Digital Electronics Fundamentals

Binary number System

- It is a positional weighted system.
- base or radix of this no. system is 2.
- Hence it has 2 independent symbols (0 & 1)
- A binary digit is called as a bit

Decimal no.	Binary no.	Decimal no.	Binary no.
0	0	9	1001
1	1	10	1010
2	10	11	1011
3	11	12	1100
4	100	13	1101
5	101	14	1110
6	110	15	1111
7	111		
8	1000		

Binary to decimal Conversion

$(10101)_2$ to decimal.

(a) $(10101)_2 = (1\times2^4) + (0\times2^3) + (1\times2^2) + (0\times2^1) + (1\times2^0)$

$= 16 + 0 + 4 + 0 + 1 = (21)_{10}$

(b) $(11011.101)_2 = (1\times2^4) + (1\times2^3) + (0\times2^2) + (1\times2^1) + (1\times2^0)$
$+ (1\times2^{-1}) + (0\times2^{-2}) + (1\times2^{-3})$

$= (16 + 8 + 0 + 2 + 1) + (0.5 + 0 + 0.125)$

$= (27.625)_{10}$.

Decimal to binary conversion

a) Convert $(163.875)_{10}$ to binary.

Ans: The given no. is a mixed no. we therefore convert its integer and fraction parts separately.

(4) The integer part is $(163)_{10}$

	Remainder
2 | 163	1
2 | 81	1
2 | 40	0
2 | 20	0
2 | 10	0
2 | 5	1
2 | 2	0
2 | 1	1
0	

$(163)_{10} = (10100011)_2$

Conversion of $(0.875)_{10}$

Given fraction

	0.875
0.875×2	1.75
0.75×2	1.5
0.5×2	1.0

$\therefore (163.875)_{10} = (10100011.111)_2$

Binary addition

$0 + 0 = 0$

$0 + 1 = 1$

$1 + 0 = 1$

$1 + 1 = 10$ 0 with a carry of 1

Ex. Add the binary numbers 1010 and 111

Solution

$$\begin{array}{r} {}^{1}\,{}^{1}\quad\; \\ 1010 \\ 111 \\ \hline 10001 \end{array}$$

Ex: 2 Add the binary numbers 1101.101 and 111.011

$$
\begin{array}{r}
1101.101 \\
111.011 \\
\hline
10101.000 \\
\hline
\end{array}
$$

Binary subtraction

$0 - 0 = 0$

$1 - 1 = 0$

$1 - 0 = 1$

$0 - 1 = 1$, with a borrow of 1.

Ex: Subtract 10_2 from 1000_2

8	4	2	1	- Column numbers
1	0	0	0	
		1	0	
0	1	1	0	

Ex: $(111.111)_2$ from $(1010.01)_2$

8	4	2	1	.	2^{-1}	2^{-2}	2^{-3}	- Column no
1	0	1	0	.	0	1	0	
	1	1	1	.	1	1	1	
0	0	1	0	.	0	1	1	

Binary multiplication

$0 \times 0 = 0$

$1 \times 1 = 1$

$1 \times 0 = 0$

$0 \times 1 = 0$

Ex 1. Multiply $(1101)_2$ by $(110)_2$

```
      1 1 0 1
  ×     1 1 0
  -------------
      0 0 0 0
    1 1 0 1
  1 1 0 1
  1
  -------------
1 0 0 1 1 1 0
```

Ex 2 Multiply $(1011.101)_2$ by $(101.01)_2$

```
                1 0 1 1 . 1 0 1
              ×     1 0 1 . 0 1 0
              ---------------------
                0 0 0 0 0 0 0
              1 0 1 1 1 0 1
            0 0 0 0 0 0 0
          1 0 1 1 1 0 1
        0 0 0 0 0 0 0
      1 0 1 1 1 0 1
        1 1 10 1 10 1 1
  ---------------------------------
  1 1 1 1 0 1 0 . 0 0 0 1 0
```

```
  1 1
  1 1
  -----
1 0 0
```

Binary division

Ex: Divide $(101101)_2$ by $(110)_2$

```
110 ) 1 0 1 1 0 1 ( 111.1
      1 1 0
      -----------
      1 0 1 0
        1 1 0
      -----------
        1 0 0 1
          1 1 0
        ---------
          0 1 1 0
            1 1 0
          -------
              ×
```

Ex: Divide $(110101.11)_2$ by $(101)_2$

```
101 ) 1 1 0 1 0 1 . 1 1 ( 1010.11
      1 0 1
      ---------
      0 0 1 1 0
          1 0 1
      ---------
          0 0 1 1 1
              1 0 1
          ---------
              0 1 0 1
                1 0 1
              -------
                  ×
```

The octal number system

- The octal number system was extensively used by early mini computers. It is also a positional weighted system.
- Its base or radix is 8.
- It has 8 independent symbols

0, 1, 2, 3, 4, 5, 6, 7.

- Since its base $8 = 2^3$, every 3 bit group of binary can be represented by an octal digit

Ex: Convert $(367.52)_8$ to binary

Ans: Replace each octal digit by its 3-bit binary equivalent.

3	6	7	.	5	2
011	110	111		101	010

$\Rightarrow (367.52)_8 = (011110111.101010)_2$

Ex: Convert $(110101.101010)_2$ to octal.

Group of 3 bits are 110 101 . 101 010
6 5 5 2.

$\therefore (110101.101010)_2 = (65.52)_8$

Ex: $(10101111001.0111)_2$ to octal.

Sln: Groups of 3 bits are.

010 101 111 001 . 011 100
2 5 7 1 3 4

$\therefore (10101111001.0111)_2 = (2571.34)_8$

Octal to decimal Conversion

$(4057.06)_8 = 4\times8^3 + 0\times8^2 + 5\times8^1 + 7\times8^0$
$+ 0\times8^{-1} + 6\times8^{-2}$

$= 2048 + 0 + 40 + 7 + 0 + 0.0937$.

$= (2095.0937)_{10}$.

