Fax Brain . . .
DVD
Touchscreen
Pendrive

- Mainframe
- Micro
- Super
- PC
- Mini c

DIGITAL LOGIC

⇒ Is the study of digital pulses.

In computer, reasoning is done by logic gates.

Logic gates - high speed switches which uses transistors and diodes.

In logic gates a transistor which is used is a one acting as a switch

In switching

ON - high (1)
OFF - low (0)

0 and 1 are known as binary digits (bits)

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DIGITAL ELECTRONICS FOR COMP SCIENTIST

Date ___/___/___

Destription of logic gates is done by truth table.

Truth table - is a table consisting of truth values.

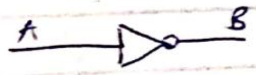
Types of logic gates

i) AND
ii) OR
iii) NOR
iv) NAND
v) Exclusive OR
vi) Exclusive NOR
vii) NOT

NOT GATE

- Inverts inputs

Symbol

input  output

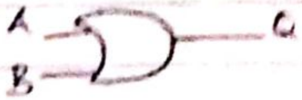
A	$\bar{A} = B$
1	0
0	1

AND GATE

$A \times B = AB = A \wedge B$

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

OR GATE ($\wedge$)



$\cancel{A * B = AB = A \wedge B}$

$A + B$

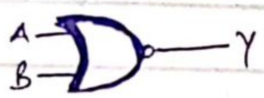
A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

NAND GATE (AND-NOT)

$Y = \overline{A \cdot B}$

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

NOR GATE (OR-NOT)



$Y = \overline{A+B}$

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

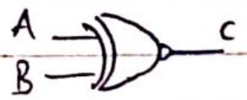
EXCLUSIVE OR GATE

$Y = \bar{A}B + A\bar{B} = A \oplus B$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

EXCLUSIVE NOR GATE

$\odot$ ExNOR



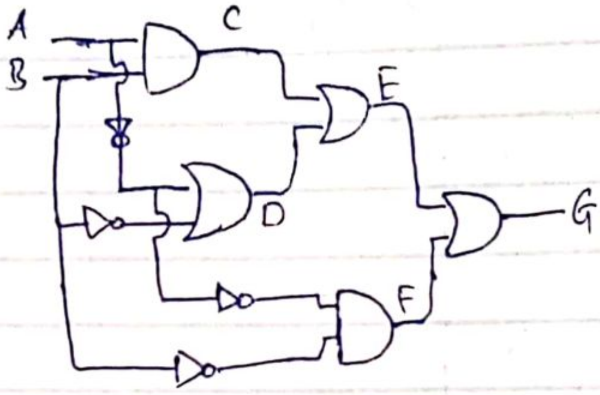
$C = A \odot B$

$\cancel{C = \overline{AB}}$

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

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

Date __/__/__

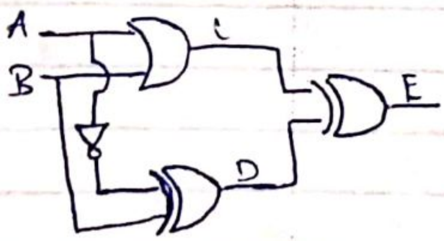


A	B	$\bar{A}$	$\bar{B}$	C	D	E	F	G
0	0	1	1	0	1	1	0	1
0	1	1	0	0	1	1	0	1
1	0	0	1	0	1	1	0	1
1	1	0	0	1	0	1	0	1

