Digital Design

CSE 232 Computer Systems Fundamentals

Administrative Rules

Course Syllabus and Outline

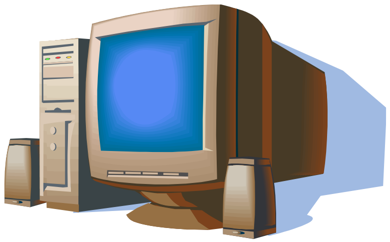
Binary Number Revision and new concepts

What is CSE 232

It is a freshmen level course that provides a comprehensive understanding of DIGITAL SYSTEMS using integrated circuits (IC's)

A digital system is any system that gives its output in the forms of digits 9 1 2 5

Perquisite not needed



DIGITAL SYSTEMS

Why CSE232

For Computer majors it is very essential and crucial in understanding all Hardware and Electronic related materials.

For Engineering majors it is very essential in understanding the operational behavior in any MACHINE

To understand how to build a digital circuit.

How to design and debug a digital system.

How to use digital systems in other applications

Objectives

- Understand different numerical codes and how to transform to or from the Binary numerical system
- Understand Boolean algebra and its relevance to digital logic design
- Describe the basic logic functions and gates (AND, OR, NOT, NAND, NOR, XOR)
- Understand combinational logic components—such as adders, decoders, encoders, multiplexers, etc.
- Analyze and design combinational and sequential circuits
- Design larger components from compositions of smaller ones

Syllabus

Check the course outline

Instructor: Dr. *Gamal Fahmy*
Instructor Office Hours: Monday, 12:00 pm to 3:00 pm in AO.I.256
Reference Book, Morris Mano, Digital Design
“To book time for office hours please send an email to Gamal.Fahmy@gu.edu.eg and expect a confirmation”.

Weekly Assignments shall be handed-in before deadline; no late assignments will be accepted. It is due EVERY week before tutorial. There will be **NO** makeup examinations for students not attending the Quizzes, Mid Term and Final Examination, except with admin excuse. No marks will be given to students attending the examinations in a different time other than their assigned examination time.

Grading Criteria

Semi Weekly / Weekly Quizzes	**25**
Tutorial Assignments	**15**
Mid Term Examination	**10**
Final Examination	**40**
Project	**10**
Total	**100**

Reminders

Visit the class web site regularly

It will be posted electronically

Don’t postpone your work

Cheating will not be tolerated

Keep in touch with Instructor and TA’s

Numbers

Natural Numbers

Zero and any number obtained by repeatedly adding one to it.

Examples: 100, 0, 45645, 32

Negative Numbers

A value less than 0, with a – sign

Examples: -24, -1, -45645, -32

→ Binary Numirical
→ Decimal
→ Hexadecimal

Bin 0, 1

Decimal

Hex

0, 1, 2, 3, 4, 5, 6, 9,

7, 8

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

This is our 1st pentab

Digital Design

Morris Mano

Convert from Decimal to Binary

B
D
X

9

9 → Bin

5A1 ? B ×
D ×
X ✓

01011 ? B ✓
D ✓
X ✓

539 ? B ×××
D ✓
X ✓

9	
4	1 ← LSB
2	0
1	0
0	1 ← MSB

1001 → 9

13	← LSB
6	1
3	0
1	1
0	1 ← MSB

1101 13

7	
3	1
1	1
0	1

7 → 111

Convert Binar to Decimal

$\boxed{1011}_2$

$\boxed{573}_{10}$

$\boxed{A1B}_{16}$

$$(1011)_2 = 1\times2^0 + 1\times2^1 + 0\times2^2 + 1\times2^3 = 1+2+0+8 = (11)_{10}$$

$$(10110)_2 = 0\times2^0 + 1\times2^1 + 1\times2^2 + 0\times2^3 + 1\times2^4 = 0+2+4+0+16 = 22$$

$$(73)_{10} = 3\times10^0 + 7\times10^1 = 3+70 = 37$$

Convert Hex to Bin & Bin to H

	0	0000
	1	0001
	2	0010
	3	0011
	4	0100
	5	0101
	6	0110
	7	0111
	8	
	9	1000
16	A	1001
11	B	1010
12	C	1011
13	D	1100
14	E	1101
1	F	111

$(A1B)_x \rightarrow (101000011011)$

$0\,(0\,0\,1\,0\,1\,1\,0\,1\,1\,1\,0\,0\,1\,0\,1)_2$

$?_x \rightarrow (16E5)_x$

Convert $X \to D$

Hex $\to$ Decimal

$(10)_{10} \to ? (A)_X$

10	
0	A

$(573)_{10} \to ?_X$

573		
3	9	L
0	3	M

$(39)_X$

A

C

E F

$(A1B)_X = B \times 16^0 + 1 \times 16^1 + A \times 16^2$

$= 11 \times 1 + 16 + 256 = 283$

Numbers

Integers

A natural number, a negative number, zero

Examples: 249, 0, - 45645, - 32

Rational Numbers

An integer or the quotient of two integers

Examples: -249, -1, 0, 3/7, -2/5

Natural Numbers

How many ones are there in 642?

600 + 40 + 2 ?

Or is it

384 + 32 + 2 ?

Or maybe…

1536 + 64 + 2 ?

Natural Numbers

Aha!

