Digital systems :-

Digital

Systems :- set of things working together as apart of mechanism.

input → system componant → output

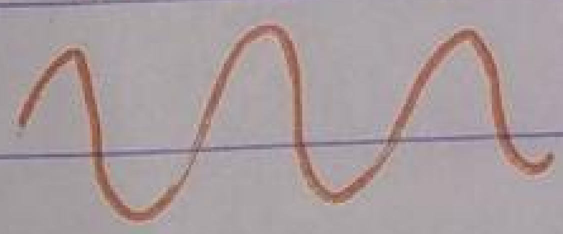
input → electrical system → output

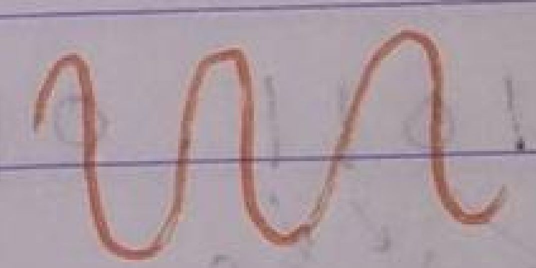
electrical system: componants connected together.

Analog system ← electrical system → Digital system.

input → analog system → output
signal → analog system → signal.

Continuous signal: electric system with continous signal variable

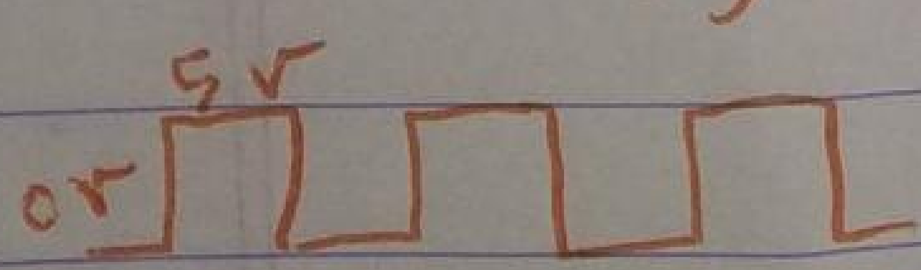


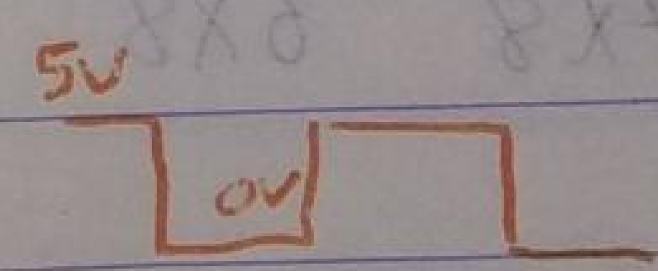


In electronics :- asignal is an or electromagnasim current that is aset for carrying data from one device ~~or~~ to another.

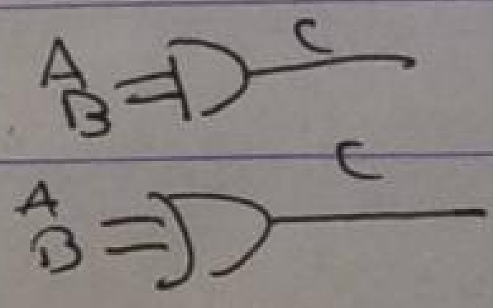
Input signal → digital system → output signal

electric system operate using discrete signal





. (بوابات) logic system



Numbering systems.

Decimal system: Base = 10.

There are 10 different digits in the system.

0	$(10)_{10}$	20 ...	100.
1	$(11)_{10}$	21	
2	$(12)_{10}$		
3			
4			
5			
6			
7			
8			
9			

57021

$10^4 \; 10^3 \; 10^2 \; 10^1 \; 10^0$

$= 5 * 10^4 + 7 * 10^3 + 0 * 10^2 + 2 * 10^1 + 1 * 10^0.$

$= 50000 + 70000 + 0 + 20 + 1 = 57021$

Binary system:— Base = 2.

0	10	100	1000
1	11	101	1001
		110	1010
		111	1011
			1100
			1101
			1110
			1111

Octal system : Base = 8.

0	$(10)_8$	$(20)_8$	$(100)_8$.
1	11		
2	12		
3	13		
4	14		
5	15		
6	16		
7	17	.	77

Hexadecimal (Hex) : Base = 16.

0	$(10)_{16}$	$(20)_{16}$.	A	1A
1	11			
2	12		B	1B
3	13			
4	14		C	1C
5	15			
6	16		D	1D
7	17		E	1E
8	18			
9	19		F	1F.

10 معناها
بال decimal

exp Base = 4.

0	$(10)_4$	$(20)_4$	$(30)_4$ ---
1	11	21	--
2	12	22	--
3	13	23	--

التحويل :-

$(1011101)_2$

$2^6 \; 2^5 \; 2^4 \; 2^3 \; 2^2 \; 2^1 \; 2^0$

$1*2^6 + 0*2^5 + 1*2^4 + 1*2^3 + 1*2^2 + 0*2^1 + 1*2^0$.

$= 64 + 0 + 16 + 8 + 4 + 0 + 1 = (93)_{10}$.

$(3702)_8 = 3*8^3 + 7*8^2 + 0*8^1 + 2*8^0 = (\quad)_{16}$

$8^3 \; 8^2 \; 8^1 \; 8^0$

$(20A4)_{16} = 2*16^3 + 0*16^2 + 10*16^1 + 4*16^0 = ($

$16^3 \; 16^2 \; 16^1 \; 16^0$

عند التحويل نضع قيمهن بالأرقام.

Conversion :-

Binary → decimal.

$$\overset{2^4\,2^3\,2^2\,2^1\,2^0}{(1\,1\,0\,1\,1)_2} = 2^4 + 2^3 + 0 + 2^1 + 2^0$$

$$= 16 + 8 + 0 + 2 + 1 = (27)_{10}.$$

decimal → Binary.

we devide by 2.