Decimal to octal

Convert $(378.93)_{10}$ to octal.

$$\begin{array}{r|l l}
8 & 378 & \\
8 & 47 & 2 \\
 & 5 & 7 \\
 & 0 & 5
\end{array}$$

$0.93\times8 = 7.44$
$0.44\times8 = 3.52$
$0.52\times8 = 4.16$
$0.16\times8 = 1.28$

$(378.93)_{10} = (572.7341)_8$

Ex: Convert $(5497)_{10}$ to binary.

An: Since the given no. is large, we first convert this no. to octal and then convert the octal to binary.

$$\begin{array}{r|l l}
8 & 5497 & \\
8 & 687 & 1 \\
8 & 85 & 7 \\
8 & 10 & 5 \\
8 & 1 & 2 \\
 & 0 & 1
\end{array}$$

$\therefore (5497)_{10} = (12571)_8$

Now
$1 = 001$
$2 = 010$
$5 = 101$
$7 = 111$
$1 = 001$

$\therefore (12571)_8 = (001010101111001)_2$

Ex: Convert $(101111010001)_2$ to decimal.

Sm $(101111010001)_2 = (5721)_8$

$= 5 \times 8^3 + 7 \times 8^2 + 2 \times 8^1 + 1 \times 8^0$

$= 2560 + 448 + 16 + 1 = (3025)_{10}$

The Hexadecimal number System

Binary nos are long. & are too lengthy to be handled by human beings. So there is a need to represent the binary nos. concisely. With this objective, one no. system developed. i.e Hexadecimal no. system.

→ This system is a positional - weighted system.

→ The base of this system is 16.

→ The symbols used are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

→ Since its base is $16 = 2^4$, every 4 binary digit combination can be represented by one hexadecimal digit.

→ A 4 bit group is called a nibble.

→ Since computer words come in 8-bit, 16-bits, 32 bits & so on, i.e multiples of 4 bits, they can be easily represented in hexadecimal.

→ This system is useful for human comm with computers.

Binary to hexadecimal Conversion

Hexadecimal	Binary	Hexadecimal	Binary
		8	1 0 0 0
0	0 0 0 0	9	1 0 0 1
1	0 0 0 1	10-A	1 0 1 0
		11-B	1 0 1 1
2	0 0 1 0	12-C	1 1 0 0
3	0 0 1 1	13-D	1 1 0 1
4	0 1 0 0	14-E	1 1 1 0
5	0 1 0 1	15-F	1 1 1 1
6	0 1 1 0		
7	0 1 1 1		

Ex: Convert $(1011011011)_2$ to hexadecimal.

Sln

1 0 1 1 0 1 1 0 1 1 — Make group of 4 bits

0010	1101	1011
2	D	B.

$\therefore (1011\,011\,011)_2 = (2DB)_{16}$

Ex: Convert $(01011111011.011111)_2$ to hexadecimal.

Sln 0 1 0 1 1 1 1 1 0 1 1 . 0 1 1 1 1 1

0010	1111	1011	.	0111	1100
2	F	B		7	C.

Ans: $(2FB.7C)_{16}$

Hexadecimal to binary

Ex: Convert $(4BAC)_{16}$ to binary

Sln

A	B	A	C
0100	1011	1010	1100

$\therefore$ The result is $(0100\,1011\,1010\,1100)_2$

Ex: Convert $(3A9E.B0D)_{16}$ to Binary.

Sln

3	A	9	E	.	B	0	D
0011	1010	1001	1110	.	1011	0000	1101

$\therefore$ Result is $(11101010011110.101100001101)_2$

Hexadecimal to Decimal

Ex: Convert $(5C7)_{16}$ to decimal

Sln $(5C7)_{16} = 5 \times 16^2 + 12 \times 16^1 + 7 \times 16^0$

$= 1280 + 192 + 7 = (1479)_{10}$.

Ex: Convert $(A0F9.0EB)_{16}$ to decimal.

Sln $= 10 \times 16^3 + 0 \times 16^2 + 15 \times 16^1 + 9 \times 16^0 + 0 \times 16^{-1}$

$+ 14 \times 16^{-2} + 11 \times 16^{-3}$.

$= 40960 + 0 + 240 + 9 + 0 + 0.0546 + 0.0026$

$= (41209.0572)_{10}$

Decimal to Hexadecimal

Ex: Convert $(2598.675)_{10}$ to hexadecimal.

Sln

Division	Remainder Decimal	Remainder hex
16 | 2598		
16 | 162	6	6
16 | 10	2	2
0	10	A

Conversion of $(0.675)_{10}$

$0.675 \times 16 = 10.8$

$.8 \times 16 = 12.8$

$.8 \times 16 = 12.8$

$.8 \times 16 = 12.8$

$\therefore (2598.675)_{10} = (A26.ACCC)_{16}$.

Ex: Convert $(49056)_{10}$ to binary

Sln Successive division

$$16\,\underline{|\,49056}$$
$$16\,\underline{|\,3066}$$
$$16\,\underline{|\,191}$$
$$16\,\underline{|\,11}$$
$$0$$

Remainder Decimal	Remainder Hex	Binary group
0	0	0000
10	A	1010
15	F	1111
11	B	1011

$\therefore (49056)_{10} = (BFA0)_{16} = (1011\,1111\,1010\,0000)_2$

Ex: Convert $(1011011101101110)_2$ to decimal.

Sln

1011 0111 0110 1110

B 7 6 E

$\therefore (1011\,0111\,0110\,1110)_2 = (B76E)_{16}$

$= 11\times16^3 + 7\times16^2 + 6\times16^1 + 14\times16^0$

$= 45056 + 1792 + 96 + 14$

$= (46958)_{10}$

Octal to hexadecimal Conversion

To convert an octal number to hexadecimal, the simplest way is to first convert to binary and then the binary to hexadecimal.

Ex: Convert $(756.603)_8$ to hex

Sln

7 5 6 6 0 3 — octal

111 101 110 110 000 011

0001 1110 1110 . 1100 0001 1000

1 E E . C 1 8

Ans: $(1EE.C18)_{16}$.

Hexadecimal to Octal

~~Convert~~ To Convert a hexadecimal number to octal, the simplest way is to first convert the given hexadecimal number to binary and then the binary to octal.

Ex: Convert $(B9F.AE)_{16}$ to octal.

