EARNEST ACADEMY

SUBJECT: DIGITAL COMPUTER PRINCIPLES

FACULTY NAME: JYOTHSNA S MOHAN

TOPICS WE HAVE TO COVER

Digital Computer Principles: Number systems – Binary, Decimal, Octal and Hexadecimal Conversion, Arithmetic operations, Boolean algebra, Logic gates, SOP, POS, minterm and maxterms, Boolean expression, simplification, Postulates and theorems, Simplifications, K-Map, Combinational logic circuits – Adder, Subtractor, Multiplexer, Demultiplexer, Encoder, Decoder, Sequential Circuits – SR, JK, T, D flip flops, Shift registers, Asynchronous, synchronous and Modulo n Counters.

NUMBER SYSTEM

- A way to represent or express numbers using a given set of symbols.
- People use the decimal number system.
- In digital electronics, binary number system and digital codes are used for representing the information.
- The number of unique symbols in a number system: **Radix or Base**

COMMON NUMBER SYSTEMS

- Based on the number of unique symbols, number systems are classified.

Number system	Base	Symbols
Decimal	10	0,1,2,3,4,5,6,7,8,9
Binary	2	0,1
Octal	8	0,1,2,3,4,5,6,7
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

Q) Radix of hexadecimal system is [Tradesman IT Idukki 2016]

a) 8 b) 3 c) 2 d)16

Ans. d) 16

- A number N in base b can be written as:

  $(N)_b = d_{n-1}\ d_{n-2}$ — — — — $d_1\ d_0\ .\ d_{-1}\ d_{-2}$ — — — — d_{-m}

- In the above, d_{n-1} to d_0 is integer part, then follows a radix point, and then

  d_{-1} to d_{-m} is fractional part.

- d_{n-1} = Most significant digit (MSD)
- d_{-m} = Least significant digit (LSD)

THE DECIMAL NUMBER SYSTEM

- Contains 10 unique symbols : 0,1,2,3,4,5,6,7,8,and 9
- Radix = 10
- If base value not given , it is decimal number
- Any number (integer, fraction) of any magnitude can be represented by the use of these ten symbols only.
- Each symbol in the number is called digit.
- Integer part . Fractional part

- It is a positional weighted system- Value attached to a symbol depends on its location with respect to decimal point.

- Integer part - The column weights are positive powers of ten that increase from right to left beginning with 10^0

  $\ldots 10^5\ 10^4\ 10^3\ 10^2\ 10^1\ 10^0.$

- Fractional part- The column weights are negative powers of ten that decrease from left to right: $.\ 10^{-1}\ 10^{-2}\ 10^{-3}\ 10^{-4}$

- $10^2\ 10^1\ 10^0.\ 10^{-1}\ 10^{-2}\ 10^{-3}\ 10^{-4}$

REPRESENTATION OF DECIMAL NUMBER

- Decimal number can be expressed as the sum of the products of each digit times the column value for that digit

- <u>Example:</u>

$7240 = (7 * 10^3) + (2 * 10^2) + (4 * 10^1) + (0 * 10^0) = 7 * 1{,}000 + 2 * 100 + 4 * 10 + 0 * 1$

$980.52 = (9 \times 10^2) + (8 \times 10^1) + (0 \times 10^0) + (5 \times 10^{-1}) + (2 \times 10^{-2}) = 9 * 100 + 8 * 10 + 0 * 1 + 5 * .1 + 2 * .01$

THE BINARY NUMBER SYSTEM

- Radix/base=2
- Symbols- 0,1
- Each symbol is called bit
- For digital systems, the binary number system is used.
- The column weights of binary numbers are powers of 2.
- For integer part column weights increase from right to left beginning with $2^0 = 1$:
- $\ldots 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0.$
- For fractional binary numbers, the column weights are negative powers of two that decrease from left to right: $.2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4} \ldots$
- $2^2\ 2^1\ 2^0.\ 2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4} \ldots$

COUNTING IN BINARY

DECIMAL	BINARY
0	0
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

With n bits ,its is possible to count upto a number equal to 2^n-1

$2^n-1=15$

$2^{n=}16$

$n=4$

WEIGHTING STRUCTURE OF BINARY NUMBERS

+ve powers of 2	-ve powers of 2
$2^0 = 1$	
$2^1 = 2$	$2^{-1} = 1/2$
$2^2 = 4$	$2^{-2} = 1/4$
$2^3 = 8$	$2^{-3} = 1/8$
$2^4 = 16$	$2^{-4} = 1/16$
$2^5 = 32$	$2^{-5} = 1/32$
$2^6 = 64$	$2^{-6} = 1/64$
$2^7 = 128$	$2^{-7} = 1/128$
$2^8 = 256$	$2^{-8} = 1/256$