$(38)_{10} \overset{?}{=} (\quad)_2.$

(الباقي) Reminder	÷
0	38
1	19
1	9
0	4
0	2
1	1
	0

اتجاه الكتابة. ↑

left → 1

$(38)_{10} = (100110)_2.$

Octal → decimal.

$$\overset{8^2\,8^1\,8^0}{(2\,0\,5)_8} = 2 * 8^2 + 0 * 8^1 + 5 * 8^0$$

$$= 128 + 0 + 5 = (133)_{10}.$$

decimal → Octal

we divide by 8.

$(95)_{10} = (\quad)_8$.

Reminder	÷ 8
	95
7	11
3	1
left → 1	0

$(95)_{10} = (137)_8$.

Decimal → Hex

$(93)_{10} = (\quad)_{16}$.

we divide by 16.

Reminder	÷ 16
	93
D = 13	5
left → 5	0

$(93)_{10} = (5D)_{16}$.

اذا الرقم بنقدر نحطه ل 16 (بالحروف) بنعكسو.

Hex → decimal

$(2A1) = 2 * 16^2 + 10 * 16^1 + 1 * 16^0$.

$16^2 \; 16^1 \; 16^0$

$= 512 + 160 + 1 = (673)_{10}$.

Octal Binary $\Rightarrow 8 = 2^3$

Base = 8 Base = 2

Hex Binary $\Rightarrow 16 = 2^4$.

Base = 16 Base = 2

Result :-

1- Each Octal digit is equal 3 binary digit.

2- Each Hex digit is equal 4 binary digit.

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

Octal → Binary.

we replace every octal digit with it's equivilant 3 binary digit

$(5024)_8 = (101000010100)_2$.

↓

$(\quad)_{10} = (\quad)_{10}$.

Binary → octal.

- we group from the right every 3 binary digit and score the equivalent octal digit.

$$\underbrace{001}\,\underbrace{010}\,\underbrace{100}\,\underbrace{111}\,\underbrace{010}.$$

$(1\ \ 2\ \ 4\ \ 7\ \ 2)_8$.

Hex → Binary.

- Replace every Hex digit with 4 binary digit.

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

$(\underbrace{0011}\,\underbrace{0010}\,\underbrace{1111}\,\underbrace{1010})_2 = (32FA)_{16}$.

$(2B9)_{16} = (001010111001)_2$.

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Binary Addition :-

$$\begin{array}{r} {}^{1\,1\,0\,1} \\ 110110 \\ 11110 + \\ \hline 1010100 \end{array}
\qquad
\begin{array}{r} {}^{1\,0\,1} \\ 111011 \\ 11100 + \\ 11000 \\ \hline 1101111 \end{array}$$

Fraction in Binary :-

Recall : In decimal.

$$52.23 = 5*10^1 + 2*10^0 + 2*10^{-1} + 3*10^{-2}.$$

10^1, 10^0, 10^{-1}, 10^{-2}.

=

In Binary :-

$$1011.11 = 2^3 + 0 + 2^1 + 1 + 2^{-1} + 2^{-2}.$$

$2^3\ 2^2\ 2^1\ 2^0\ \ 2^{-1}\ 2^{-2}$

$2^{-1} \to \frac{1}{2}$, $2^{-2} \to \frac{1}{4}$.

$= 11.75$.

Fractions in Binary Number

(Floating point Number).

$$\underbrace{1\ 0\ 1\ 1}_{\text{integer part}} \ . \ \underbrace{1\ 0\ 1\ 1}_{\text{fraction}}$$

$$2^3\ 2^2\ 2^1\ 2^0 \qquad 2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4}$$

$$2^3 + 2^1 + 2^0 \ . \ 2^{-1} + 0 + 2^{-3} + 2^{-4}.$$

$$11 \ . \ 0.5 + 0.1250 + 0.0625.$$

$$11.6875.$$

أمثلة :-

Floating point number → Binary.

25 . 375

11001 . 011

	÷ 2
1	25
0	12
0	6
1	3
→ 1	1
	0

	x 2
من هون بنكتب → 0	0.375
1	0.75
1	1.5
	1.0 → stop
	0.0

١ ١
٠٫٣٧٥
٠٫٧٥

25.2

$11001.\overline{0011}$

	$\times 2$
0	0.2
0	0.4
1	0.8
1	1.6
	1.2

→ رح يضل يتكرر

25.3

$11001.0\overline{1001}$

	$\times 2$
0	0.3
1	0.6
0	1.2
0	0.4
1	0.8
	1.6

→ رح يضل يتكرر

How do Computers Represent Digits?

CPU :- Central processing Unit. وحدة المعالجة المركزية

↳ Consist of

1. ALU : Arithmetic logic Unit. ← Addition +, Sub −, Mult *, div ÷ — Comperision $x > y$
2. CU : Control Unit
3. Registers : Memory

Note There is No subtraction operation in Computer

⟹ Subtraction Must be Changed to addition.

Complements :- To change subtraction to addition

$= M - N = M +$ complement N.

مهم

Complements :- ① Diminshed complement.
(r-1) comp ② Radix complement.
(r comp).

Diminshed compl :- what the 9's compl of 6. Answer:- 3 (3+6 = 9). (r = 10).

- what is the 9 compl of 66 → (r = 10)

Answer: $\underbrace{99 - 66}_{2\text{ digits}} = 33$.

Given a number N in base r having n digits the (r-1)'s Comp of N is $(r^n - 1) - N$.

ex) what is the First comp of $\boxed{1011}$ in base 2.

N = 1011 n = 4 r = 2.

$(2^4 - 1) - 1011$

15 - 1011

1111 - 1011 = $\boxed{0100}$.

ex what is the 9's comp of 5555 in base 10

n = 4 r = 10

$(10^4 - 1) - 5555$

9999 - 5555 = 4444

Radix compl :- The r's comp of number N with n digit is defined $(r^n - N)$ For $N \neq 0$.

ex what is 10's comp of 666 in base = 10

$10^3 - 666 = 1000 - 666$

334.

