Week 4

Number Systems

Arithmetic Operations

Codes

Logic Circuits Course
AIU-IE

Ch. 2
Number Systems
Arithmetic Operations
Codes

Key Terms of lecture-1

- Analog
- Digital
- Binary
- Bit
- Pulse
- Clock
- Timing diagram
- Serial
- Parallel
- Logic
- Input
- Output
- Gate
- NOT
- Inverter
- AND
- OR
- Integrated Circuits ICs

Number Systems

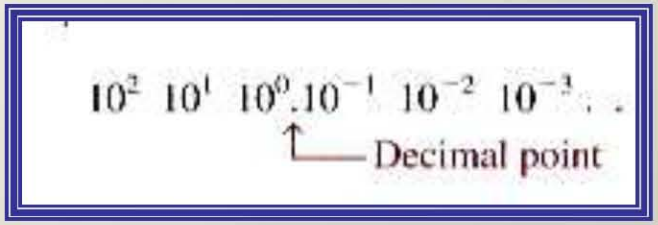
1. Decimal Numbers
2. Binary Numbers
3. Binary to Decimal Conversion
4. Decimal to Binary Conversion
5. Binary Arithmetic
6. 1st and 2nd Complement
7. Representing Signed Numbers
8. Evaluation of Signed numbers
9. Arithmetic Operation with Signed Numbers
10. Hexadecimal Numbers
11. Octal Numbers
12. Binary Coded Decimal
13. Digital Codes
14. Floating point Binary Numbers

1-Decimal Numbers

The decimal number system has ten digits .

These are : 0 , 1 , 2 , 3, 4 , 5 , 6 , 7 , 8 , 9 .

The decimal number system has the base = 10



Example -1-

$$47 = (4 \times 10^1) + (7 \times 10^0)$$
$$= (4 \times 10) + (7 \times 1) = \mathbf{40 + 7}$$

Example -2-

$$568.23 = (5 \times 10^2) + (6 \times 10^1) + (8 \times 10^0) + (2 \times 10^{-1}) + (3 \times 10^{-2})$$
$$= (5 \times 100) + (6 \times 10) + (8 \times 1) + (2 \times 0.1) + (3 \times 0.01)$$
$$= \mathbf{500 + 60 + 8 + 0.2 + 0.03}$$

2- Binary Numbers

- The binary number system has two digits: 0 and 1

- The binary numbering system has a base of 2 with each position weighted by a factor of 2:

POSITIVE POWERS OF TWO (WHOLE NUMBERS)									NEGATIVE POWERS OF TWO (FRACTIONAL NUMBER)					
2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}
256	128	64	32	16	8	4	2	1	1/2	1/4	1/8	1/16	1/32	1/64
									0.5	0.25	0.125	0.0625	0.03125	0.015625

Binary Numbers

The binary number system has two digits (bits) .

These are : 0 , 1.

The binary number system has the base = 2

$$2^{n-1} \ldots 2^3\ 2^2\ 2^1\ 2^0 . 2^{-1}\ 2^{-2} \ldots 2^{-n}$$

Binary point

The weight of a bit increases from right to left in a binary whole number

DECIMAL NUMBER	BINARY NUMBER			
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

3- Binary to Decimal Conversion

Method : Add the weights of all "1"s in a binary number to get the decimal values

Example -1-

Weight: $2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

Binary number: 1 1 0 1 1 0 1

$$1101101 = 2^6 + 2^5 + 2^3 + 2^2 + 2^0$$
$$= 64 + 32 + 8 + 4 + 1 = \mathbf{109}$$

Example -2-

Weight: $2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4}$

Binary number: 0 . 1 0 1 1

$$0.1011 = 2^{-1} + 2^{-3} + 2^{-4}$$
$$= 0.5 + 0.125 + 0.0625 = \mathbf{0.6875}$$

