DIGITAL LOGIC CIRCUITS

UNIT I

BOOLEAN ALGEBRA AND LOGIC GATES

1. **What is digital systems? State its advantage over analog systems?**

   The electrical systems able to process only discrete values(Digital signals) are called digital systems.
   Any digital signal is represented in binary form (0 or 1) and the data processing is carried out by binary logic elements and results are stored in binary storage elements.
   Digital systems are programmable, simple and reliable than analog systems.

2. **Define number systems**. **List the different number systems?**
   A collection of digits make a number, it has integer and fractional parts separated by a radix point(.) with each digit position having specific weightage. Basically Number systems are used for counting and quantify anything.
   List of different number systems
   i)Decimal Number system
   ii) Binary Number system
   iii) Octal Number system
   iv) Hexadecimal Number system

3. **Define radix or base of a number system**
   Total number of values a digit can represent in the particular number system.
   i) Decimal Number system - radix 10
   ii) Binary Number system – radix 2
   iii) Octal Number system – radix 8
   iv) Hexadecimal Number system – radix 16

4. **What is meant by bit, nibble, byte.**
   bit - binary digit
   nibble - group of four bits
   byte - group of eight bits

5. **Find the decimal equivalent of $(101101)_2$**
   $=1X2^5+0X2^4+1X2^3+1X2^2+0X2^1+1x2^0$
   = 32+0+8+4+0+1+0.5+0+0.
   =45.65625 D

6. **Convert $(126)_{10}$ to Octal number and binary number.**
   $126_{10} = 1111110_2$ & 176_8

7. **Convert $(0.6875)_{10}$ to binary.**

	INTEGER		FRACTION	COEFFICIENTS
– 0.6875 x 2 =	1	+	0.3750	$a_{-1} = 1$
– 0.3750 x 2 =	0	+	0.7500	$a_{-2} = 0$
– 0.7500 x 2 =	1	+	0.5000	$a_{-3} = 1$
– 0.5000 x 2 =	1	+	0.0000	$a_{-4} = 1$

Answer: $(0.6875)_{10} = (0.a_{-1}a_{-2}a_{-3}a_{-4})_2 = (0.1011)_2$

8. **Find the octal equivalent of the hexadecimal number DC.BA.**

   $DC.BA_{16} = 11011100.10111010_2 = 334.564_8$

9. **Find the octal equivalent of hexadecimal numbers AB.CD.**
   (i) Convert the hexadecimal to binary equivalent
   $(AB.CD)_{16}=(1010\ 1011.1100\ 1101)_2$
   (ii) Then convert binary equivalent to octal number
   $(10101.1100\ 1101)_2=$**$(253.315)_8$**

10. **Convert the following Excess-3 numbers to decimal numbers (a)1011 (b)1001 0011 0111**
    (a) Excess-3 : 1011→ 11-3=8→ Decimal : 8
    (b) Excess-3 : 1001 0011 0111

1001	0011	0111
9	3	7
-3	-3	-3
=6	=0	=4

$\therefore (1001\ 0011\ 0111)_{XS3} = (604)_{10}$

11. **Add $(1111\ 0)_2$ and $(1100)_2$**
    11110
    1100
    Answer $=(101010)_2$

12. **Add $(1011)_2$ and $(10\ .1)_2$**
    1011.0
    0010.1
    Answer =1101.1

13. **What are the different types of number complements?**
    i) r's Complement
    ii) (r-1)'s Complement.

14. **Find 2'S complement of $(101000.11)_2$**
    0101110.01- 1's Complement
    +1
    010111010 -2's complement.