BINARY TO DECIMAL CONVERSION

Adding the weights of all bits that are 1

Q. Convert the binary whole number 1101101 to decimal

$$\begin{array}{ccccccc} 1 & 1 & 0 & 1 & 1 & 0 & 1 \end{array}$$

$$2^6 + 2^5 + 2^3 + 2^2 + 2^0$$

$$64 + 32 + 0 + 8 + 4 + 0 + 1 = (109)_{10}$$

Q. Covert the fractional binary number 0.1011 to decimal.

$$0\,.\;1\quad 0\quad 1\quad 1$$

$$2^{-1} + 2^{-3} + 2^{-4} = 0.5 + 0.125 + 0.0625 = 0.\,6875$$

DECIMAL TO BINARY

CONVERSION OF FIXED DECIMALS TO BINARY

Methods

- Sum of weights
- Repeated division by 2

Sum of weights:

1.Determine the sets of binary weights whose sum is equal to the decimal number.

2. Placing 1's in those weight positions and 0's in the remaining positions

Repeated division by 2:

1. Take decimal number as dividend.
2. Divide this number by 2
3. Store the remainder in an array
4. Repeat the above two steps until the number is greater than zero.
5. Print the array in reverse order

SUM OF WEIGHTS

Q. Find the binary equivalent of 9

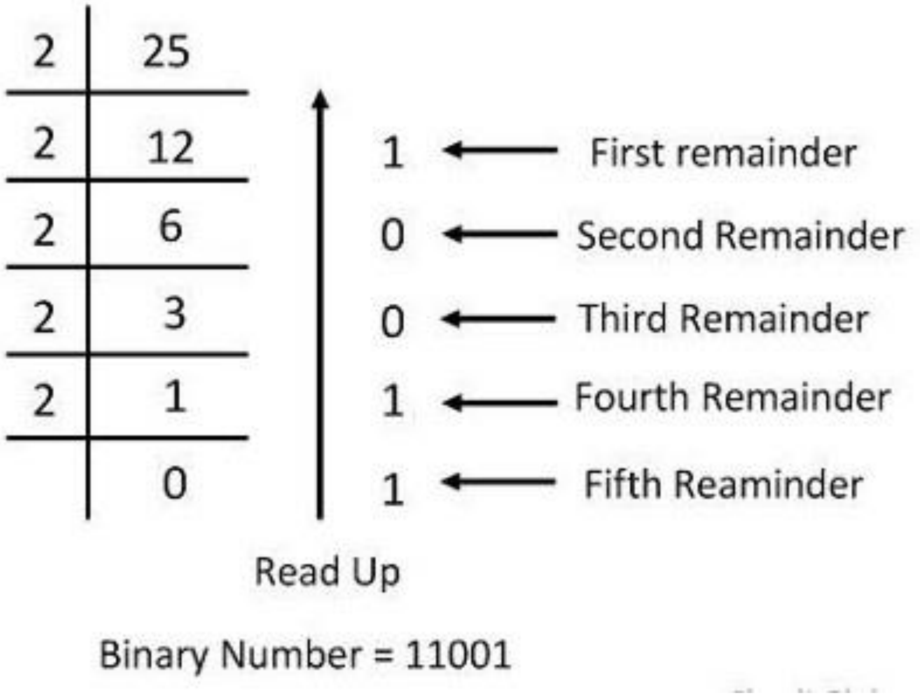
2^4	2^3	2^2	2^1	2^0
16	**8**	4	2	**1**
0	1	0	0	1

Q. Binary number of the decimal number 15 is: [Sub Inspector]

a) 1010 b) 1111 c)1101 d)1001

REPEATED DIVISION BY 2

Q) Binary number of the decimal number 25 is



Q. Binary number of the decimal number 15 is: [Sub Inspector]

a) 1010 b) 1111 c)1101 d)1001

CONVERSION OF DECIMAL FRACTIONS

Methods

- Sum of weights
- Repetitive multiplication by 2

Sum of weights:

1.Determine the sets of binary weights whose sum is equal to the fraction value.

2. Placing 1’s in those weight positions and 0’s in the remaining positions

Repeatitive multiplication by 2:

1. Multiply the fractional decimal number by 2.

2.Integral part of resultant decimal number will be first digit of fraction binary number.

3. Repeat step 1 using only fractional part of decimal number and then step 2 till all fractional bits become 0 or upto a required precision.