Sln.

B	9	F	.	A	E
11		15		10	14
1011	1001	1111	.	1010	1110

$\underline{101}\,\underline{110}\,\underline{011}\,\underline{111} \cdot \underline{101}\,\underline{011}\,\underline{100}$

$(5637.534)_8$

1's and 2's Complement

→ If the number is positive, the magnitude is represented in its true binary form and a sign bit 0 is placed in front of the MSB (Most significant bit) i.e left most bit.

→ If the number is negative, the magnitude is represented in its 2's (or 1's) complement form and a sign bit 1 is placed in front of the MSB.

Ex: Find 1's complement + 2's complement of 7.

Sln Binary representation of 7 = 111

1's complement = 000

2's complement = 000
$+1$

$\overline{001}$.

→ To get 1's complement of a binary number, simply invert the given number.

→ To get 2's complement of a binary number, simply invert the given number and add 1 to the least significant bit (LSB) of given result.

→ In 1's complement replace 0 with 1 & 1 with 0.

ex: 1's complement of 1011 is 0100

2's complement of 1011 is 0100 + 1

i.e 0101.

Ex: +51 in sign magnitude form

$$\begin{array}{r|l l} 2 & 51 & \\ 2 & 25 & 1 \\ 2 & 12 & 1 \\ 2 & 6 & 0 \\ 2 & 3 & 0 \\ 2 & 1 & 1 \\ & 0 & 1 \end{array}$$

$(51)_{10} = (110011)_2$

+51 = | 0 | 1 | 1 | 0 | 0 | 1 | 1 | in sign mag. form

Sign bit

−51 = | 1 | 1 | 1 | 0 | 0 | 1 | 1 | in sign. mag. form.

Sign bit

−51 (in 1's ~~magnitude~~ complement form) = | 1 | 0 | 0 | 1 | 1 | 0 | 0 |

−51 (in 2's complement form) = | 1 | 0 | 0 | 1 | 1 | 0 | 1 |

Ex: Each of the following numbers is a signed binary number. Determine the decimal value in each case, if they are in (i) sign magnitude form (ii) 2's complement form, and (iii) 1's complement form.

Sln.	Given number	Sign mag. form	2's complement form	1's complement form
(a)	01101	+13		
(b)	010111	+23		
(c)	10111	−7		
(d)	1101010	−42		

(a) 0|1101 = +13 in sign mag. form

0010 = 2 1's complement

+1

0011 = 3 2's complement

(b) 0|10111 = +23 in sign mag. form

01000 = 8 1's complement

+1

1001 = 9 2's complement

(c) 1|0111 = −7 in sign mag form

1000 = −8 in 1's complement form

+1 = −9 in 2's complement form

1001

(d) 1|101010 = −42 in sign mag. form

010101 = −21 in 1's complement form

+1

10110 = −22 in 2's complement form.

Axioms and Laws of Boolean Algebra.

There are some sets of logical expressions which we accept as true and upon which we can build a set of useful theorems. These sets of logical expressions are known as Axioms or postulates of Boolean Algebra.

An axiom is nothing more than the definition of three basic logic operations (AND, OR & NOT)

All axioms defined in boolean algebra are the results of an operation that is performed by a logical gate.

Axiom 1: $0 \cdot 0 = 0$

2: $0 \cdot 1 = 0$

3: $1 \cdot 0 = 0$

4: $1 \cdot 1 = 1$

5: $0 + 0 = 0$

Axiom 6: $0 + 1 = 1$

7: $1 + 0 = 1$

8: $1 + 1 = 1$

9: $\bar{0} = 1$

10: $\bar{1} = 0$

Based on these axioms, we can conclude many laws of Boolean Algebra which are listed below.

Complementation Law

→ If $A = 0$ then $\bar{A} = 1$

→ $A = 1$ then $\bar{A} = 0$

→ $\bar{\bar{A}} = A$

AND law

$A \cdot 0 = 0$

$A \cdot 1 = A$

$A \cdot A = A$

$A \cdot \bar{A} = 0$

OR Law

$A + 0 = A$

$A + 1 = 1$

$A + A = A$

$A + \bar{A} = 0$

Commutative Laws

$$A + B = B + A$$

$$A \cdot B = B \cdot A$$

Associative Laws

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

$$(A \cdot B) \cdot C = A \cdot (B \cdot C)$$

Distributive Laws

$$A (B + C) = AB + AC$$

$$A + BC = (A + B) \cdot (A + C)$$

Idempotence Law

$$A \cdot A = A$$

$$A + A = A$$

Complementation Law or Negation Laws

$$A \cdot \bar{A} = 0$$

$$A + \bar{A} = 1$$

Identity Laws

$$A \cdot 1 = A$$

$$A + 1 = 1$$

Null Law

$$A \cdot 0 = 0$$

$$A + 0 = A$$

Absorption law

$$A + A \cdot B = A$$

$$A(A+B) = A$$

Consensus Theorem

Theorem 1: $AB + \bar{A}C + BC = AB + \bar{A}C$

Proof:

$$
\begin{aligned}
LHS &= AB + \bar{A}C + BC \\
&= AB + \bar{A}C + BC(A+\bar{A}) \\
&= AB + \bar{A}C + BCA + BC\bar{A} \\
&= AB(1+C) + \bar{A}C(1+B) \\
&= AB(1) + \bar{A}C(1) \\
&= AB + \bar{A}C = RHS
\end{aligned}
$$

Theorem 2: $(A+B)(\bar{A}+C)(B+C) = (A+B)(\bar{A}+C)$

$$
\begin{aligned}
LHS &= (A+B)(\bar{A}+C)(B+C) \\
&= (A\bar{A} + AC + B\bar{A} + BC)(B+C) \\
&= (AC + BC + \bar{A}B)(B+C) \\
&= ABC + BC + \bar{A}B + BC + AC + \bar{A}BC \\
&= AC + BC + \bar{A}B.
\end{aligned}
$$

$$
\begin{aligned}
RHS &= (A+B)(\bar{A}+C) \\
&= A\bar{A} + AC + BC + \bar{A}B \\
&= AC + BC + \bar{A}B = LHS.
\end{aligned}
$$

Transposition Theorem

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

Proof: $RHS = (A+C)(\bar{A}+B)$

$= A\bar{A} + AB + C\bar{A} + CB$

$= 0 + \bar{A}C + AB + BC$

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

$= AB + ABC + \bar{A}C + \bar{A}BC$

$= AB + \bar{A}C = \underline{LHS}$.