15. **Using 10's complement subtract 72532 – 3250.**
    M = 72532 +
    10's complement of N = 96750
    Sum = 169282
    Carry ..M>N, Discard end carry Ans= 69282

16. **Subtract 111001_2 from 101011_2 using 2's complement method**
    101011+
    000111-2'scomp.of111001

17. **Given the two binary numbers X = 1010100 and Y = 1000011, perform the subtraction Y – X by using 2's complements.**

Y:	1000011	+
2' s complement of X (1010100):	0101100	
No carry	1101111	
Take 2's complement of result	-0010001	

18. Given two binary numbers A=1010010 and B=1000011, find A-B and B-A using 2's complements.

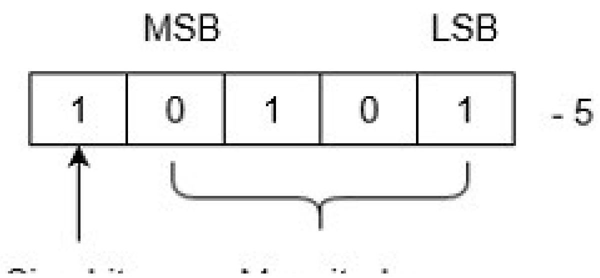
A:	1010010	+
2' s complement of B (1000011):	0111101	
Ignore carry	10001111	
Result	0001111	

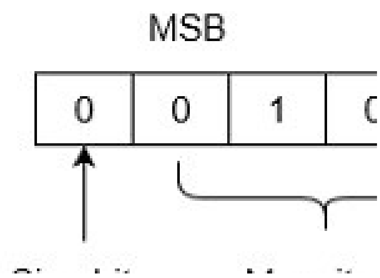
B:	1000011	+
2' s complement of A (1010010):	0101110	
No carry	1110001	
Take 2's complement of result	-0001111	

19. What are the different ways to represent a negative number?

(i) Signed Magnitude Method:

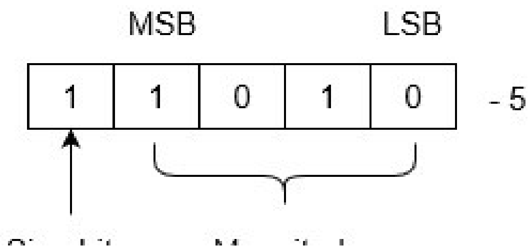
In this method, number is divided into two parts: Sign bit and Magnitude. If the number is positive then sign bit will be 0 and if number is negative then sign bit will be 1. Magnitude is represented with the binary form of the number to be represented

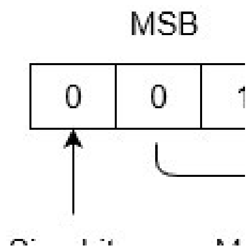




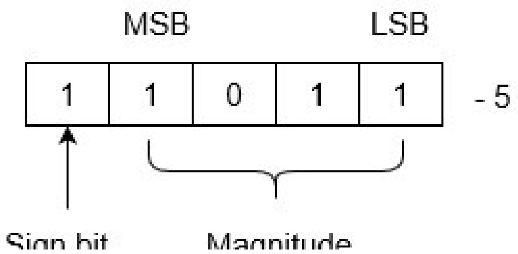
(ii) **1's Complement Method:**

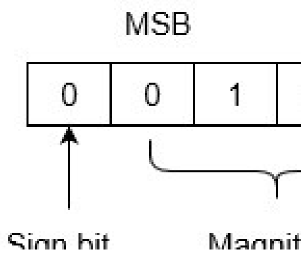
Positive numbers are represented in the same way as they are represented in sign magnitude method. If the number is negative then it is represented using 1's complement. First represent the number with positive sign and then take 1's complement of that number.





(iii) **2's Complement Method:** Positive numbers are represented in the same way as they are represented in sign magnitude method. If the number is negative then it is represented using 2's complement. First represent the number with positive sign and then take 2's complement of that number.





20. What is meant by self-complementing codes?

A self-complementing code is the one in which the members of the number system complement on themselves. This requires the following two conditions to be satisfied.(
i)The complement of the number should be obtained from that number by replacing 1s with 0s and 0s with 1s.
(ii)The sum of the number and its complement should be equal to decimal 9.
Example of a self-complementing code is i. 2-4-2-1 code. ii. Excess-3 code

21. What are cyclic / unit distance codes?

In this code each successive code word differ from the preceding one in only one bit position. Adjecent codes differ only one bit.
Ex:- Gray code-It is often used for translating an analog quantity such as shaft position into a digital form.
Application:- For error detection and correction .

22. Represent 3856 in BCD and 2421 code.

	BCD	**2421**
3856	0011 1000 0101 0110	0011 1110 1011 1100

23. What is meant by singed magnitude form?

Representation of both positive and negative numbers using a sign bit as the most significant bit (MSB), with 0 for positive number and 1 for negative number is called signed magnitude form.