642 is 600 + 40 + 2 in BASE 10

The base of a number determines the number of digits and the value of digit positions

Positional Notation

Continuing with our example…

642 in base 10 *positional notation* is:

$$\begin{aligned} & 6 \times 10^2 = 6 \times 100 = 600 \\ + & 4 \times 10^1 = 4 \times 10 = 40 \\ + & 2 \times 10^0 = 2 \times 1 = 2 \quad = 642 \text{ in base 10} \end{aligned}$$

This number is in base 10

The power indicates the position of the number

Positional Notation

Example: 642 is $6 * 10^2 + 4 * 10 + 2$

R is the base of the number

As a formula:

$$d_n * R^{n-1} + d_{n-1} * R^{n-2} + \ldots + d_2 * R + d_1$$

n is the number of digits in the number

d is the digit in the i^{th} position in the number

Positional Notation

What if 642 has the base of 13?

$$
\begin{aligned}
&+ 6 \times 13^2 &= \ & 6 \times 169 &= 1014 \\
&+ 4 \times 13^1 &= \ & 4 \times 13 &= 52 \\
&+ 2 \times 13^0 &= \ & 2 \times 1 &= 2 \\
& & & &= 1068 \text{ in base } 10
\end{aligned}
$$

642 in base 13 is equivalent to 1068 in base 10

Numerical System Review

$$(56.32)_{10} = 5*10^{1} + 6*10^{0} + 3*10^{-1} + 2*10^{-2}$$

$$(34)_{8} = 3*8^{1} + 4*8^{0}$$

$$(E1)_{16} = 14*16^{1} + 1*16^{0}$$

$$(010.11)_{2} = 0*2^{2} + 1*2^{1} + 0*2^{0} + 1*2^{-1} + 1*2^{-2}$$

Numbers in the Decimal System starts from 0 to 9 NOT from 1 to 10 (which represents 2 digits)

Binary 0 to 1, Octal 0 to 7, Hexadecimal 0 to F(15)

Counting

- Counting in Decimal(Base 10:Symbol 0- 9):
- 0   0+1=1   1+1=2   2+1=3 . . .

$$\begin{array}{r} 1\ \text{Carry} \\ 09 \\ +\ 01 \\ \hline 10 \end{array} \quad \bullet\ \bullet\ \bullet \quad \begin{array}{r} 1\ \text{Carry} \\ 19 \\ +\ 01 \\ \hline 20 \end{array}$$

- Counting in Binary (Base 2: Symbols 0-1):

$$\begin{array}{r} 00 \\ +\ 01 \\ \hline 01 \end{array} \qquad \begin{array}{r} 1\ \text{Carry} \\ 01 \\ +\ 01 \\ \hline 10 \end{array}$$

Decimal Binary Equivalence

Decimal	Binary	
0	0	0
1	0	1
2	1	0
3	1	1

Decimal	Binary		
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

Conversion

$$(34)_{10} = (?)_2$$

$$34/2 = 17 + 0 \qquad a_0 = 0$$

$$17/2 = 8 + 1/2 \qquad a_1 = 1$$

$$8/2 = 4 + 0 \qquad a_2 = 0$$

$$4/2 = 2 + 0 \qquad a_3 = 0$$

$$2/2 = 1 + 0 \qquad a_4 = 0$$

$$1/2 = 1/2 \qquad a_5 = 1$$

$$(34)_{10} = (a_5 a_4 a_3 a_2 a_1 a_0)_2$$

MSB $\longrightarrow$ LSB

Conversion

$(34)_{10} = (?)_2$

$$(53)_{10} = (\boxed{1}\boxed{1}\boxed{0}\boxed{1}\boxed{0}\boxed{1})_2 = (65)_8 = (35)_{16}$$

34	0
17	1
8	0
4	0
2	0
1	1
0	

LSB

MSB

$(47)_{10} = (?)_8 \qquad = (57)_8$

47	7
5	5
0	

LSB

MSB

Example

What Base system are we using if 46/2=8

$$(4*r^1+6*r^0)/(2*r^0)=8*r^0$$

$4r+6=16$ $\qquad$ *does not exit*

Arithmetic

Addition

$$\begin{array}{r} 11010 \\ 11001 \\ \hline 110011 \end{array}$$

Carry

Arithmetic

Multiplication

```
      11010
        101
  ---------
      11010
     00000
    11010
  ---------
    10000010
```

Subtraction

$$
\begin{array}{r}
101101 \\
110 \\
\hline
100111
\end{array}
$$

1's Complement and 2's Complement

An easier implementation for negative numbers in the subtraction process

1's complement of C(N)=2^n - N -1

1's complement of C(N)=(1000-1)-110=001

2's complement of C(N)=1's complement + 1

=010

Subtraction with 2's complement

$K + C(N) = K - N + 2^n$

If K > N, then you get a carry that you can discard

If K < N, then you get the 2's complement of the result

Example

X=1001 Y=0110

X-Y=1001+1010

=1 0011

X=0110 Y=1010

X-Y=0110+0110

= 1100 take its 2's

= 0100

Codes

Binary Coded Decimals (BCD):

Each decimal digits 4 binary digits

ASCII
Each character get 7 binary digits

Gray Coded Numbers:
1 bit change per one increment

Home work

Problems:

Number 3, 5 due next week in tutorial