De Morgan's Theorem

$$\overline{A+B} = \bar{A}\,\bar{B}$$

$$\overline{AB} = \bar{A} + \bar{B}$$

Reducing Boolean Expression

Every Boolean expression must be reduced to as simple a form as possible before realization, because every logic operation in the expression represents a corresponding element of hardware.

- It results in reduction of cost and complexity and increase in reliability.
- To reduce Boolean expressions, all the laws of Boolean algebra may be used.

Procedure

- Multiply all variables necessary to remove parentheses
- Look for identical terms.

$$AB + AB + AB + AB = AB$$

- Look for a variable and its negation in the same term. This term can be dropped.

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

$$ABC\bar{C} = AB.0 = 0$$

- Look for pairs of terms that are identical except for one variable which may be missing in one of the terms. The larger term can be dropped.

Ex: $AB\bar{C}\bar{D} + AB\bar{C} = AB\bar{C}(\bar{D}+1) = AB\bar{C}\cdot 1 = AB\bar{C}$

- Look for the pairs of terms which have the same variables, with one or more variables complemented. If a variable in one term of such a pair is complemented while in the 2nd term it is not, then such terms can be combined into a single term with that variable dropped.

Ex: $AB\bar{C}\bar{D} + AB\bar{C}D = AB\bar{C}(\bar{D}+D)$

$$= AB\bar{C}\cdot 1 = AB\bar{C}$$

$$AB(C+D) + AB(\overline{C+D}) = AB[(C+D)+(\overline{C+D})]$$

$$= AB\cdot 1 = AB.$$

Ex: Reduce the expression $A[B+\bar{C}(\overline{AB+A\bar{C}})]$

Sln $A[B+\bar{C}(\overline{AB+A\bar{C}})]$

$$= A[B+\bar{C}(\overline{AB}\cdot\overline{A\bar{C}})]$$

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

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

$$= A[B+\bar{C}\bar{A}+\bar{C}\bar{A}C+\bar{C}\bar{B}\bar{A}+\bar{C}\bar{B}C]$$

$$= A(B+\bar{C}\bar{A}+0+\bar{C}\bar{B}\bar{A}+0)$$

$$= AB + A\bar{C}\bar{A} + A\bar{C}\bar{B}\bar{A} = AB + 0 + 0 = \underline{\underline{AB}}.$$

Ex: Reduce the expression $A + B[AC + (B+\bar{C})D]$.

Sln $A + B[AC + (B+\bar{C})D]$

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

$= A + BAC + B.B.D + B\bar{C}D$

$= A + ABC + BD + BD\bar{C}$

$= A(1+BC) + BD(1+\bar{C})$

$= A.1 + BD.1$

$= A + BD.$

Ex: Reduce the expression $(\overline{A+\bar{B}C})(A\bar{B} + ABC)$

Sln: $(\overline{A+\bar{B}C})(A\bar{B} + ABC)$

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

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

$= \bar{A}BCA\bar{B} + \bar{A}BCABC$

$= 0 + 0 = 0$

Ex: Reduce the expression $(B+BC)(B+\bar{B}C)(B+D)$

Sln: $(B+BC)(B+\bar{B}C)(B+D)$

$= (BB + B\bar{B}C + BCB + BC.\bar{B}C)(B+D)$

$= (B + 0 + BC + 0)(B+D)$

$= B(1+C)(B+D)$

$= B.1(B+D)$

$= BB + BD$

$= B + BD$

$= B(1+D)$

$= B.1 = B.$

Ex: Show that $AB + A\bar{B}C + B\bar{C} = AC + B\bar{C}$

Sln LHS $AB + A\bar{B}C + B\bar{C}$

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

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

$= A \cdot 1 (B + C) + B\bar{C}$

$= AB + AC + B\bar{C}$

$= AB(C + \bar{C}) + AC + B\bar{C}$

$= ABC + AB\bar{C} + AC + B\bar{C}$

$= AC(1 + B) + B\bar{C}(1 + A)$

$= AC \cdot 1 + B\bar{C} \cdot 1$

$= AC + B\bar{C} = RHS.$

Ex: Show that $A\bar{B}C + B + B\bar{D} + AB\bar{D} + \bar{A}C = B + C$

Sln: LHS $= A\bar{B}C + B + B\bar{D} + AB\bar{D} + \bar{A}C$

$= A\bar{B}C + \bar{A}C + B(1 + \bar{D} + A\bar{D})$

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

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

$= C \cdot 1 (\bar{A} + \bar{B}) + B$

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

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

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

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

$= B + C(1 + \bar{A})$

$= B + C \cdot 1 = B + C$

Logic Gates

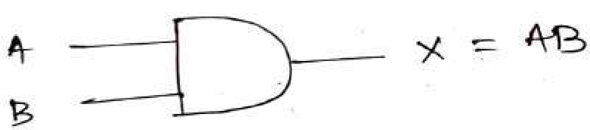
Introduction:

Logic gates are the fundamental building blocks of digital systems. There are three basic types of gates. – AND, OR and NOT. The inter-connection of gates to perform a variety of logical operations is called logic design.

Input & output of logic gates can occur only in 2 ~~ways~~ levels. These 2 levels are termed High & Low or True & False or ON & OFF or simply 1 & 0.

A table which lists all the possible combinations of input variables and the corresponding outputs is called a truth table.

AND gate



Truth table

Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

OR gate

Truth table

Input		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

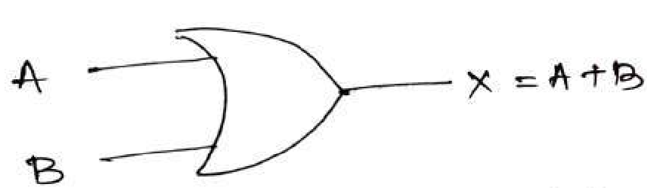
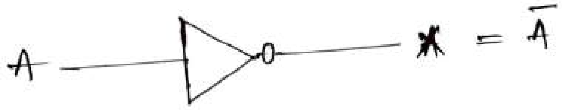


Fig: Logic Symbol.