24. State the abbreviations of ASCII and EBCDIC code?

ASCII-American Standard Code for Information Interchange.
The code uses 7 bits to encode 128 unique characters.

EBCDIC-Extended Binary Coded Decimal Information Code.

25. What is the significance of BCD code.

(i) Any large decimal number can be easily converted into corresponding binary number
(ii) A person needs to remember only the binary equivalents of decimal number from 0 to 9.
Conversion from BCD into decimal is also very easy.

26. List the advantages and disadvantages of BCD code

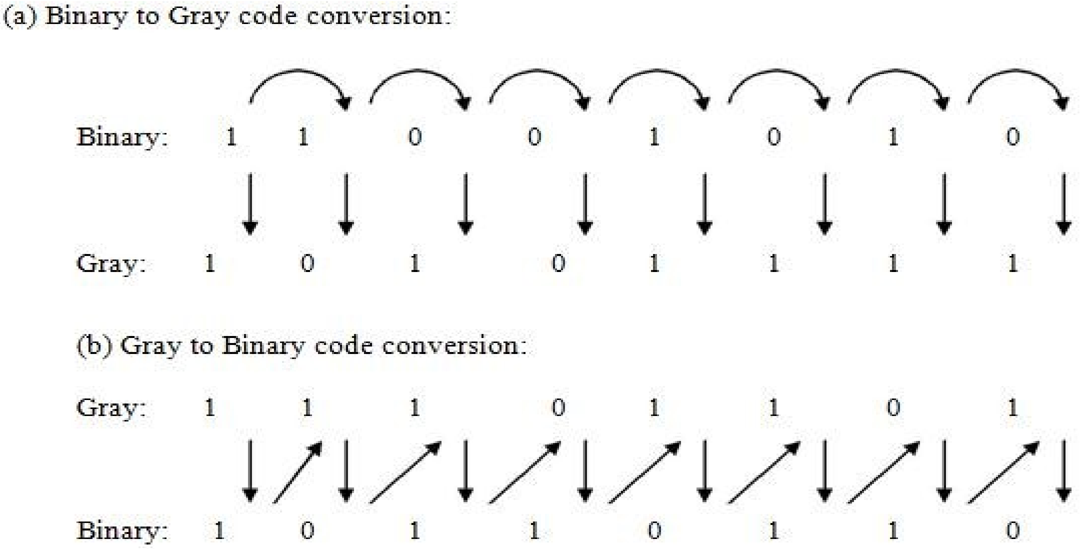
The advantages of BCD code are
(i)Any large decimal number can be easily converted into corresponding binary number
(ii)A person needs to remember only the binary equivalents of decimal number from 0 to 9.
(iii)Conversion from BCD into decimal is also very easy.

The disadvantages of BCD code are
(i) The code is least efficient. It requires several symbols to represent even small numbers.
(ii)Binary addition and subtraction can lead to wrong answer.
(iii)Special codes are required for arithmetic operations.
(iv)This is not a self-complementing code.
(v)Conversion into other coding schemes requires special methods.

27. What is the feature of gray code? What are its applications.

The advantage of gray code also called reflected code over pure binary numbers is that a number in gray code changes by only one bit as it proceeds from one number to the next. A typical application of the reflected code occurs when the analog data are represented by a continuous change of a shaft position. The shaft is portioned into segments and each segment is assigned a number. If adjacent segment are made to correspond to adjacent reflected-code numbers, ambiguity is reduced when detection is sensed in the line that separates any two segments. So in 3-bit code, error may occur due to one bit position, other two bit positions of adjacent sectors are always same and hence there is no possibility of error. Thus in 3-bit code, probability of error is reduced to 66 % and in 4-bit code it is reduced upto 25%.

28. a)Convert (11001010)2 into gray code.
b) Convert a Gray code 11101101 into binary code.