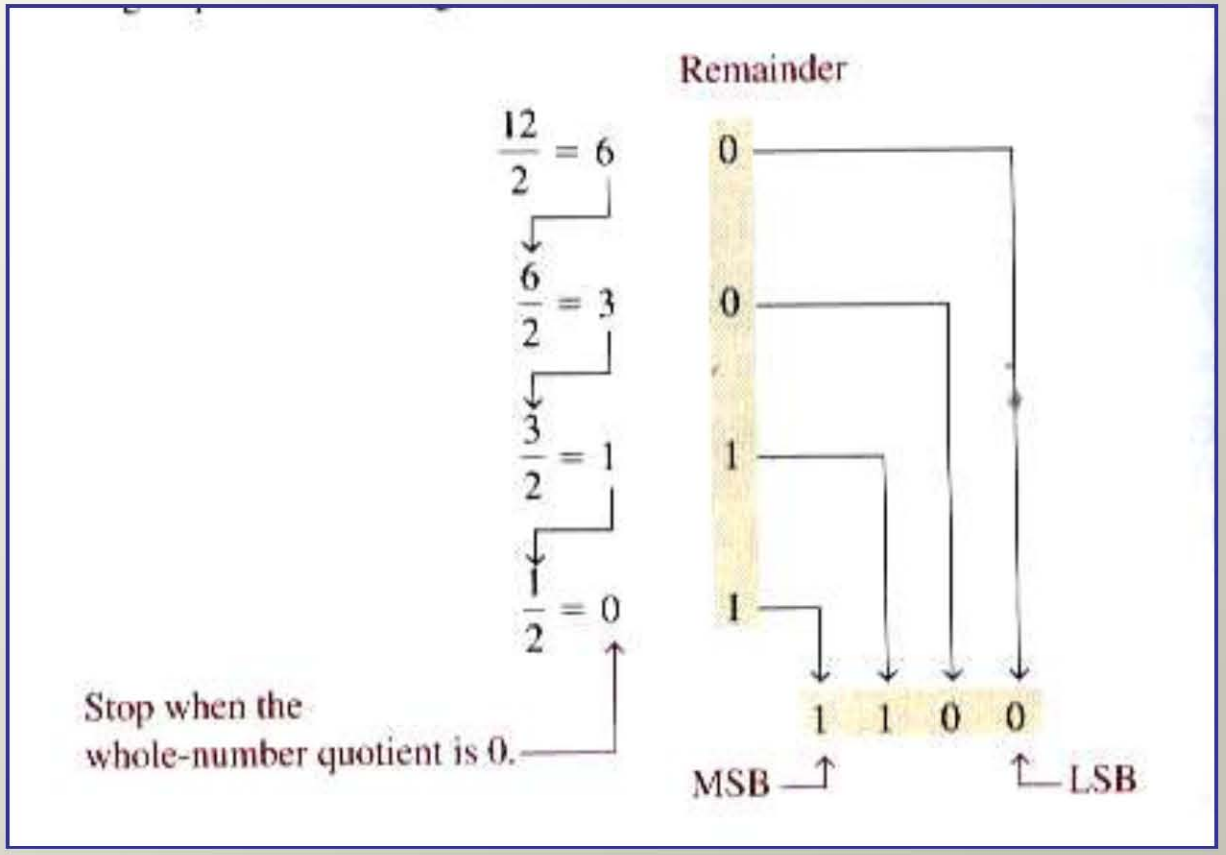
Example -3- : convert the following binary numbers into decimal number :

10101110 **11.011101**

4- Decimal to Binary Conversion

Method : To get the binary number for a given decimal number , divide decimal number by 2 until the quotient is 0 . Remainders form the binary number .

Example -1-



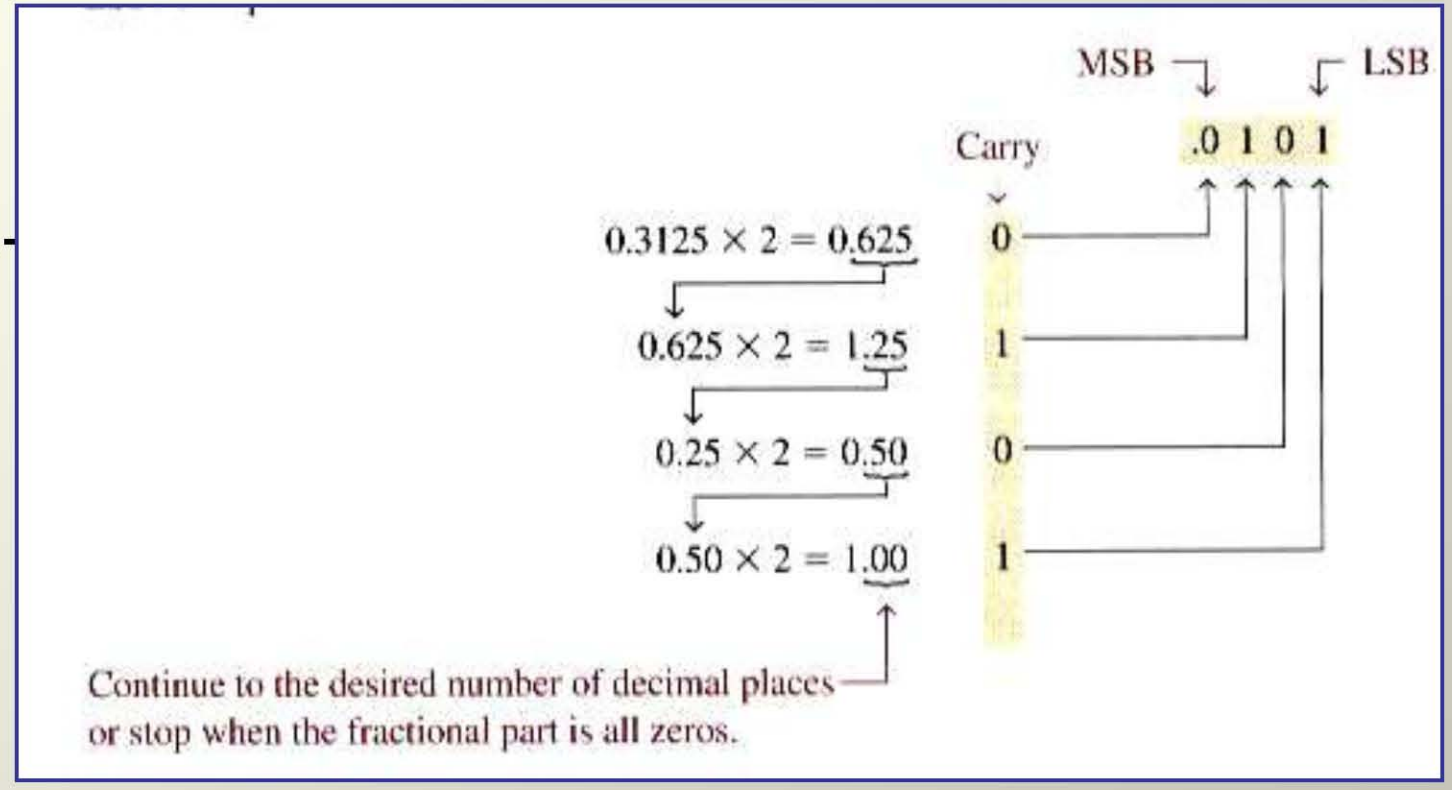
Example -2- : convert the following decimal numbers into binary :

