PGTRB - PHYSICS

UNIT 10 - ELECTRONICS

NUMBER SYSTEM

INTRODUCTION

Everywhere, except for computer related operation the main system of mathematical notation today is the decimal system, which is a base 10 system. As in the other number systems, the position of a symbol in terms of exponential values of the base. That is in the decimal system, the quantity represented by any of the ten symbols used 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 depends on its position in the number.

Unlike the decimal system, only two digits 0, 1 suffice is representing the number in the binary system. The binary system plays a crucial role in computer science and technology.

DECIMAL SYSTEM

The base or the radix of a number system is defined as the number of digits it uses to represent the numbers in the system. Since, the decimal number system uses 10 digits 0 to 9 its base or radix is 10, the decimal number system is also called base 10 number system. The weight of each digit of a decimal number system depends on its relative position within the number.

Example:

$$2763 = 2000 + 700 + 60 + 3$$

in other words,

$$2763 = 2 \times 10^3 + 7 \times 10^2 + 6 \times 10^1 + 3 \times 10^\circ$$

BINARY SYSTEM

The binary system is a great help in the Nim-like games plainim, Nimble, Turning, Turtle, Scoring, Northcott's game etc. More importantly, the binary system underlies modern technology of electronic digital computers. Computer memory comprises small elements that may only be in two states — OFF / ON that are associated with digits 0 and 1. Such an element is said to represent one bit — binary digit.

For example, 1101

To represent numbers the decimal system uses the powers of 10, whereas the binary system uses in a similar manner the power of 2.

$$(1101)2 = 1.2^3 + 1.2^2 + 0.2 + 1$$

The numbers are different, In fact

$$(1101)_2 = 8 + 4 + 0 + 1 = (13)_{10}$$

Table:

Decimal	Binary
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111
16	10000
17	10001
18	10010
19	10011
20	10100

BINARY ADDITION AND SUBTRACTION

Binary Addition

Binary addition is performed in the same manner as decimal addition. Actually, binary arithmetic is much simpler to learn. The complete table for binary addition as follows,

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$1 + 1 = 0$ plus a carry over of 1.

Examples of binary addition:

1. 7 + 2

Decimal	Binary
7	111
2	010
9	**1001**

2. 4 + 8

Decimal	Binary
4	100
8	1000
12	**1100**

3. 12 + 15

Decimal	Binary
12	1100
15	1111
27	**11011**

4. 17 + 18

Decimal	Binary
17	10001
18	10010
35	**100011**

Binary Subtraction

binary numbers is when 1 is subtracted from 0. The remainder is 1, but it is necessary to borrow
Binary subtraction is the inverse operation of addition. The only case in which this occurs with

1 from the next column to the left. This is the binary subtract table.

0 – 0 = 0

1 – 0 = 1

1 – 1 = 0

0 – 1 = 1 with a borrow of 1.

Examples of binary Subtraction:

1. 7 – 4

Decimal	Binary
7	111
–4	100
3	**011**

2. 18 – 6

Decimal	Binary
18	10010
–6	110
12	**1100**

3. 16 – 4

Decimal	Binary
16	10000
– 4	00100
12	**1100**

4. 12 – 2

Decimal	Binary
12	1100
–2	0010
10	**1010**

BINARY MULTIPLICATION AND DIVISION

Binary Multiplication

The table for binary multiplication is very short, with only four entries instead of the necessary for decimal multiplication.

$$0 * 0 = 0$$
$$0 * 1 = 0$$
$$1 * 0 = 0$$
$$1 * 1 = 1$$

Examples for binary Multiplication:

1. 4 × 3

Decimal	Binary
4 × 3	100 × 011 100 100 000
12	**01100**

2. 10 × 4

Decimal	Binary
10 × 4	1010 × 100 0000 0000 1010
40	**101000**

3. 102 × 8

Decimal	Binary
102 × 8	1100110 × 1000 0000000 0000000 0000000 1100110
816	**1100110000**

Binary Division

It is a very simple. As in the decimal system (or in any other), division by zero is meaningless. The complete table as,

0/1 = 0

1/0 = 1

Examples for binary division:

1. 25 ÷ 5

Decimal	Binary
5 5) 25 25 0	101 101) 11001 101 0101 0101 0

2. 20 ÷ 4

	Decimal		Binary
	5		101
4	20	100	10001
	20		101
	0		00100
			00100
			0

3. 18 ÷ 6

	Decimal		Binary
	6		110
3	18	011	10010
	18		011
	0		011
			011
			0

4. 29 ÷ 12

	Decimal		Binary
	2.416		10.011010101
12	29	1100	11101.00
	24		1100
	50		10100
	48		1100
	20		10000
	12		1100
	80		10000
	72		1100
			……..

CONVERTING DECIMAL NUMBER TO BINARY

There are several methods for converting a decimal number to a binary number for instance, suppose that you want to convert decimal into corresponding binary number.