29. What is meant by parity bit?

A parity bit is an extra bit included with a message to make the total number of 1’s either even or odd. Consider the following two characters and their even and odd parity:

ASCII A = 1000001 01000001 11000001 With odd parity
ASCII T = 1010100 11010100 01010100 With even parity

In each case we add an extra bit in the left most position of the code to produce an even number of 1’s in the character for even parity or an odd number of 1’s in the character for odd parity. The parity bit is helpful in detecting errors during the transmission of information from one location to another.

30. Show that excess 3 code is self complementing.

1's complement of the excess 3 code of any number is the 9’s complement of the number.
Excess3 code of 4 is 0111
1’s complement of 0111= 1000 = Excess 3 code of 5 (where 5 is the 9’s complement of 4)

31. Define weighted codes. Give two examples

Weighted binary codes are those binary codes which obey the positional weight principle. Each position of the number represents a specific weight. Several systems of the codes are used to express the decimal digits 0 through 9

Binary codes each digit having a specific weightage is called binary codes.
Eg. 8421,2421

32. What is meant by non weighted codes?

Binary codes which do not obey the weights sequence binary numbers or positional weight principle are non weighted codes.
unweighted sequence code: Excess3 code
unweighted nonsequence code: gray code

33. State the principle of duality.

The duality theorem states that starting with a Boolean relation we can drive another Boolean relationby changing OR operation i.e., + sign to an and operation i.e., dot and vice versa. Complement any 0 and 1appearing in the expression i.e., replacing contains 0 and 1 by 1 and o respectively.

34. State the commutative property of Boolean algebra.

The commutative property states that the order in which the variables are OR ed makes no difference. The commutative roperty is: A+B=B+A, A.B=B.A

35. State the associative property of boolean algebra.

The associative property of Boolean algebra states that the OR or AND operation of several variables results in the same regardless of the grouping of the variables.
The associative property is stated as: A+ (B+C) = (A+B) +C, A.(B.C) = (A.B).C

36. State the distributive property of Boolean algebra.

The distributive property states that AND ing several variables and OR ing the result with a single variable is equivalent to OR ing the single variable with each of the several variables and then AND ing the sums. The distributive property is: A+(B.C)= (A+B).(A+C), A.(B+C)= (A.B)+ (A.C)

37. State DeMorgan's theorem.

De-Morgan's theorem 1: The complement of product of any number of variables is equivalent to sum of the individual complements.
De-Morgan's theorem 2: The complement of sum of any number of variables is equivalent to product of the individual complements.

Proof:

a) (AB) '= A'+ B'

A	B	AB	**(AB)'**		A'	B'	**A'+B'**
0	0	0	**1**		1	1	**1**
0	1	0	**1**		1	0	**1**
1	0	0	**1**		0	1	**1**
1	1	1	**0**		0	0	**0**

b) (A+B)' = A'B'

A	B	A+B	**(A+B)'**		A'	B'	**A'B'**
0	0	0	**1**		1	1	**1**
0	1	1	**0**		1	0	**0**
1	0	1	**0**		0	1	**0**
1	1	1	**0**		0	0	**0**

38. State and prove consensus theorem.

Theorem: AB+A'C+BC = AB+A'C
Proof:
AB+A'C+BC = AB+A'C+BC.1

=AB+A’C+BC(A+A’)
= AB+A’C+ABC+A’BC
= AB(1+C) + A’C(1+B) = AB+A’C

39. **Simplify the following Boolean equation F= x’y’+xy+x’y**
F = x’y’+xy+x’y
=x’(y’+y) +xy
=x’+xy =x’+y

40. **Simplify the expression Z = AB+AB’ (A’C’)’**
Z=AB+AB’(A’C’)’
=AB+ AB’(A+C)
=AB + AB’+AB’C
=A(B+B’+B’C)
=A

41. **Prove the following using Demorgan’ theorem [(X+Y)’+(X+Y)’]’= X+Y**
= [(X+Y)’+(X+Y)’]’
= X+Y’’. X+Y’’
= (X+Y). (X+Y)
= X+Y

42. **Describe the canonical forms of the Boolean function.**
Sum of minterms: Combination of minterms using OR operation.