19 - 45

Convert Decimal Fraction to Binary

Method : Repeated multiplication by 2 until fractional part is zero

Example -1-



Example -2- : convert the following decimal numbers into binary :

0.375 0.559

5- Binary Arithmetic

- Binary addition
- Binary subtraction
- Binary multiplication
- Binary division

5-1 Binary Addition :

The four basic rules for adding binary digits are :

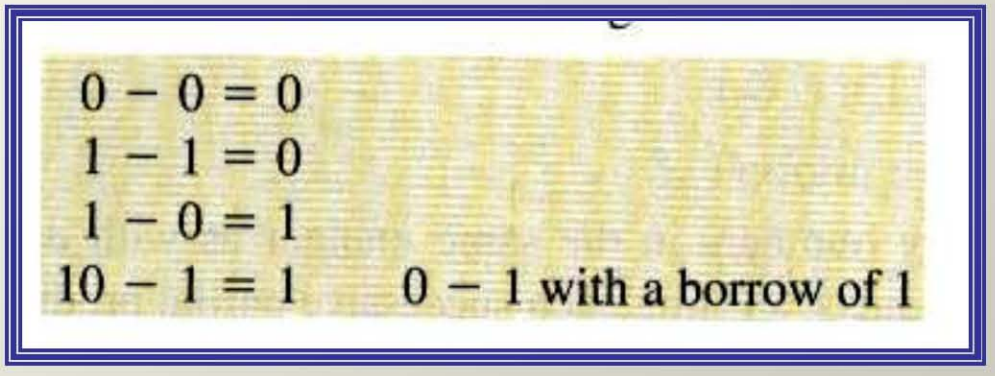
0 + 0 = 0	Sum of 0 with a carry of 0
0 + 1 = 1	Sum of 1 with a carry of 0
1 + 0 = 1	Sum of 1 with a carry of 0
1 + 1 = 10	Sum of 0 with a carry of 1

Example -1- Perform the following binary additions :

1101 + 1010 , 10111 + 01101

5-2 Binary Subtraction :

The four basic rules for subtracting binary digits are :

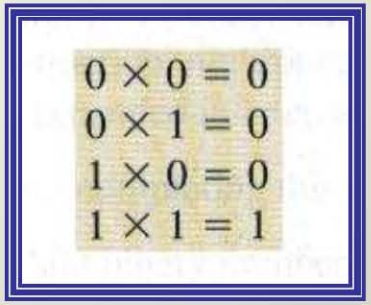


Example -1- Perform the following binary subtraction :

1101 – 0100 , 1001 - 0111

5-3 Binary Multiplication :

The four basic rules for multiplying binary digits are :



Example -1- Perform the following binary multiplication :

1101 – 0100 , 1001 - 0111

5-4 Binary Division :

Division in Binary follows the same procedure as division in decimal .

110 ÷ 11 = 10

6 ÷ 3 = 2

110 ÷ 10 = 11

6 ÷ 2 = 3

110 ÷ 11 >> 1

-11

00

0 >> 10

110 ÷ 10 >> 1

10

01

10 >> 11

- 10

00