10's Complement = 9's comp + 1.

ex What is the 2's compl 1011 in base = 2

2's compl = 1^{st} Comp + 1.

0100 + 1. = 0101.

M - N = M + Compl N.

1. M > N → end Carry must be discarded.

ex 99 - 79 = 99 + 10's comp 79.

99 + 21 ← $10^2 - 79$.

1.
$$\begin{array}{r} 99 \\ + \quad 21 \\ \hline \cancel{1}20 \end{array} = 20.$$

ex 222 - 122 = 222 + 10's comp 122.

$10^3 - 122$.

= 878.

$$\begin{array}{r} 222 \\ + \quad 878 \\ \hline \cancel{\boxed{1}}100 \end{array} = 100$$

ex 1111 - 0111   r = 2.

M > N

1111 + 2's comp 0111

$$\begin{array}{r} 1111 \\ + \quad 1001 \\ \hline \cancel{1}1000 \end{array} = 1000.$$

2's comp 0111

1^{st} comp + 1

1000 + 1

1001.

(2) M < N → No end carry and the result will be negative so to obtained the final answer the r's comp of the summation

ex 79 - 99 = 79 + 10's comp 99.
M < N = 79 + 1 = 80.
final answer = 10's comp 80 = -20.

ex 122 - 222 = 122 + 10's comp 222.
= 122 + 778 ← $10^3 - 222$
= 900.

final answer = 10'comp 900 = -100.

ex 0111 - 1111 = 0111 + 2's comp 1111
0111 + 0001 = 1000 1's comp + 1
0000 + 1 = 0001
final answer = 2's comp 1000 = 0111 + 1 = -1000

أسئلة :—

1) 2220 - 1220 = 2220 + 10's 1220

$\updownarrow$ 10's comp   2220 + 8780 $10^4 - 1220$

= ~~1~~1000 = $\boxed{1000}$

2) 1220 - 2220

1220 + 10's comp 2220

1220 + 7780 = 9000

final answer = 10's 9000 = $\boxed{-1000}$

3) 10000 - 01111   10000 + 2's comp 01111

$\updownarrow$ 2's comp $\underbrace{}_{1's\ +1}$

1) 10000 +
10001

~~1~~00001 = $\boxed{00001}$ 10000 + 1 = 10001

4) 01111 - 10000

01111 + 2's 10000 = 01111 + 11110

01111 +
10000
11111

01111 +
11110
00000

final answer = 2's 11111 = 00000 + 1 = $\boxed{-00001}$

Signed Binary Number :-

- There is no sign way in computer.

left most bit → sign.

آخر رقم من الجهة اليسار .

اذا كانت الإشارة (-) الرقم 1 .

اذا كانت الاشارة (+) الرقم 0 .

Note :- (1) There is one way to represent the positive numbers.

ex +9 → $\underline{0}\underbrace{1001}$ → 9 هاد رقم

للإشارة .

ex +15 [signed Binary number].

01111

+15 representation by 4 bits? → Overflow.

⇒ I Can't

⇒ minimum 5 bits.

مع ال signed number.

ex +13 → 01011 5 bits | 4 bits → overflow.

ex Signed number → decimal.

$\boxed{0}\underbrace{1110}_{14}$ → +14.

+

Carry → unsignd number. (M>N discared).

ex +41

2	41
1	20
0	10
0	5
1	2
0	1
1	0

[0101001].

7 bits.

إذا عن طريق 8bits ←

00101001

للإشارة. = زيادة.

② There are three ways to represent negative number.

① signed magnitude. −7 → $\underset{-}{1}\underbrace{111}_{7}$ −7

→ −15 → 11111

= للإشارة.

→ −14 representation 4 bits → overflow.

signed magnitude. $\underbrace{1111}0$ 5 bits.

101110 6 bits.

② First Complement.

→ −7 First Complement 8 bit.

$00000111 \xrightarrow[\text{Comp}]{\text{First}} 11111000$ → −7

③ Two's Complement.

→ -7 Two Complement.

00000111

11111000 ← First Complement.

1 +

11111001 ← Two complement.

اذا حكالنا نهاد اني رقم بتل بال decimal

بنقلب الصفر واحد والواحد صفر وبنجمع ١ بيعطينا (-7)

ex ⓪11111 signed magnitude decimal.

$1\times2^0 + 1\times2^1 + 1\times2^2 + 1\times2^3 + 1\times2^4 = +31$

ex -14 First complement 6 bits.

14 → 001110

1^{st} comp → 110001

2^s comp → 1 +

110010

ex A = -15 B = 25 do the following operations using signed two complement in 6 bits representation.

15 → 001111

2's Comp → 110001

25 → 011001

2's comp → 100110

1 +

100111

⟹

① A + B   -15 + 25.

متشابهات $\boxed{1}$ 1 1 0 0 0 1 +

0 1 1 0 0 1

$\boxed{1}$ 0 0 1 0 1 0 ✓

اذا آخر two carry متشابهين ← no overflow

carry X

② A - B   -15 - 25.

مختلفات $\boxed{1}$ 0 1 1 0 0 0 1

↕   1 0 0 1 1 1 +

overflow. $\boxed{1}$ 0 1 1 0 0 0

Final answer:-

0 1 0 0 1 1 1

1 +

(-) 0 1 0 1 0 0 0

$\boxed{-40}$ = . $40 = 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

Binary Cods :-

suppose we have language with 4 symbols

	A	B	C	D
Code	00	01	10	11

ABC
000110

language 8 symbols.

A	B	C	D	0	1	2	3
000	001	010	011	100	101	110	111

ABC 000001010

ASCII Code. 8 bits.

A B ... Z (26).

a b ... z (26).

0 1 ... 9 (10)

? ! : , ; + ... (100).