For examples of Decimal to Binary:

1.

2	74	
2	37	– 0
2	18	– 1
2	9	– 0
2	4	– 1
2	2	– 0
	1	– 0

$(74)_{10} = (1001010)_2$

2.

2	93	
2	46	– 1
2	23	– 0
2	11	– 1
2	5	– 1
2	2	– 1
	1	– 0

$$(93)_{10} = (1011101)_2$$

3.

2	121	
2	60	– 1
2	30	– 0
2	15	– 0
2	7	– 1
2	3	– 1
	1	– 1

$$(121)_{10} = (1111001)_2$$

CONVERTING BINARY NUMBER TO DECIMAL

The conversion of binary to decimal may be accomplished by using several techniques.

Example of Binary to decimal:

1. (1 0 1)2

$$1 \times 2^0 = 1 \times 1 = 1$$

$$0 \times 2^1 = 0 \times 2 = 0$$

$$1 \times 2^2 = 1 \times 4 = 4$$

$$5$$

$$(101)_2 = (5)_{10}$$

2. (1 0 1 1)2

$$1 \times 2^0 = 1 \times 1 = 1$$

$$1 \times 2^1 = 1 \times 2 = 2$$

$$0 \times 2^2 = 0 \times 4 = 0$$

$$1 \times 2^3 = 1 \times 8 = 8$$

$$11$$

$$(1011)_2 = (11)_{10}$$

NEGATIVE NUMBER REPRESENTATION

There are three methods usually employed to represent negative integer in binary system. These methods are known as

(*i*) Signed magnitude method

(*ii*) One's complement method

(*iii*) Two's complement method

The Signed Magnitude Method

In this method the signed magnitude method, the sign bit is assigned the value of 1 to denote that it is a negative number.

Examples of signed magnitude method:

Example 1:

$$(24)_{10} = 11000$$
$$(-24)_{10} = 1\ \ 11000$$

2	24
2	12 – 0
2	6 – 0
2	3 – 0
	1 – 1

Example 2:

$$(147) = 10010111$$
$$(-147) = 1\ \ 10010111$$

2	147
2	73 – 1
2	36 – 1
2	18 – 0
2	9 – 0
2	4 – 1
2	2 – 0
	1 – 1

One's Complement Method

Subtracting using the 1's complement system is also straight forward. The 1's complement of a number is formed by changing each 1 is the number to a 0 and each 0 is the number to 1.

When subtracting is performed in the 1s complement system, any end-around carry is added to the least significant.

For examples:

1. Binary → 11011   11011
10110 → 1's 01001
00101   1) 00100
→ 1
00101

2. 111011 → 111011
10110 → 1's 101010
100110   1 | 100101
1
0100110

Two's Complement

The 2s complement of a binary number is formed by simply subtracting each digit (bit) of the number from the radix minus one and adding a 1 to the least significant bit. Since, the radix in the binary number system is 2, each bit of the binary number is subtracted from 1. The application of this rule is actually very simple; every 1 in the number is changed to a 0 and every 0 to a 1. Then, a 1 is added to the least significant bit of the number formed.

For examples:

1. 11011 → 11011
(–)10100 → 1's 01011
2's 1
01100
11011
Carry is dropped   1 00111

2. 11100 → 11100
(–)00100 → 11011
1
11000

11100
11100

Carry is dropped   1|11000

DECIMAL COMPONENTS

In the decimal system the two types are referred to as the 10's complement and 9's complement.

9's Complement

This complement of a decimal number is formed by subtracting each digit of the number from 9.

For examples of 9's complement:

(*i*) 23 – 9's

$$\begin{array}{r} 99 \\ 23 \\ \hline 76 \\ \hline \end{array}$$

(*ii*) 48 – 9's

$$\begin{array}{r} 99 \\ 48 \\ \hline 51 \\ \hline \end{array}$$

10's Complement

The 10's complement of any number may be formed by subtracting each digit of the number from 9 and then adding 1 to the least significant digit of the number thus formed.

For example of 10's complement:

Normal subtracts: **10's complement:**

1.

$$\begin{array}{r} 78 \\ -24 \\ \hline 54 \\ \hline \end{array} \qquad \text{carry is dropped} \qquad \begin{array}{r} 78 - 78 \\ 24 - 76 \\ \hline 1 \mid 54 \\ \hline \end{array}$$

Where,

$$\begin{array}{r} 99 \\ 24 \\ \hline 75 \\ 1 \\ \hline 76 \\ \hline \end{array}$$

OCTAL NUMBER SYSTEM

The octal number system has a base or radix; of 8, eight different symbols are used to represent the numbers. There are commonly 0, 1, 2, 3, 4, 5, 6 and 7. An octal number can be converted easily into the binary number with a group of three binary digits replacing each digits of octal system.