NOT gate



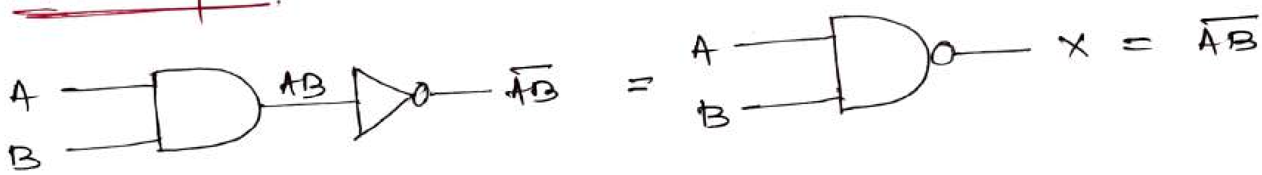
Truth table

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

The Universal Gates

There are 2 types of universal gates.
a) NAND gate b) NOR gate.

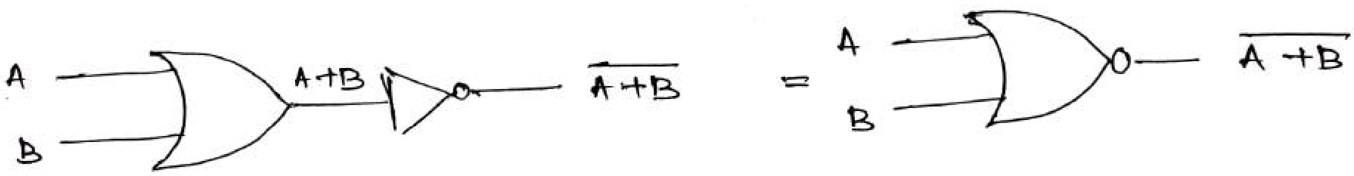
a) NAND Gate



Truth table.

Input			Output
A	B	AB	$X = \overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

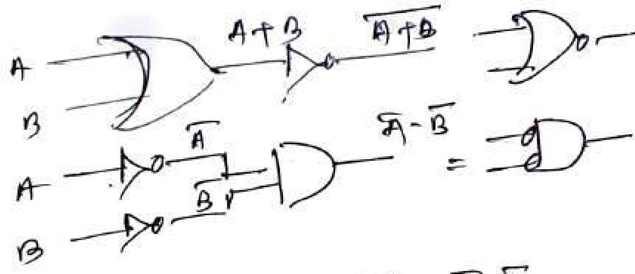
(b) NOR gate



Truth table

Input			Output
A	B	A+B	$X = \overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

Prove De. Morgan's Theorem



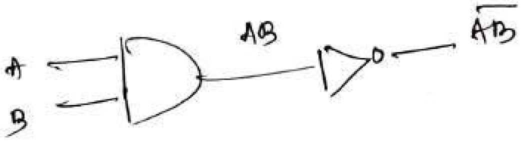
Law-1: $\overline{A+B} = \overline{A}\cdot\overline{B}$

A	B	A+B	$\overline{A+B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

A	B	$\overline{A}$	$\overline{B}$	$\overline{A}\cdot\overline{B}$
0	0	1	1	1
0	1	1	0	0
1	0	0	1	0
1	1	0	0	0

LHS = RHS.

Law 2: $\overline{AB} = \overline{A} + \overline{B}$



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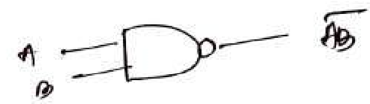

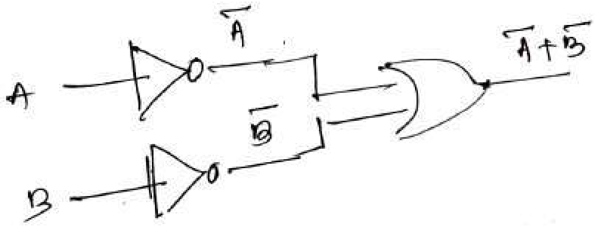

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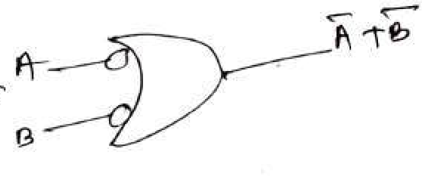


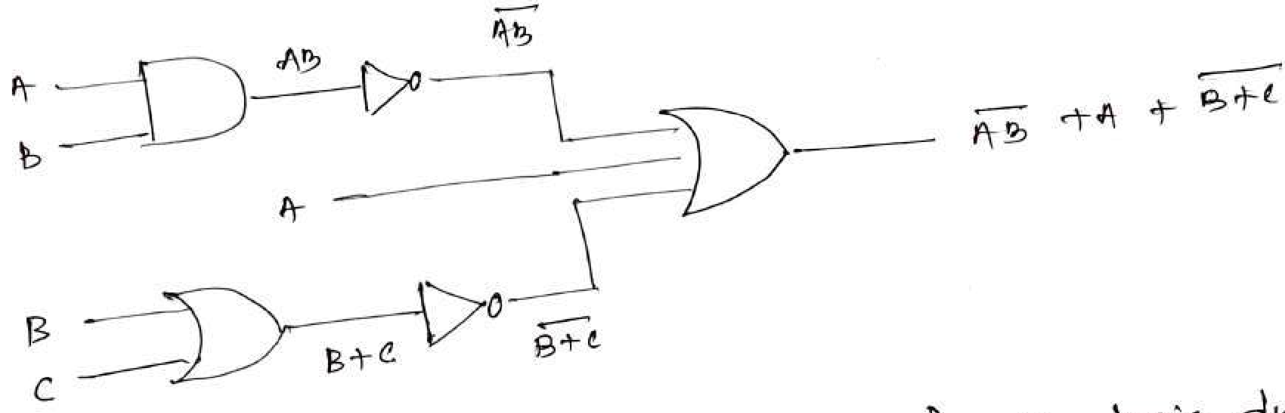
A	B	AB	$\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

A	B	$\overline{A}$	$\overline{B}$	$\overline{A}+\overline{B}$
0	0	1	1	1
0	1	1	0	1
1	0	0	1	1
1	1	0	0	0.