Minterm (standard product) is a combination of n variables using AND operation for the function of n variables.
Example for function of two variables A & B: F = A‘B + AB = m_1 + m_3 F = ∑m(1,3)

Product of maxterms: Combination of maxterms using AND operation.
Maxterm (standard sum) is a combination of n variables using OR operation for the function of n variables.F = (A+B) (A‘+B) = M_0 M_2 F = ∏M(0,2)

43. **Describe the importance of don’t care conditions.**
(i) Functions that have unspecified outputs for some input combinations are called incompletely specified functions. We simply don‘t care what value is assumed by the function for the unspecified minterms.
(ii) The unspecified minterms are called don‘t care conditions.

These don‘t care conditions can be used on a map to provide further simplification of the Boolean expression.

44. **What is prime implicant and non-prime implicant?**

Prime implicant is a product term obtained by combining the maximum possible number of adjacent squares in the K-map. It can not be enclosed by a larger implicant. Non prime implicant can be enclosed by a larger group.

45. **What is essential prime implicant?**

If a minterm is covered by only one prime implicant that is said to be essential and it must be included in the minimum sum of products.

46. **What is incompletely specified functions/don‟t care conditions?**

In certain digital systems some combinations of input variables do not occur. The outputs corresponding to that input combinations do not matter. So the designer can assume a 0 or 1 as output for each of these combinations. This condition is known as don‟t care conditions denoted by X in K-map.

47. What are the limitations of K-map?

The map method is convenient as long as the number of variables does not exceed five or six. As the number of variable increases, the excessive number of squares prevents a reasonable selection of adjacent squares.

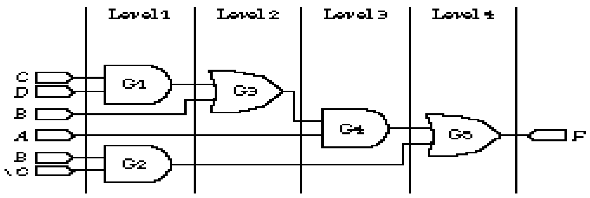
48. Define minterm and maxterm.

Minterm(standard product) is a combination of n variables using AND operation for the function of n variables. Possible minterms for a function of two variables A & B: A'B', A'B, AB', AB

Maxterm(standard sum) is a combination of n variables using OR operation for the function of n variables. Possible maxterms for a function of two variables A & B: A+B, A+B', A'+B, A'+B'

49. What is meant by multilevel gates networks?

A number of gates cascaded in series between a network input and output is referred to as the number of levels of gets. Don't count inverters as a level. Figure shows 4 level networks.

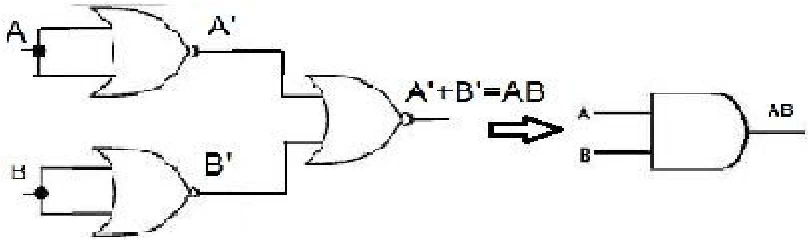


50. Discuss the NOR operation with a truth table.

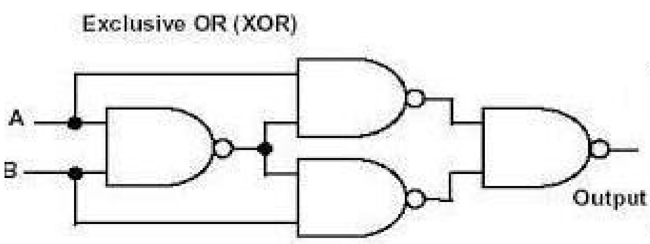
This is a NOT-OR gate which is equal to an OR gate followed by a NOT gate. The outputs of allNOR gates are low if any of the inputs are high.

2 Input NOR gate		
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

51. Implement AND gate using only NOR gate .



52. Realize XOR gate using only 4 NAND gates



A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

53. Which gates are called as the universal gates? What are its advantages?
The NAND and NOR gates are called as the universal gates. These gates are used to perform any type of logic operation. Any logic function can be realized by using only NAND gate or only NOR gates alone. So they are called as universal gates.

54. Implement half Adder using NAND Gates.