FRACTIONAL DECIMAL TO BINARY - SUM OF WEIGHTS

Q. Convert 0.1875 to binary

2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}
0.5	**0.25**	**0.125**	**0.0625**	0.03125
0	0	1	1	0

Ans: 0.0011

Q. The decimal value of 0.25 [GATE 2002]

a) is equivalent to binary 0.1

b) is equivalent to binary 0.01

c) is equivalent to binary 0.00111

d) Cannot be represented precisely in binary

Ans: b) is equivalent to binary 0.01

FRACTIONAL DECIMAL TO BINARY WITH REPETITIVE MULTIPLICATION BY 2

Q) The binary equivalent of the decimal number 0.34375 is :

[Lecturer in polytechnic IT 2015]

A. 0.0111

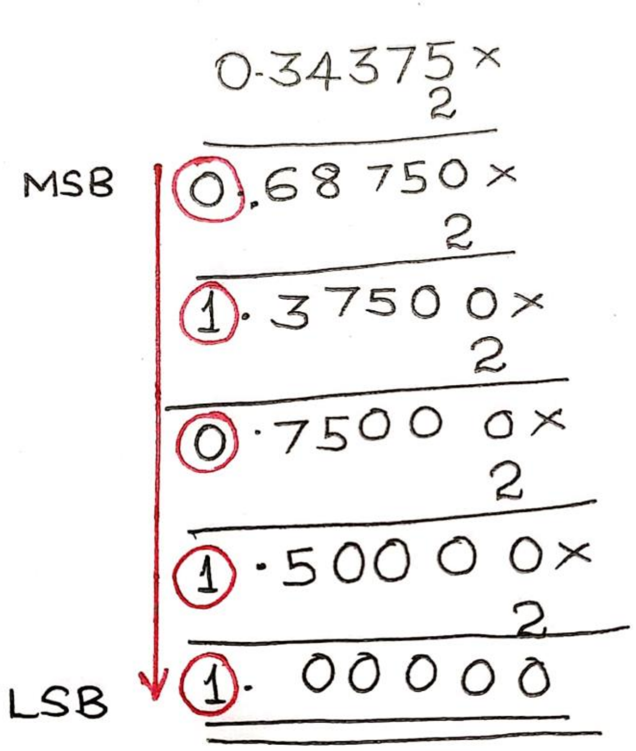
B. 0.01111

C. 0.01011

D. 0.01110 1

Ans: 0.01011

Solution:



Q) The binary equivalent of the number 0.3125

Ans: 0.0101

Q)The binary equivalent od decimal number 20.625 is: [Lecturer in CS 2015]

a)10100.1011 b) 10100.1100

c)10100.1010 d) 10101.1010

Ans: c) 10100.1010

BINARY ARITHMETIC

- Binary addition
- Binary subtraction
- Binary Multiplication
- Binary division

BINARY ADDITION

Rules for binary addition

Case	A	+	B	Sum	Carry
1	0	+	0	0	0
2	0	+	1	1	0
3	1	+	0	1	0
4	1	+	1	0	1

$$\begin{array}{rr} {\color{red}{0\,1\,1\,1}} & \\ 00111 & 7 \\ 10101 & 21 \\ \hline 11100 & {\color{red}{=}}\,28 \end{array}$$

Q. Find 1011.11 + 011.101

	1	1	1					
1	0	1	1	.	1	1	0	+
	0	1	1	.	1	0	1	
---	---	---	---	---	---	---	---	
1	1	1	1	.	0	1	1	

BINARY SUBTRACTION

Rules for binary subtraction

Case	A - B	Subtract	Borrow
1	0 - 0	0	0
2	1 - 0	1	0
3	1 - 1	0	0
4	0 - 1	$\boxed{1}$	1

0011010 - 001100 = 00001110

$$
\begin{array}{rl}
1\;1\quad & \text{borrow} \\
0\,0\,\cancel{1}\,\cancel{1}\,0\,1\,0 & = 26_{10} \\
-\,0\,0\,0\,1\,1\,0\,0 & = 12_{10} \\
\hline
0\,0\,0\,1\,1\,1\,0 & = 14_{10}
\end{array}
$$

Q. Subtract $(10)_2$ from $(1000)_2$

$$
\begin{array}{cccc}
 & 1 & 1 & \\
\mathbf{1} & \mathbf{0} & \mathbf{0} & \mathbf{0}\ - \\
 & & \mathbf{1} & \mathbf{0} \\
\hline
\mathbf{0} & \mathbf{1} & \mathbf{1} & \mathbf{0}
\end{array}
$$

Q. Subtract $(111.111)_2$ from $(1010.01)_2$

		1	1		1	1	1	
1	0	1	0	.	0	1	0	-
	1	1	1	.	1	1	1	
-------	-------	-------	-------	-------	-------	-------	-------	
0	0	1	0	.	0	1	1	

Thank you…..