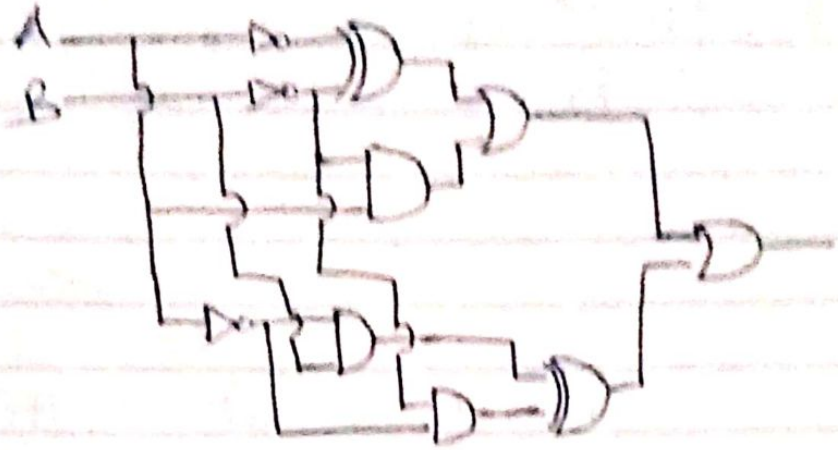
Given i) $(A \vee B) \oplus (\sim A \oplus B)$

ii) $[(\sim A \oplus B) \vee (A \wedge \sim B)] \vee [(\sim A \wedge B) \oplus (\sim A \wedge \sim B)]$

i)



ii)



Given

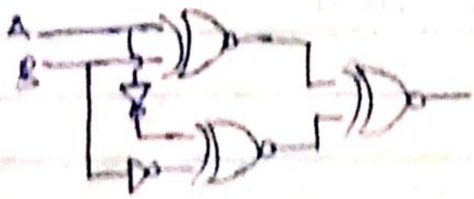
i) $(A \odot B) \ominus (\sim A \oplus \sim B)$

ii) $\sim[\sim(\sim A \vee B) \wedge (A \oplus \sim B)]$

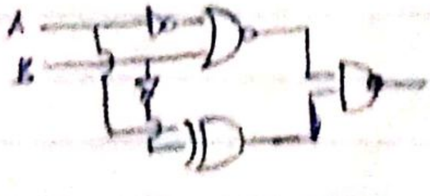
iii) $\sim[\sim(A \wedge \sim B) \oplus (\sim A \odot B)]$

Soln:

i)



ii)



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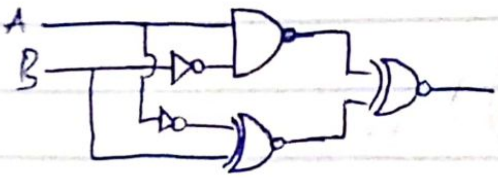

LAWS OF BOOLEAN ALGEBRA

Idempotent 1: $A \wedge A \equiv A$

$A \vee A \equiv A$

Identity 2: $A \vee 1 \equiv 1$

$A \wedge 1 \equiv A$

$A \vee 0 \equiv A$

$A \wedge 0 \equiv 0$

Commutative 3: $A \vee B \equiv B \vee A$

$A \wedge B \equiv B \wedge A$

Distributive 4: $A \vee (B \wedge C) \equiv (A \vee B) \wedge (A \vee C)$

$A \wedge (B \vee C) \equiv (A \wedge B) \vee (A \wedge C)$

Association 5: $A \vee (B \vee C) \equiv (A \vee B) \vee C$

$A \wedge (B \wedge C) \equiv (A \wedge B) \wedge C$

Complement 6: $A \vee {\sim}A \equiv 1$

$A \wedge {\sim}A \equiv 0$

Double negation 7: ${\sim}{\sim}A = A$

demorgans 8: ${\sim}(A \wedge B) \equiv {\sim}A \vee {\sim}B$

${\sim}(A \vee B) \equiv {\sim}A \wedge {\sim}B$

Absorption 9: $A \vee (A \wedge B) \equiv A$

$A \wedge (A \vee B) \equiv A$

Take 0 ≡ F
1 ≡ T

SOP & POS

SOP (Some Of Products) – for high output
POS (Product Of Sum) – for low output

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

Using SOP

$$(\sim A \cdot B \cdot C) + (A \cdot \sim B \cdot C) + (A \cdot B \cdot \sim C)$$

$$\left[((\sim A \cdot B) \cdot C) + ((A \cdot \sim B) \cdot C)\right] + ((A \cdot B) \cdot \sim C)$$

$$\left[C \cdot ((\sim A \cdot B) + (A \cdot B))\right] + ((A \cdot B) \cdot \sim C)$$

$$C \cdot ((\sim A \cdot B) + (A \cdot \sim B))]$$

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DATA PRESENTATION

Binary - are two digits which are represented in terms of HIGH (1) and LOW (0) which are intermsof arithmetic

Binary operations are centred in addition and multiplication

ADDITION OF BINARY DIGITS (BITS)

High + High = High & Low

eg High + Low = Low

eg:

a)
```
  110
+  11
 ----
 1001
```

b)
```
  11100
   1110
 ------
 101010
```

c)
```
  111110
+   1111
 -------
 1001101
```

d)
```
  11110101
   1110011
 ----------
 1001100000
```

BINARY MULTIPLICATION

$0 \times 1 = 0$

$1 \times 1 = 1$

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eg.
```
    1110
  x  111
  ------
    1110
   1110
+ 1110
  ------
 1100010
```

```
0 - 0 = 0
1 - 0 = 1
1 - 1 = 0
10 - 1 = 1
```

```
 11101
  1111
 -----
  1110
```

BINARY CONVERSION

1. Binary to decimal (vice versa)
2. Binary to hexadecimal
3. Binary to octal
4. BCD (Binary Coded decimal)
5. Gray code
6. Complement (1's, 2's)

Binary - 2
Dec - base 10
Oct - 8

BINARY TO DECIMAL

Date __/__/__

Convert to decimal

a) $11101.11011 = 1\times2^4 + 1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 +$
$+ 1\times2^{-2} + 0\times2^{-3} + 1\times2^{-4} + 1\times2^{-5}$

$=$

b) 11.001111

DECIMAL TO BINARY

- Repeating divide by two until the last digit or remainder is zero

Least significant binary number is obtained from the first remainder

Most significant binary number is obtained for the last remainder.

Example

a) 5_{10}

$\frac{15}{2} = 2$ rem 1 (LSB)

$\frac{12}{2} = 1$ rem 0

$\frac{1}{2} = 0$ rem $\underline{1}$ (MSB)

$\therefore 5_{10} = \underline{101}_2$

b) 7_{10}

$\frac{7}{2} = 3$ rem 1 (LSB)

$\frac{3}{2} = 1$ rem 1

$\frac{1}{2} = 0$ rem 1 (MSB)

$7_{10} = \underline{111}_2$

c) 15_{10}

$\frac{15}{2} = 7$ rem 1 (LSB)

$\frac{7}{2} = 3$ rem 1

$\frac{3}{2} = 1$ rem 1

$\frac{1}{2} = 0$ rem 1 (MSB)

$15_{10} = 1111_2$

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Date __/__/__

d) 45_{10}.

$\frac{45}{2} = 22$ rem 1 (LSB)

$\frac{22}{2} = 11$ rem 0

$\frac{11}{2} = 5$ rem 1

$\frac{5}{2} = 2$ rem 1

$\frac{2}{2} = 1$ rem 0

$\frac{1}{2} = 0$ rem 1 (MSB)

$45_{10} = 101101_2$

e) 165_{10}

$\frac{165}{2} = 82$ rem 1

$\frac{82}{2} = 41$ rem 0

$\frac{41}{2} = 20$ rem 1

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$\frac{20}{2} = 10$ rem 0

$\frac{10}{2} = 5$ rem 0

$\frac{5}{2} = 2$ rem 1

$\frac{2}{2} = 1$ rem 0

$\frac{1}{2} = 0$ rem 1

$165_{10} = 10100101_2$

f) 0.375_{10}

MSB

$= 0.375 \times 2 = 0.75$

$= 0.75 \times 2 = 1.5$

$= 0.5 \times 2 = 1.0$

$= 0.0 \times 2 = 0.0$

LSB

$0.375_{10} = 011_2$

g) 512.375_{10}

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Date ___/___/___

$\frac{512}{2} = 256$ rem 0

$\frac{256}{2} = 128$ rem 0

$\frac{128}{2} = 64$ rem 0

$\frac{64}{2} = 32$ rem 0

$\frac{32}{2} = 16$ rem 0

$\frac{16}{2} = 8$ rem 0

$\frac{8}{2} = 4$ rem 0

$\frac{4}{2} = 2$ rem 0

$\frac{2}{2} = 1$ rem 0

$\frac{1}{2} = 0$ rem 1

$0.375_{10} = 011$

$512_{10} = 1000000000$

$512.375_{10} = 1000000000.011$

$0.\dot{3}3$

$0.33 \times 2 = 0.66$

$0.66 \times 2 = 1.32$

$0.32 \times 2 = 0.64$

$0.64 \times 2 = 1.28$

$0.28 \times 2 = 0.56$

$0.56 \times 2 = 1.12$

HEXADECIMAL TO BINARY

Hexadecimal, a group of four bits ie 0.0000
Hexadecimal is alwys in base 16

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

Date ___/___

Convert Hex into B

a) $28AF_{16}$
b) $1ABE_{16}$
c) $F018_{16}$

Soln

a)
2 8 A F
0010 1000 1010 1111

$28AF_{16} = 0010100010101111_2$

b)
1 A B E
0001 1010 1011 1110

$1ABE_{16} = 0001101010111110_2$

c) $F018_{16}$

F 0 1 8
1111 0000 0001 1000

$F018_{16} = 1111000000011000$

BINARY TO HEXADECIMAL.

eg

a) 110001110_2

$= \underset{1}{0001} \mid \underset{8}{1000} \mid \underset{E}{1110}$

$= 110001110_2 = 18E_{16}$

b) 1111001100111001_2

$= \underset{F}{1111} \mid \underset{3}{0011} \mid \underset{3}{0011} \mid \underset{9}{1001}$

$\Rightarrow 1111001100111001_2 = F339$

HEXAD - DECIMAL

eg $18E_{16}$

soln;

$\overset{}{\underset{2\,1\,0}{18E}}_{16} = 1 \times 16^2 + 8 \times 16^1 + 14 \times 16^0$

$18E_{16} = 398_{10}$

Date ___/___/___

b) $3EA2F1_{16}$

$= 3\times16^5 + 14\times16^4 + 10\times16^3 + 2\times16^2 + 15\times16$

$=$

OCTAL TO BINARY

Octal numbers contains only 3 bits

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

Convert to binary

a) 376_8 $= 011111110_2$

b) 407_8 $= 100000111_2$

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Convert binary to octal

a) $1111001100110_2 = 17146_8$

OCTAL TO DECIMAL

a) 146_8

$= 1\times8^2 + 4\times8^1 + 6\times8^0$

$146_8 = 102_{10}$

Convert 102_{10} $\xrightarrow{\text{Binary}}$ to octal ~~then~~ and to hexa

102_{10}

$\frac{102}{2} = 51$ rem 0

$\frac{51}{2} = 25$ rem 1

$\frac{25}{2} = 12$ rem 1

$\frac{12}{2} = 6$ rem 0

$\frac{6}{2} = 3$ rem 0

$\frac{3}{2} = 1$ rem 1

$\frac{1}{2} = 0$ rem 1

$102_{10} = 1100110_2$

$001|100|110_2 = 146_8$

$0110|0110_2 = 66_{16}$

Date __/__/__

1s COMPLEMENT

- Inversion of binary digits

eg

Find ones complement

a) 11100 → 00011

b) 101011 → 010100

2s COMPLEMENT

Addition of high to one's complement

eg

a) 11101 → 00010 → 00011

b) 0011100110 → 1100011001 → 1100011010

* ## BINARY CODED DECIMAL (BCD)

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

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Convert the following to Binary

a) 8924 $= 1000100100100100_2$

b) 124 $= 000100100100_2$

c) 2567 =

Convert binary to BCD

a) 1001100100100100_2 = 9924

GRAY CODE

- Help in discarding
- Are unweighted ie has no base
- Unweighted code which help in discarding the part in an ALU
- This help in ALU if the bits are overweighted

<u>Conversion from binary to Gray Code</u>

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$XY\bar{Z} + XWY + \bar{W}YZ$

$XY.\bar{Z}.1 + XWY.1 + \bar{W}YZ.1$

$X.Y.\bar{Z}.(W+\bar{W}) + XWY(Z+\bar{Z}) + \bar{W}YZ.(X+\bar{X})$

$XY\bar{Z}W + XY\bar{Z}\bar{W} + XWYZ + XWY\bar{Z} + \bar{W}YZX + \bar{W}YZ\bar{X}$

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

NIBBLES

- Is a group of four bits

eg

1 nibble = 0101

Nibble = Nybble

Byte - is a group of two concecutive nibbles or
- is a group of eight bits

1 Kilobyte = 2^{10} Bytes = 1024 bytes

ABbreviations

Nibble	Nibbles
Byte	B
Kilobyte	KB
Megabyte	MB
Gigabyte	GB
Terabyte	TB

Eg

Convert 36 GB to B

$= 36 \times 2^{10} \times 2^{10} \times 10^{10}$

$= 3.865 \times 10^{10}$ B

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Date ___/___/___

Convert 256 TB to i) KB ii) MB iii) B

i) $256TB = 256 \times \cancel{10}\ 2^{30} KB$

ii) $256TB = 256 \times 2^{20} MB$

iii) $256 TB = 256 \times 2^{40} B$

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MEMORY SYSTEM

Byte is unit of storage of ~~memory~~ computer

i) Primary storage is nearby processors
- are always volatile
- are very fast

Performace of the processor depends on the location of a memory

Types of memory
- Main memory (primary)
- Secondary memory

Main memory - are volatile memory in which the data lost when power is switched off
eg. Registers, Cache, RAM

Components of of memory system
i) Main memory
ii) Secondary memory

Problems with the memory system

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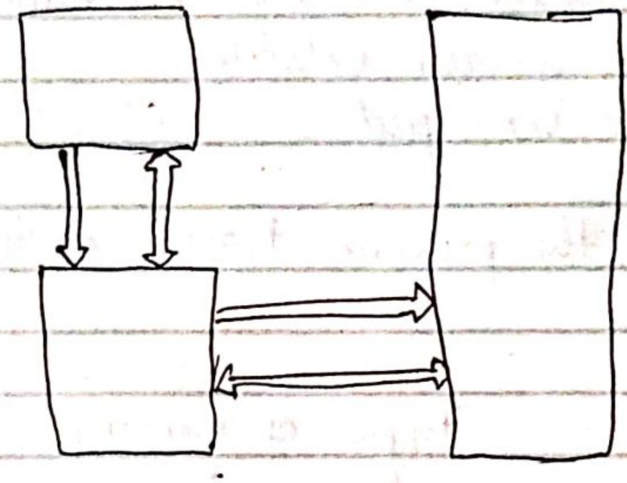
Access time | Excution time

Unified cache ⟨ Instruction, Data

Split cache ('Havard cache)



Miss rate = $\frac{\text{No of misses}}{\text{total no of accesses}}$

total no of access = No of hits + No misses

Hit rate = $\frac{\text{No of hits}}{\text{total no of access}}$

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One line in a catche is equal to 4 B

$8KB = 8 \times 2^{10}$ Bytes

$1 \text{ line} = 4B$
$\quad X \quad = 8 \times 2^{10} B$

$X = 2^{11}$ lines

Replacement Algorithm
→ to accomodate as many info as possible

- Random replacement
- Least recently used (LRU)
- First in - First Out (FIFO)
- Least frequently used (LFU)

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