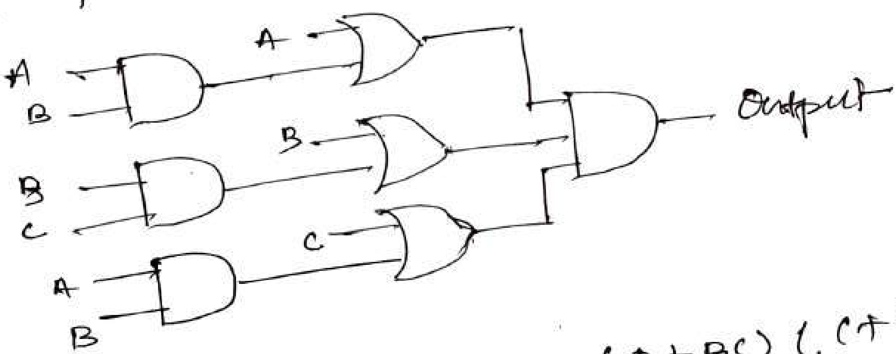
LHS = RHS.

Boolean Expressions and Logic Diagrams

$\overline{AB} + A + \overline{B+C}$



Ex: Write the Boolean expression for the logic diagram given below and simplify it as much as possible and draw the logic diagram that implements the simplified expressions.



Sln Output $= (A + AB)(B+BC)(C+AB)$

$= A(1+B)\, B(1+C)(C+AB)$

$= AB(C+AB)$

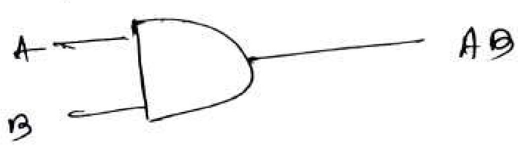
$= ABC + ABAB$

$= ABC + AB$

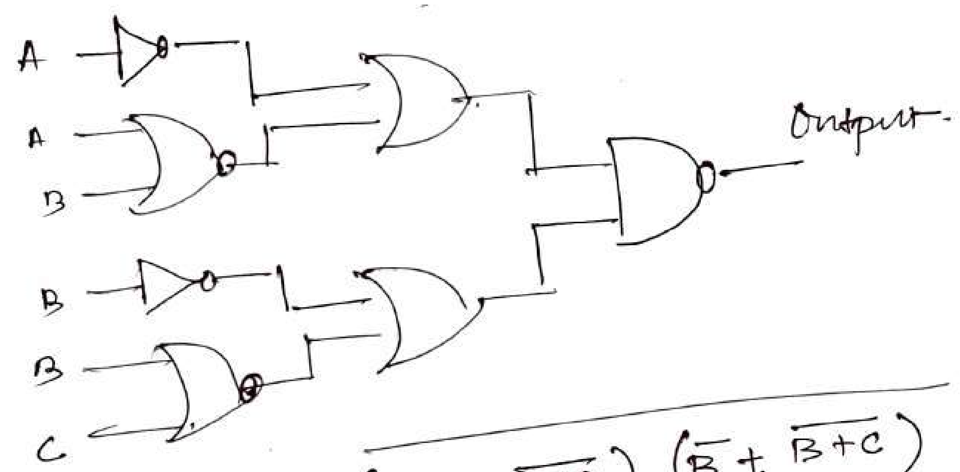
$= AB(C+1)$

$= AB$

The logic diagram to realize the simplified expression is just an AND gate shown ~~in the~~ below



Q.2 Draw the simplest possible logic diagram that implements the output of the logic diagram shown below.



Sln output $= \overline{(\overline{A} + \overline{A+B})\,(\overline{B} + \overline{B+C})}$

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

$= \overline{\overline{A}} \cdot \overline{\overline{A+B}} + \overline{\overline{B}} \cdot \overline{\overline{B+C}}$

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

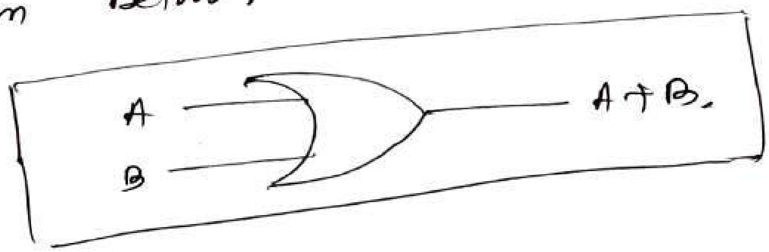
$= AA + AB + BB + BC$

$= A + AB + B + BC$

$= A(1+B) + B(1+C)$

$= A + B$

The logic diagram to implement the simplified expression is shown below.



UNIT-IV

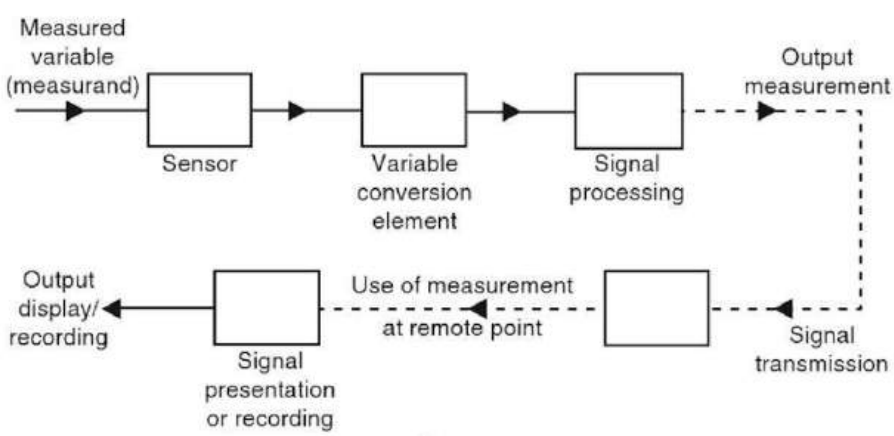
Electronic Instrumentation

Introduction: Electronic Instrumentation is about the design, realization and use of electronic systems for themeasurement of electrical and non-electrical quantities. The activity that is the basis of electronic instrumentation is measuring. The measurement of any quantity plays very important role in science, all branches of engineering, medicine and in almost all the human day to day activities.