162

128 < 162 < 256

2^7 2^8

$(13)_d \rightarrow (1101)$ conversion.

مثلاً (مش لشرط الرقم صح

$(13)_d$ ASCII (0000111100 0011110) له

Coding.

BCD Code (Binary coded decimal).

Decimal	BCD
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10-11-12-13-14-15	XXXX (Un used)

$(10)_d \rightarrow (00010000)_{BCD}$

$(10)_d \rightarrow (1010)_2$

$(185)_d \rightarrow (000110000101)_{BCD}$

Addition with BCD

$$\begin{array}{lr} 4 & \rightarrow 0100 \\ 4\,+ & 0100 \\ \hline & \underbrace{1000}_{} \end{array}$$

Valid (لأنه أقل من 10)

$$\begin{array}{lr} 5 & 0101 \\ 5\,+ & 0101\,+ \\ \hline & \underbrace{1010}_{10} \end{array}$$

valid no →

$$\begin{array}{r} 1010 \\ 0110\,+ \\ \hline 0001\,\underbrace{0001}_{1}\,\underbrace{0000}_{0} \end{array}$$

بجمعله 6 عشان يصير Valid

$$\begin{array}{lr} 4 & 0100 \\ 5\,+ & 0101\,+ \\ \hline & \underbrace{1001}_{9} \end{array}$$

valid.

$$\begin{array}{lr} 6\,+ & 0110\,+ \\ 6 & 0110 \\ \hline & \underbrace{1100}_{} \end{array}$$

valid no

$$\begin{array}{r} 1100 \\ 0110 \leftarrow 6 \\ \hline \underbrace{0001}_{1}\,\underbrace{0010}_{2} \end{array}$$

ex BCD

185	→	0001	1000	0101
925 +	→	1001	0010	0101
1110		1011	1011	1010
		0110	0110	0110
	00 01	0001	0001	0000
	1	1	1	0

ex BCD

99 +	→	1001	1001
99	→	1001	1001
198		10011	10010
		0110	0110
		11001	1000
	1	9	8

Other Decimal Code.

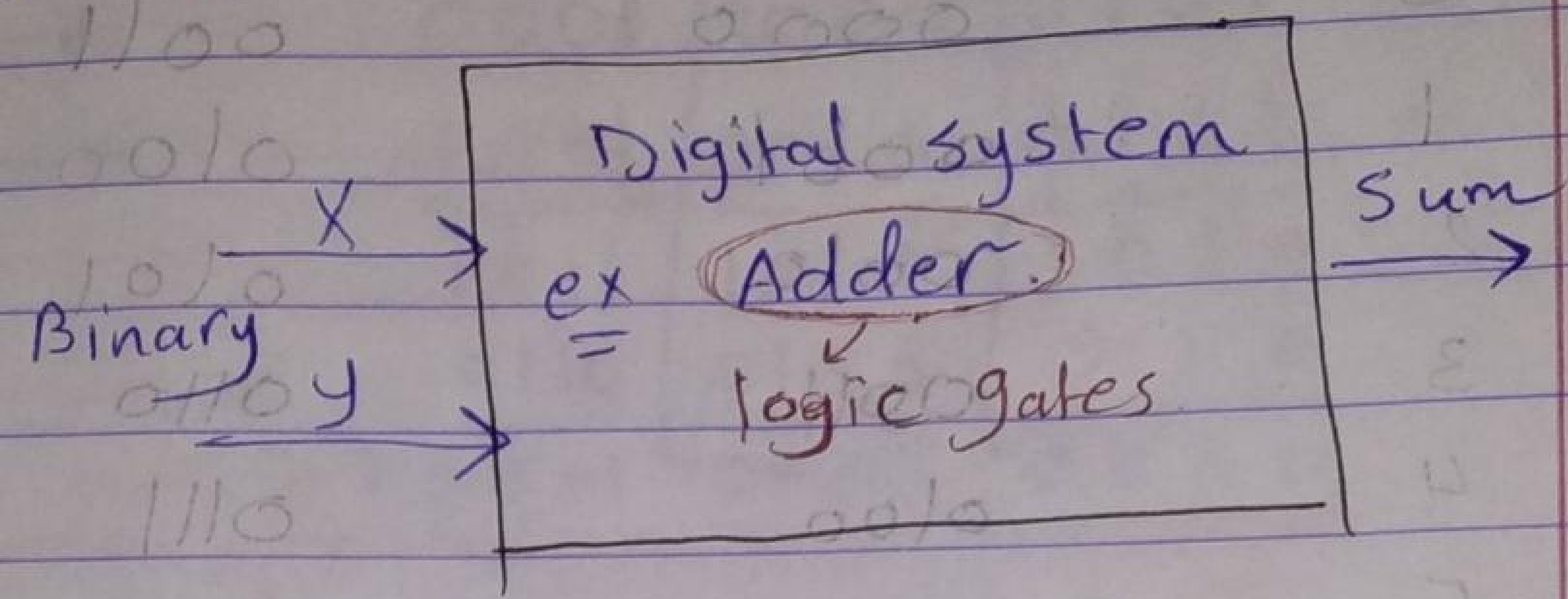
Decimal	BCD	exceis-3
0	0000	0011
1	0001	0100 ← 1+3 = 4
2	0010	0101 ← 2+3 = 5
9	1001	1100 ← 12
10	XXXX	1101 ← 13

Gray Code.

