1}-1)$

2's compl. rep. $\rightarrow -(2^{n-1}) : (2^{n-1}-1)$

Bits	1's compl. sign-mag	2's compl.
4	-7 : +7	-8 : +7
8	-127 : 127	-128 : +127

* Bit $\rightarrow$ for Binary Digit

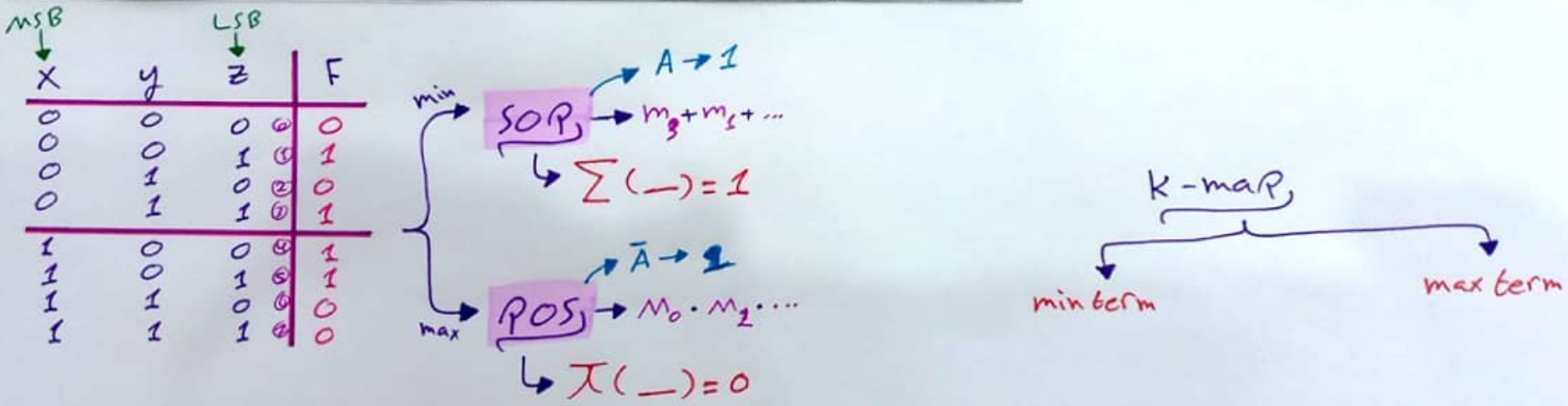
( )
AND $\doteq$
OR $\pm$

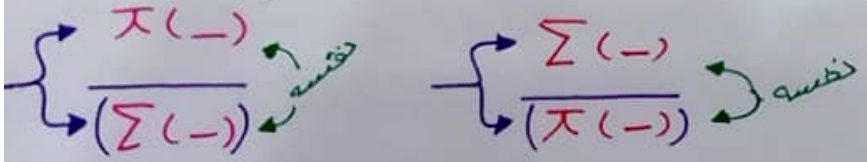
$2^0 \rightarrow 1$
$2^1 \rightarrow 2$
$2^3 \rightarrow 8$
$2^4 \rightarrow 16$
$2^5 \rightarrow 32$
$2^6 \rightarrow 64$

$2^7 \rightarrow 128$
$2^8 \rightarrow 256$
$2^9 \rightarrow 512$
$2^{10} \rightarrow 1024$

$k \rightarrow 10^3 \rightarrow 2^{10} = 1024$
$M \rightarrow 10^6 \rightarrow 2^{20} = (1024)^2$
$G \rightarrow 10^9 \rightarrow 2^{30} = (1024)^3$

NUMBER	X	Y	Z	MIN TERMS		MAX TERMS	
				TERM	DESIGNATION	TERM	DESIGNATION
0	0	0	0	$\bar{x} \cdot \bar{y} \cdot \bar{z}$	m_0	$x + y + z$	M_0
1	0	0	1	$\bar{x} \cdot \bar{y} \cdot z$	m_1	$x + y + \bar{z}$	M_1
2	0	1	0	$\bar{x} \cdot y \cdot \bar{z}$	m_2	$x + \bar{y} + z$	M_2
3	0	1	1	$\bar{x} \cdot y \cdot z$	m_3	$x + \bar{y} + \bar{z}$	M_3
4	1	0	0	$x \cdot \bar{y} \cdot \bar{z}$	m_4	$\bar{x} + y + z$	M_4
5	1	0	1	$x \cdot \bar{y} \cdot z$	m_5	$\bar{x} + y + \bar{z}$	M_5
6	1	1	0	$x \cdot y \cdot \bar{z}$	m_6	$\bar{x} + \bar{y} + z$	M_6
7	1	1	1	$x \cdot y \cdot z$	m_7	$\bar{x} + \bar{y} + \bar{z}$	M_7





K-map

2-variable

A \ B		
	m_0	m_1
	m_2	m_3

3-variable

اسطوانة

A \ BC				
	m_0	m_1	m_3	m_2
	m_4	m_5	m_7	m_6

4-variable

كرة

AB \ CD				
	m_0	m_1	m_3	m_2
	m_4	m_5	m_7	m_6
	m_{12}	m_{13}	m_{15}	m_{14}
	m_8	m_9	m_{11}	m_{10}

5-variable

كرتين بقلب بعض

BC \ DE				
	m_0	m_1	m_3	m_2
	m_4	m_5	m_7	m_6
	m_{12}	m_{13}	m_{15}	m_{14}
	m_8	m_9	m_{11}	m_{10}

AB \ DE				
	m_{16}	m_{17}	m_{19}	m_{18}
	m_{20}	m_{21}	m_{23}	m_{22}
	m_{28}	m_{29}	m_{31}	m_{30}
	m_{24}	m_{25}	m_{26}	m_{27}

Rule for minimization

1) cover all one's using
   → circles and non-zero ←

2) circles are 1, 2, 4, 8 → 2's

3) minimize → the number of circles

4) maximize → the size of each circle

◆ $\overline{(A \odot B)} = A \oplus B$ ◆ $\overline{(A \oplus B)} = A \odot B$

k-map لتبسيط { minterm, maxterm } * يفضل أحل على اللي جبنا سبب ف

ولكن إذا قاحدلي السؤال على أنو أحل
↳ بحل على اللي فيها دوائر أقل أو النقاط هو أسهل وسيبة

* إذا كان موجود بال Symmetric ← knap
↳ بعرف انه فيه { XOR, XNOR }

How to Design (1, 2, 3, ...) Bit up or down or both

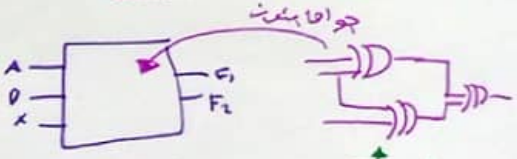
1) Find state table (truth table)

A B	F_1 F_2
1	2

2) find state Diagrame ...

3) find the function By k-map

4) Draw the circuit



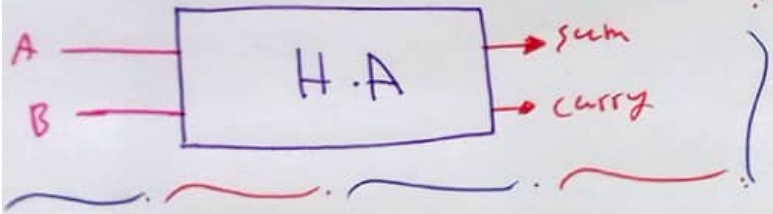
* If I have 2 variable → 2 output F_1, F_2
  3 variable → 3 output F_1, F_2, F_3
  ...

variable
↳ (A, B, C, D)
↳ بدون ال ⊗

output عدد = يعني عدد المتغيرات

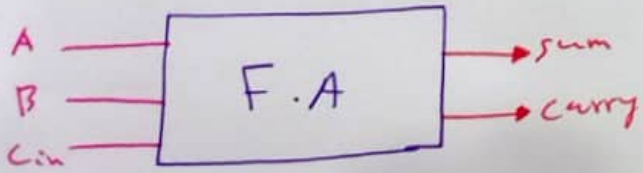
* XOR ← 2 Inputs وبقبل اكثر

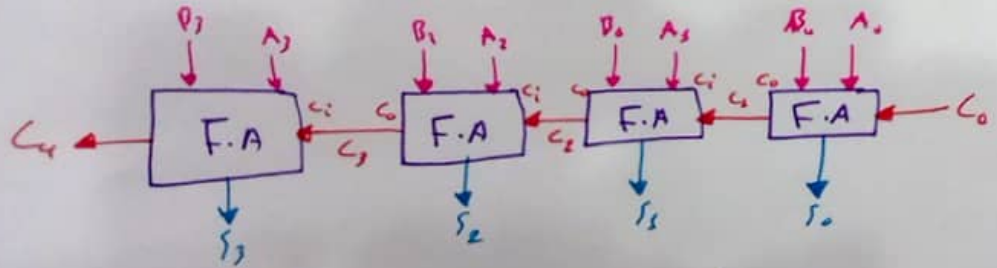
Half Adder (H.A)



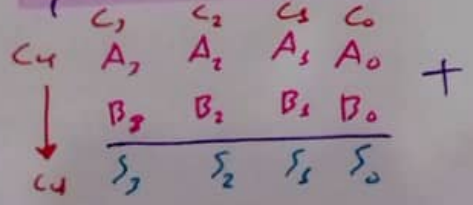
full Adder (F.A)

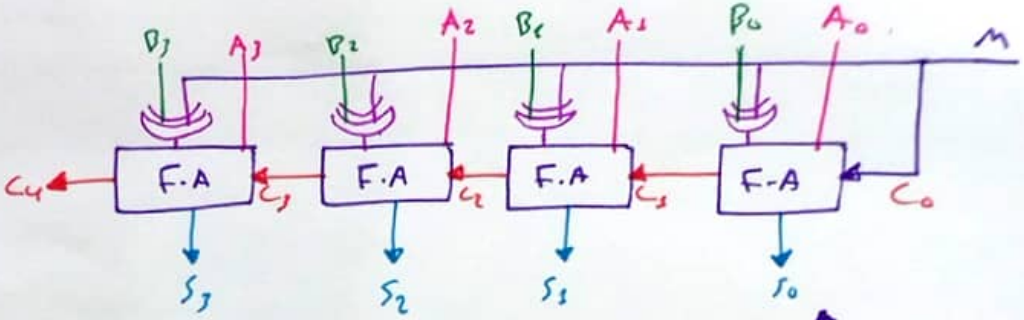
- 4-Bit Adder
- 4-Bit Adder subtractor



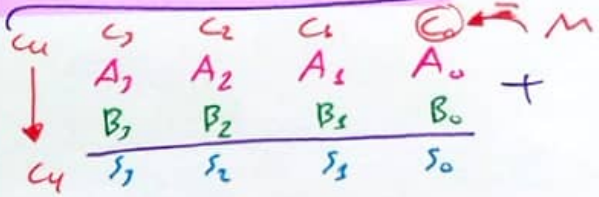


4-Bit Adder





4-Bit Adder subtractor



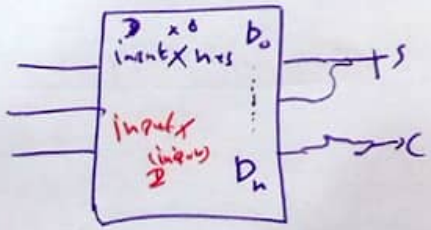
* $B \oplus M \rightarrow B \oplus 0 \rightarrow B$
  $B \oplus 1 \rightarrow \overline{B}$

* $M = 0$
  ↳ $A+B$ Addition.

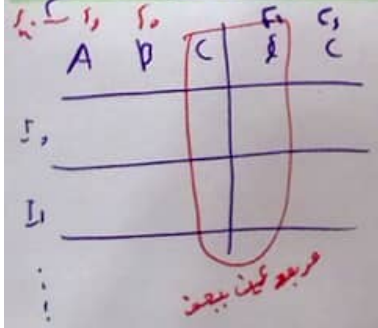
* $M = 1$
  ↳ $A + \overline{B} + 1$ subtractor.
  ($\overline{B}+1$: 2nd compl.)

Decoder

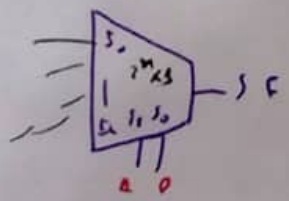
A	B	C	S	C

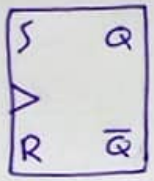
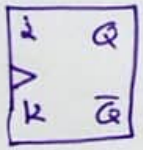
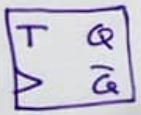
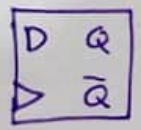


Matiplexer (mux)



	Input	selection lines	output
2x1	2	1	1
4x1	4	2	1
8x1	8	3	1
16x1	16	4	1



Name	Symbol	Truth Table	Chara. equ.	Excitation table
SR f/f		S R | Q^+ 0 0 | Q 0 1 | 0 1 0 | 1 1 1 | X	———	———
jk f/f		j R | Q^+ 0 0 | Q 0 1 | 0 1 0 | 1 1 1 | $\bar{Q}$	$Q^+ = j\bar{Q} + \bar{k}Q$	Q Q^+ | j k 0 0 | 0 X 0 1 | 1 x 1 0 | X 1 1 1 | x 0
T f/fl		T | Q^+ 0 | Q 1 | $\bar{Q}$	$Q^+ = T \oplus Q$	Q Q^+ | T 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 0
D f/f		D | Q^+ 0 | 0 1 | 1	$Q^+ = D$	Q Q^+ | D 0 0 | 0 0 1 | 1 1 0 | 0 1 1 | 1

Region	V_{BE}	V_{CE}	current relationship
cut off	< 0.6	0.C	$I_B = I_C = 0$
Active	0.6 – 0.7	> 0.7	$I_C = h_{FE}\ I_B$
saturation	0.7 – 0.8	0.2	$I_B \geq \frac{I_C}{h_{FE}}$