Advantages of Electronic Measurement

- Most of the quantities can be converted by transducers into the electrical or electronic signals.
- An electrical or electronic signal can be amplified, filtered, multiplexed, sampled and measured.
- The measurement can easily be obtained in or converted into digital form for automatic analysis and recording.
- The measured signals can be transmitted over long distances with the help of cables or radio links, without any loss of information.
- Many measurements can be carried either simultaneously or in rapid succession.
- Electronic circuits can detect and amplify very weak signals and can measure the events of very short duration as well.
- Electronic measurement makes possible to build analog and digital signals. The digital signals are very much required in computers.
- Higher sensitivity, low power consumption and a higher degree of reliability are the important features of electronic instruments and measurements.

Functional elements of an instruments



Elements of a measuring system.

Basic Principle

Basic operation principle of a measurement instrument detecting an input signal and producing an output signal. Instruments usually comprise a sensor, an amplifier, and a display.

CRT Features

Electrostatic CRTs are available in a number of types and sizes to suit individual requirements. The important features of these CR tubes are as follows.

1. Size

Size refers to the screen diameter. CRTs for oscilloscopes are available in sizes of 1, 2, 3, 5, and 7 inches. 3 inches is most common for portable instruments. For example a CRT having a number 5GP1. The first number 5 indicates that it is a 5 inch tube. Both round and rectangular CRTs are found in scopes today. The vertical viewing size is 8 cm and horizontal is 10 cm.

2. Phosphor

The screen is coated with a fluorescent material called phosphor. This material determines the color and persistence of the trace, both of which are indicated by the phosphor. The trace colors in electrostatic CRTs for oscilloscopes are blue, green and blue green. White is used in TVs, and blue-white, orange, and yellow are used for radar.

Persistence is expressed as short, medium and long. This refers to the length of time the trace remains on the screen after the signal has ended.

The phosphor of the oscilloscope is designated as follows.

- P1 - Green medium
- P2 - Blue green medium
- P5 - Blue very short
- P11 - Blue short

These designations are combined in the tube type number. Hence 5GP1 is a 5 inch tube with a medium persistence green trace. Medium persistence traces are mostly used for general purpose applications.

P11 phosphor is considered the best for photographing from the CRT screen.

3. Operating Voltages

The CRT requires a heater voltage of 6.3 volts ac or dc at 600 mA. Several dc voltages are listed below. The voltages vary with the type of tube used.

- Negative grid (control) voltage - 14 V to - 200 V.
- Positive anode no. 1 (focusing anode) - 100 V to - 1100 V
- Positive anode no. 2 (accelerating anode) 600 V to 6000 V
- Positive anode no. 3 (accelerating anode) 200 V to 20000 V in some cases

4. Deflection Voltages

Either ac or dc voltage will deflect the beam. The distance through which the spot moves on the screen is proportional to the dc, or peak ac amplitude. The deflection sensitivity of the tube is usually stated as the dc voltage (or peak ac voltage) required for each cm of deflection of the spot on the screen.

5. Viewing Screen

The viewing screen is the glass face plate, the inside wall of which is coated with phosphor. The viewing screen is a rectangular screen having graticules marked on it. The standard size used nowadays is 8 cm x 10 cm (8 cm on the vertical and 10 cm on horizontal). Each centimeter on the graticule corresponds to one division (div). The standard phosphor color used nowadays is blue.

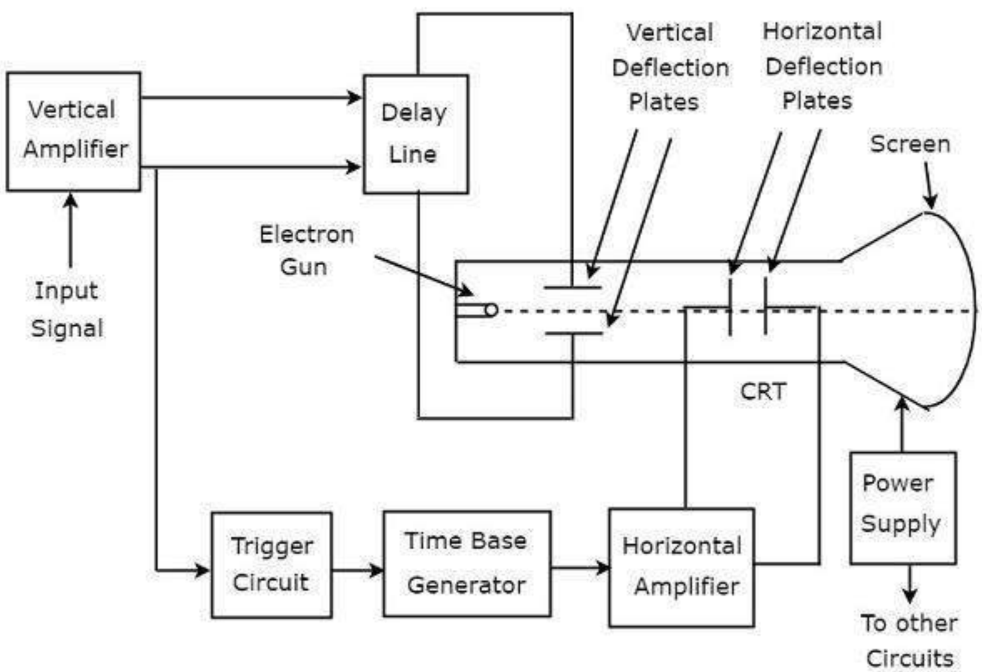
Cathode Ray Oscilloscope

The cathode ray oscilloscope is the instrument which generates the waveform of any electrical quantity. The waveform is generated in such a way that the amplitude of the signal is represented along Y-axis and the variation in the time is represented along X-axis.