The relation between the decimal system, octal system, Hexadecimal and binary system is shown in table.

Decimal	Binary	Octal	HexaDecimal
0	00000	00	0
1	00001	01	1
2	00010	02	2
3	00011	03	3
4	00100	04	4
5	00101	05	5
6	00110	06	6
7	00111	07	7
8	01000	10	8
9	01001	11	9
10	01010	12	A
11	01011	13	B
12	01100	14	C
13	01101	15	D
14	01110	16	E
15	01111	17	F
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14

CONVERT BINARY TO OCTAL

There is a simple trick for converting a binary number to an octal number simply group the binary digits into groups of 3, starting at the octal point and read each set of three binary digits.

For example of binary to octal:

$$(011\ 100)_2 \rightarrow (34)_8$$
$$(100111000)_2 \rightarrow (470)_8$$
$$(10101)_2 \rightarrow (25)_8$$
$$(1001)_2 \rightarrow (11)_8$$
$$(1011.110)_2 \rightarrow (13.6)_8$$
$$(10101.11)_2 \rightarrow (25.6)_8$$

CONVERT DECIMAL TO OCTAL

1.

8	487
8	60 – 7
	7 – 4

$(487)_{10} = (747)_8$

2.

8	200
8	25 – 0
	3 – 1

$(200)_{10} = (310)_8$

HEXADECIMAL

Most mini computers and microcomputers have their memories organized into sets of bytes, each consisting of eight binary digits. Each byte either is used as single entities to represent a single alpha numeric character or is broken into two 4 bit pieces. When the bytes are handles in two 4 bit pieces the programmer is given the option of declaring each 4 bit character as a piece of a binary number or as two, BCD numbers. For instance, the byte 00011000 can be declared a binary number in which case it is equal to 24 decimal, or as two BCD characters in which case it represents the decimal number 18.

When the machine is handling numbers in binary but in groups of four digits it is convenient to have a code for representing each of these sets of four digits. Since, 16 possible different numbers can be represented, the digits 0 through 9 will not suffice, so the letters A, B, C, D, E and F are used.

CONVERT BINARY TO HEXADECIMAL

Example:

$1010/1110/1101 \rightarrow (AED)_{16}$

$010/1010_2 = 2A_{16}$

$1010/0010 = A2_{16}$

CONVERT HEXADECIMAL TO DECIMAL

1. A B 6

$6 \times 16^0 = 6 \times 1 = 6$

$11 \times 16^1 = 11 \times 16 = 176$

$10 \times 16^2 = 10 \times 256 = 2560$

2742

$AB6_{16} = (2742)_{10}$

2. (1 A 2 E)2

$$14 \times 16^0 = 14 \times 1 = 14$$
$$2 \times 16^1 = 2 \times 16 = 32$$
$$A \times 16^2 = 10 \times 256 = 2560$$
$$1 \times 16^3 = 1 \times 4096 = 4096$$
$$\mathbf{6702}$$

$$\mathbf{(1A2E)_{16} = (6702)_{10}}$$

EXCESS – 3 CODE

The excess 3 code is another important BCD code. This code has been derived from the standard BCD code. The excess -3 code for the decimal numbers is obtained by adding 0011 to the code in standard BCD is 0110. We get the excess 3 code for 6 by adding 0011 to 0110 that is the excess 3 code for 6 is 1001. The excess 3 code is given in table

Decimal	Excess-3 Code
0	0001
1	0100
2	0101
3	0110
4	0111
5	1000
6	1001
7	1010
8	1011
9	1100
10	0100 0011
20	0101 0011
99	1100 1100
100	0100 0011 0011

GRAY CODE

This code is a unit distance code and a non-weighted code. It is not suitable for arithmetic operations but it is very useful for transducers line shaft position encoders, Input output devices, analog to digital converters and other peripheral equipments.

The relation between the gray code and the natural binary is shown in the table.

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

QUESTIONS

Fill up the blanks

1. Binary 1010 in decimal system is equivalent to ______________.
2. The decimal equivalent of the binary number 10110.0101011101 is__________.
3. Binary 101010 is equivalent to decimal number is __________.
4. The hexadecimal number A492 is equivalent to decimal number is_____________.
5. The binary number 011 1011011 is equivalent to decimal number ____________
6. The digit 0 with carry of 1 is the sum of binary addition is __________.
7. In BCD code is represented as __________
8. Octal 16 is equal to decimal _________.
9. The sum of $(111010)_2$ and $(11011)_2$ in decimal form will be__________
10. $(100101)_2$ is ____________

True or false:

1. As compared to digital computers, micro computers have high cost and big size.
2. The number of binary digits that make up the word is the word length.
3. A byte is an 8 binary digit word length.
4. BCD numbers express each decimal digit as a byte.
5. For the binary number 101101110 the equivalent octal number is 556.