0	0000	one بتغير digit.
1	0001	
2	0011	

Binary logic gates

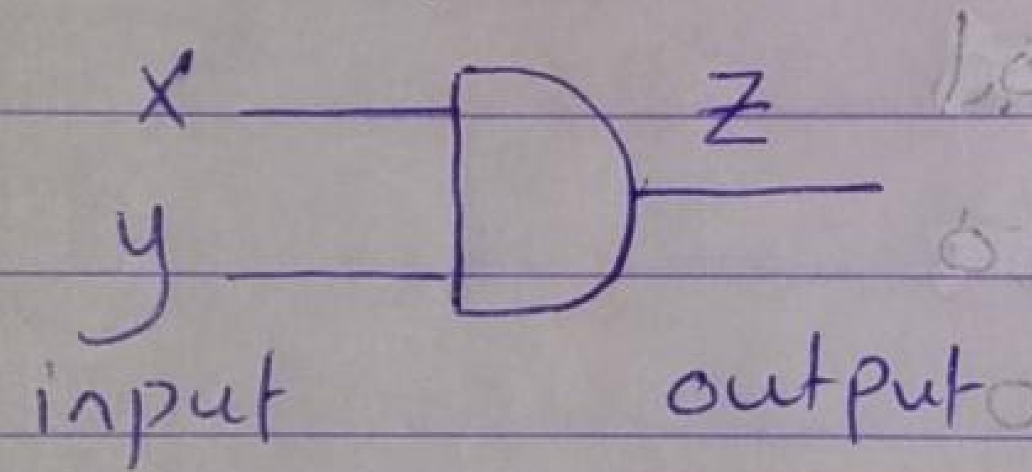
Goal



Fundamental components in

① And gate / has 2 or more inputs.

2 input



Z = X AND y

$Z = X \cdot y$

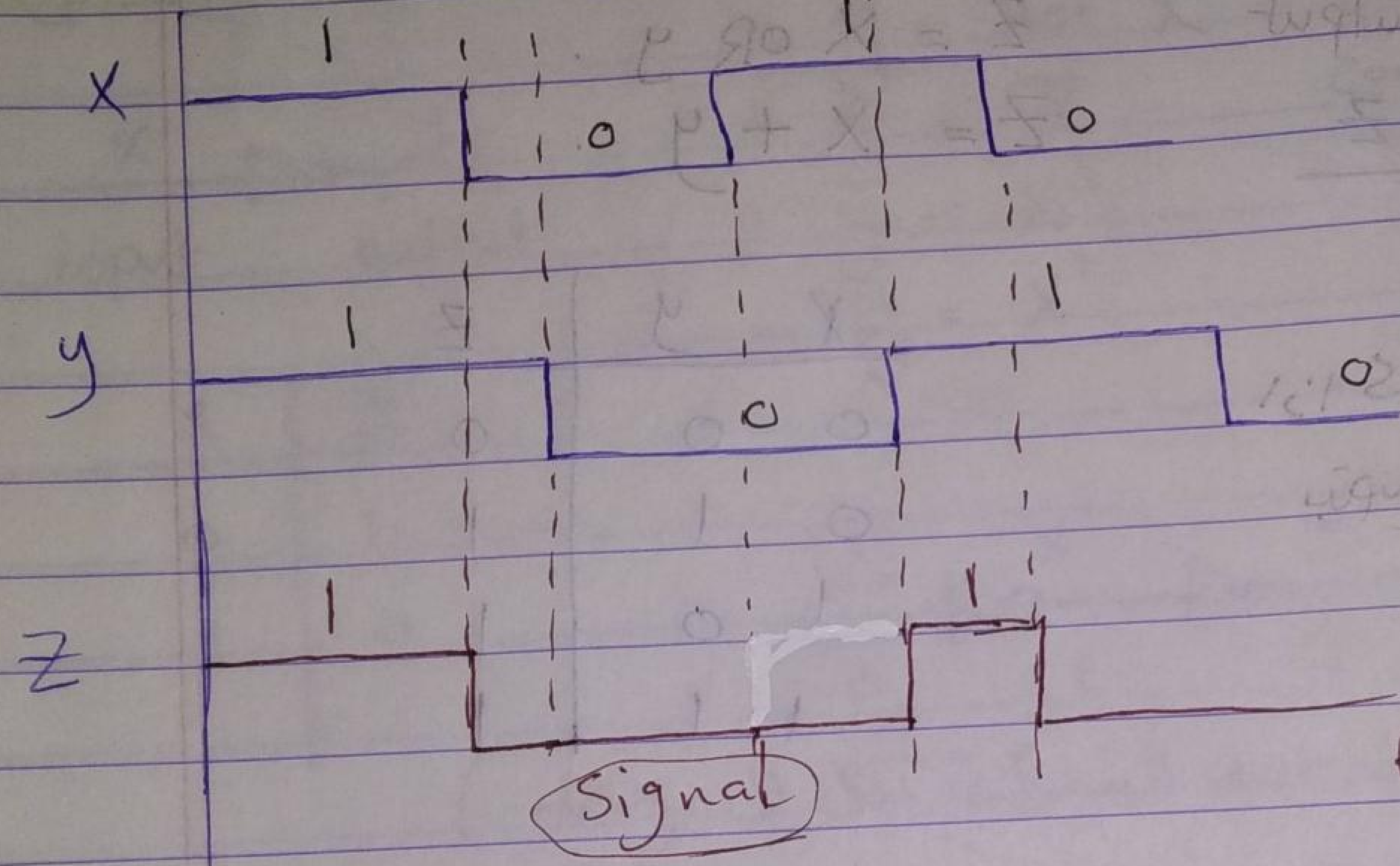
input is defined by user.

output is defined by the system.

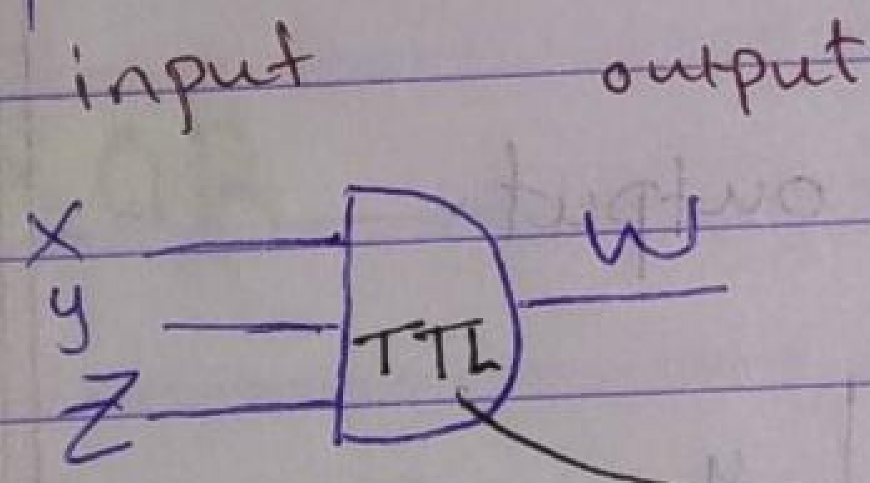
X	y	Z
0	0	0
0	1	0
1	0	0
1	1	1

Truth table.

Z equal 1 when all input equal 1.



بتساوي 1 ←
لم يكون ال
two inputs = 1



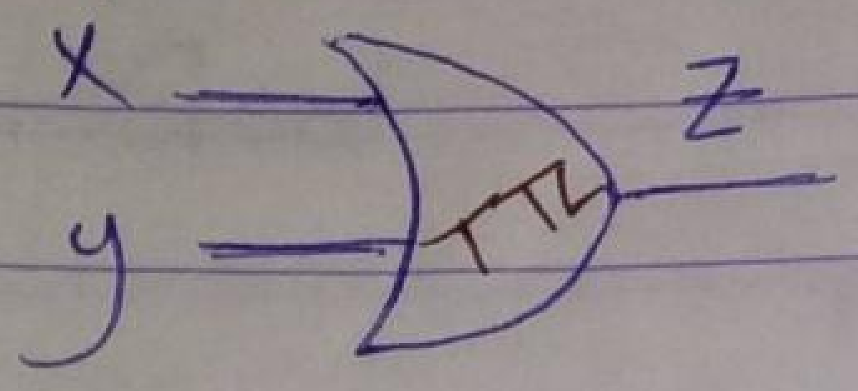
$W = X \cdot y \cdot Z$

→ Transistor– Transistor level.
group of Transistors.

x	y	Z	W
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

② OR gate

input output



$$Z = X \text{ OR } y.$$

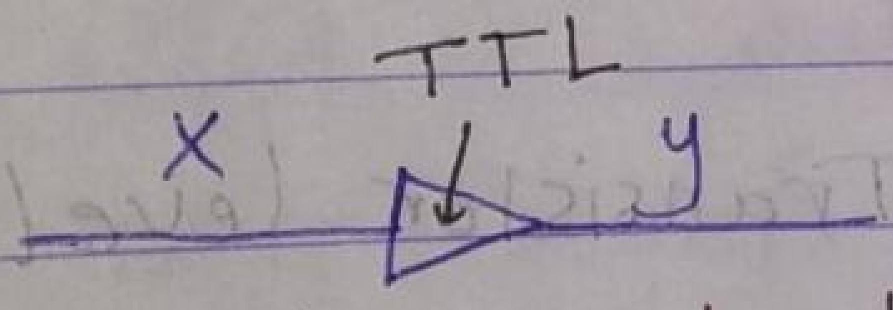
$$Z = X + y.$$

X	y	Z
0	0	0
0	1	1
1	0	1
1	1	1

اذا كلهم Zero

بتمثل open circit

③ Buffer. / one input one output.

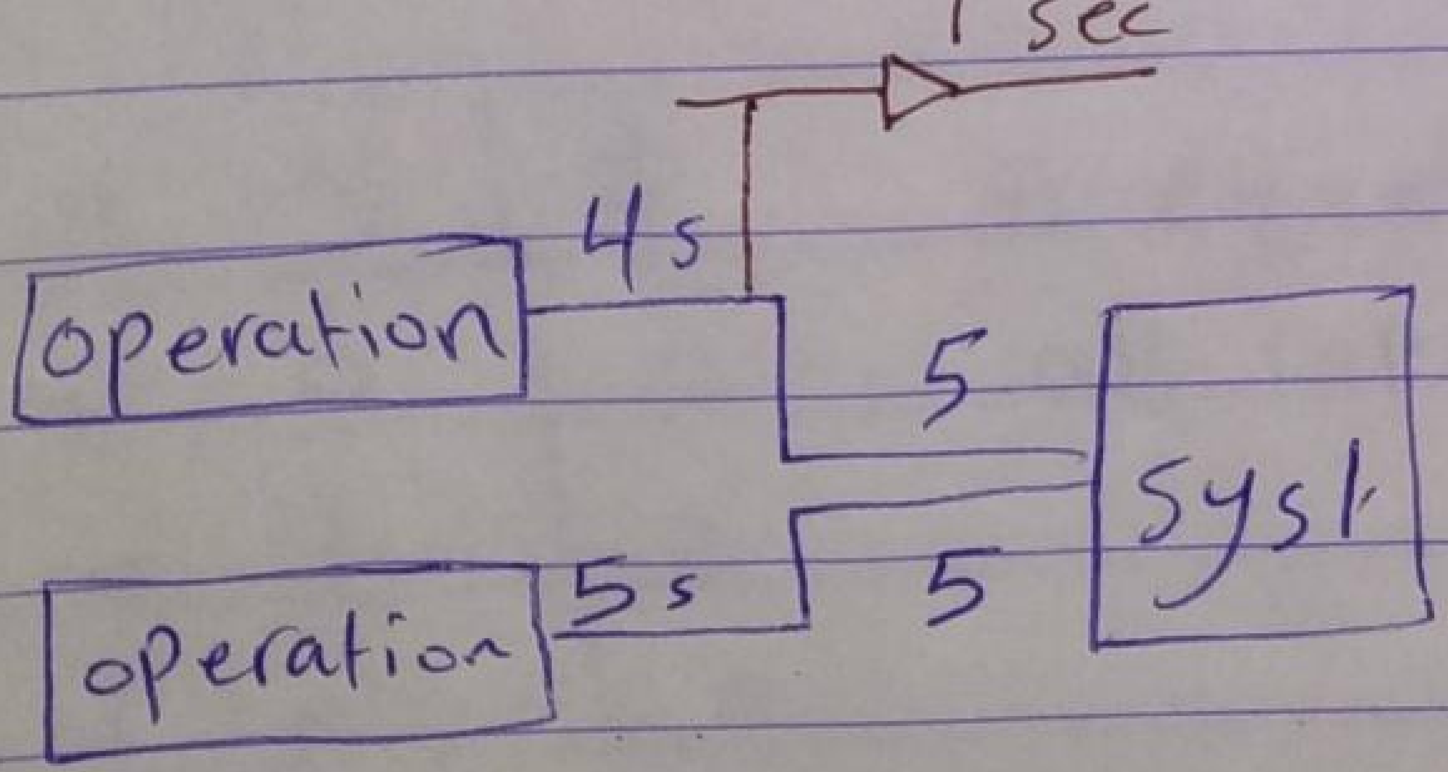


input output

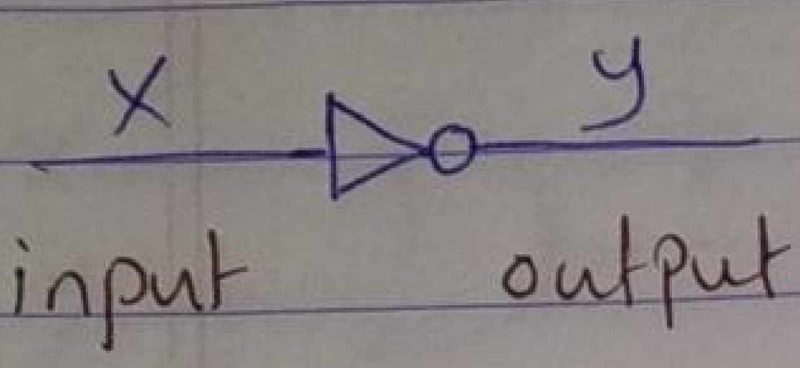
فائدتو

dely تأخير

x	y
0	0
1	1



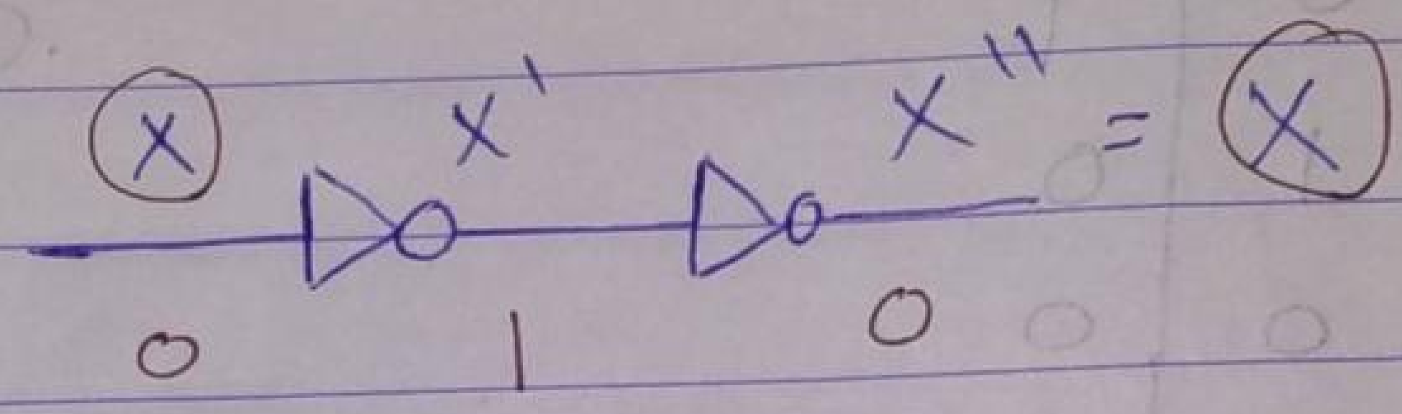
④ Inverter (not)



y = not x
$y = \overline{x}$
$y = x'$
$y = x'$

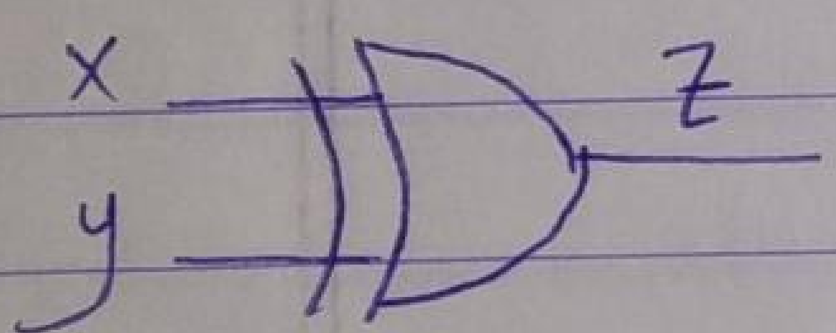
complement x
نفي x .

x	y
0	1
1	0

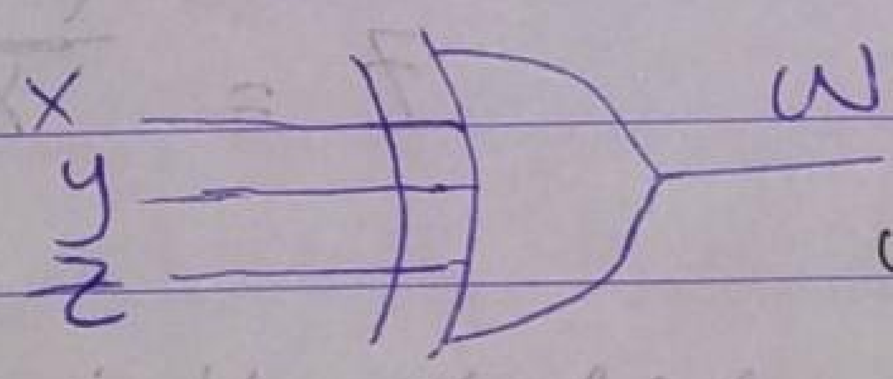


(كلما صغرنا حجم السيركت بقل ال dely .)

⑤ XOR



Z = X XOR y
$Z = X \oplus y$.



$\omega = x \oplus y \oplus z$

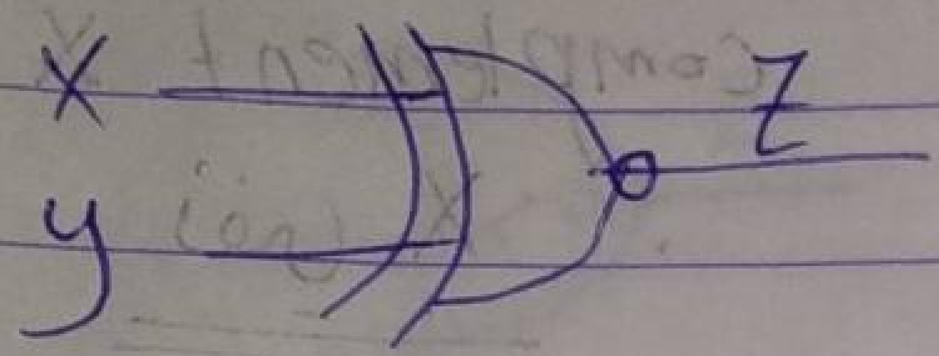
x	y	z
0	0	0
0	1	1
1	0	1
1	1	0

x	y	z	ω
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

odd Function

لم عدد الواحدات odd
بكتبوي فقط .

⑥ XNOR gate / not XOR (even)



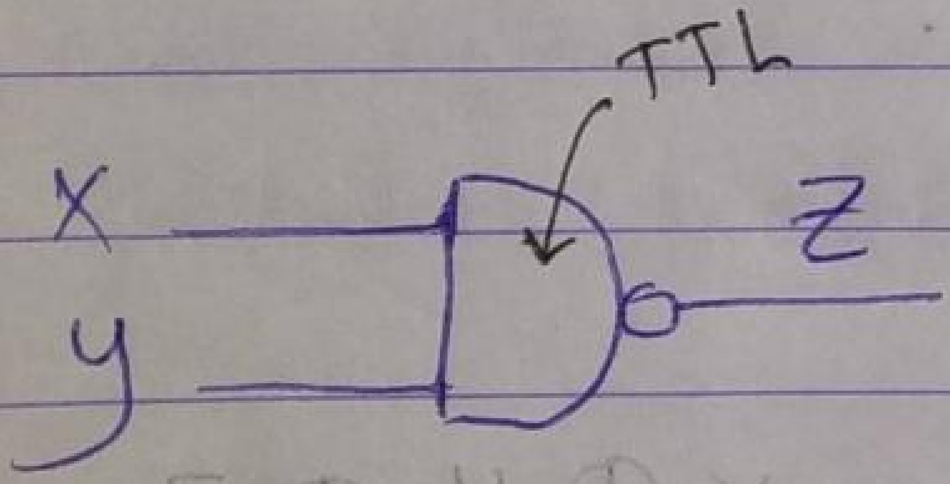
$$Z = \overline{X \oplus y}$$

$$Z = (X \oplus y)'$$

x	y	z
0	0	1
0	1	0
1	0	0
1	1	1

لما عدد الواحدات even بتحتوي.

⑦ NAND gate / Not AND



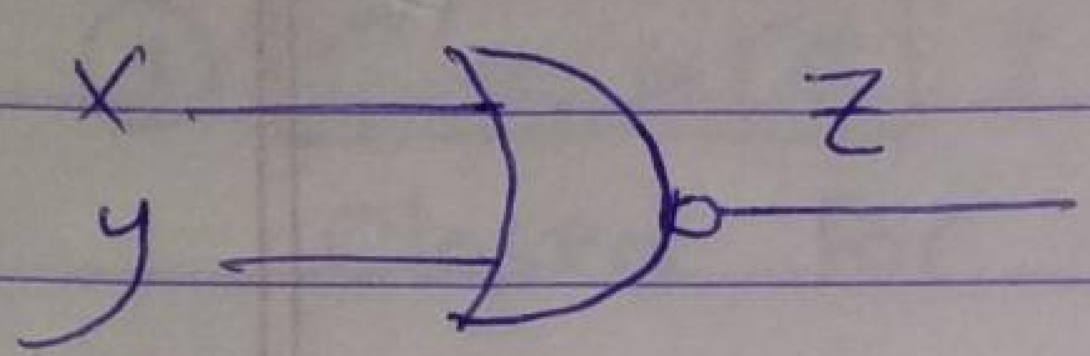
$$Z = (X \cdot y)'$$

$$Z = \overline{X \cdot y}$$

x	y	z
0	0	1
0	1	1
1	0	1
1	1	0

عدد ال transistor في ال NAND أقل من ال AND.

⑧ NOR gate / not OR.



$$z = \overline{x + y}$$

$$z = (x + y)'$$

x	y	z
0	0	1
0	1	0
1	0	0
1	1	0

Decimal	Bcd	Exess-3	Gray code
0	0000	0011	0000
1	0001	0100	0001
2	0010	0101	0011
3	0011	0110	0010
4	0100	0111	0110
5	0101	1000	
6	0110	1001	
7	0111	1010	
8	1000	1011	
9	1001	1100	
10	xxxx	1101	
11	xxxx	1110	
12	xxxx	1111	
13	xxxx	~~xxxx~~	
14	xxxx	~~xxxx~~	
15	xxxx	~~xxxx~~	

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0000
0001
0010
0011
0100
0101
0110
0111
1110
1111