CRO is the measuring device as well as it can generate waveforms in terms of amplitude andtime because it is very easy to measure the amplitude of the voltage signal to determine its intensity.

Block Diagram of Oscilloscope

The cathode-ray oscilloscope (CRO) is a common laboratory instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies. Its reliability, stability, and ease of operation makes it suitable as a general purpose laboratory instrument.



- A general purpose oscilloscope consists of the following parts:
- Cathode ray tube
- Vertical amplifier
- Delay line
- Time base generator
- Horizontal amplifier
- Trigger circuit

- Power supply

Cathode Ray Tube - It is the heart of the oscilloscope. When the electrons emitted by the electron gun strikes the phosphor screen, a visual signal is displayed on the CRT.

Vertical Amplifier - The input signals are amplified by the vertical amplifier. Usually, the vertical amplifier is a wide band amplifier which passes the entire band of frequencies.

Delay Line - As the name suggests, this circuit is used to delay the signal for a period of time inthe vertical section of CRT. The input signal is not applied directly to the vertical plates becausethe part of the signal gets lost, when the delay time is not used. Therefore, the input signal isdelayed by a period of time.

Time Base (Sweep) Generator - Time base circuit uses a uni-junction transistor, which is usedto produce the sweep. The saw tooth voltage produced by the time base circuit is required to deflect the beam in the horizontal section. The spot is deflected by the saw tooth voltage at a constant time dependent rate.

Horizontal Amplifier - The saw tooth voltage produced by the time base circuit is amplified by the horizontal amplifier before it is applied to horizontal deflection plates.

Trigger Circuit - The signals which are used to activate the trigger circuit are converted to trigger pulses for the precision sweep operation whose amplitude is uniform. Hence input signal and the sweep frequency can be synchronized.

Power supply - The voltages required by CRT, horizontal amplifier, and vertical amplifier are provided by the power supply block. It is classified into two types -

(1) Negative high voltage supply

(2) Positive low voltage supply

The voltage of negative high voltage supply is from -1000V to -1500V. The range of positive voltage supply is from 300V to 400V.

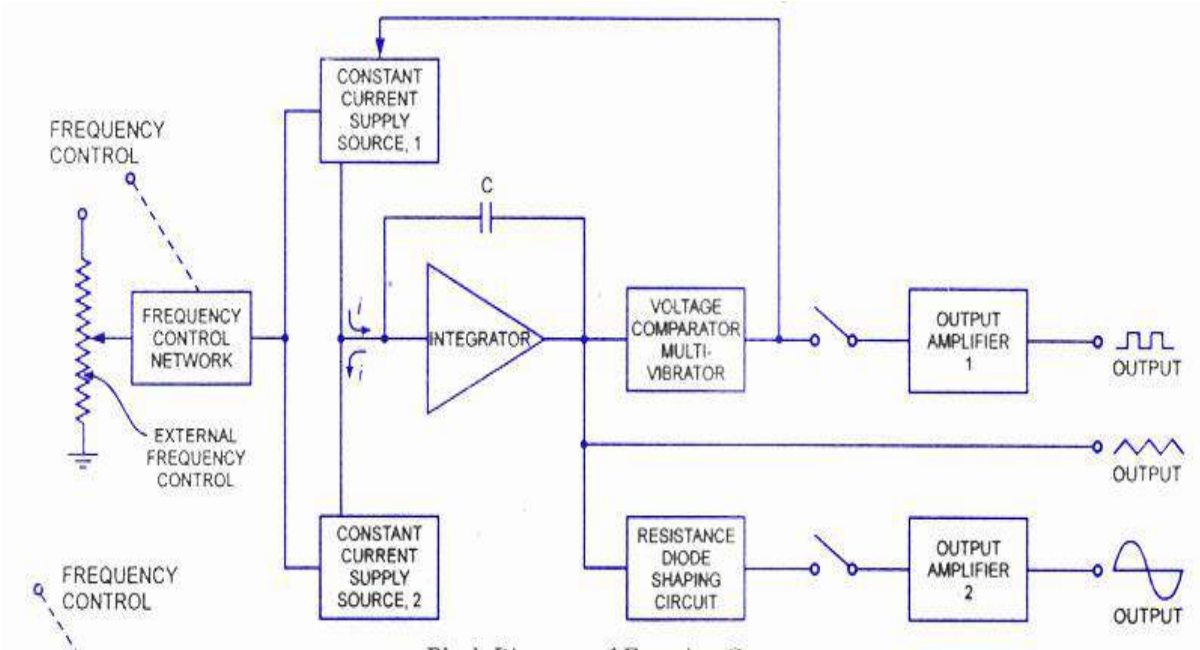
Working of Cathode Ray Oscilloscope

When the electron is injected through the electron gun, it passes through the control grid. The control grid controls the intensity of electron in the vacuum tube. If the control grid has high negative potential, then it allows only a few electrons to pass through it. Thus, the dim spot is produced on the lightning screen. If the negative potential on the control grid is low, then the bright spot is produced. Hence the intensity of light depends on the negative potential of the control grid.

After moving the control grid the electron beam passing through the focusing and accelerating anodes. The accelerating anodes are at a high positive potential and hence they converge the beam at a point on the screen.

After moving from the accelerating anode, the beam comes under the effect of the deflecting plates. When the deflecting plate is at zero potential, the beam produces a spot at the Centre. If the voltage is applied to the vertical deflecting plate, the electron beam focuses at the upward and when the voltage is applied horizontally the spot of light will be deflected horizontally.

Function generator: A function generator is a signal source that has the capability of producing different types of waveforms as its output signal.



Block Diagram of Function Generator

The block diagram of a function generator is given in the figure. In this instrument, the frequency is controlled by varying the magnitude of the current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

The frequency controlled voltage regulates two current supply sources. Current supply source 1 supplies a constant current to the integrator whose output voltage rises linearly with time. An increase or decrease in the current increases or reduces the slope of the output voltage and thus controls the frequency.

The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a pre-determined level, the voltage comparator again changes state and switches on to the current supply source. The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion