CMSC 130

Lecture 1 – Number Systems

Why study Digital Design?

- Look "under the hood" of computers
  - solid understanding – awareness of hardware resource issues
- Electronic devices becoming digital
  - better devices
  - Known as "embedded systems"
    - new devices every year – potential career opportunity (e.g. designer)

Digital signal vs Analog signal

- Analog signal
  - Infinite possible values

  Ex. Voltage on a wire created by microphone
- Digital signal
  - Finite possible values

  Ex. Button pressed on a keypad

Data Representation

- Computer memory
  - Information are stored as electric signals in a binary format
- Usually, numbers are represented by two voltage levels (1 or 0)
- Bit, nibble, byte, word, long word

Number Systems

- Number system in base N
- Common number system and base
  - binary, base 2
  - octal, base 8
  - decimal, base 10
  - hexadecimal, base 16

Number Systems

- Binary
  - Base: 2
  - Symbols: 0 and 1
  - Representation of
    - false and true in Boolean algebra
    - 0 volts and 5 volts in electronic systems
  - Value of positions is based on powers of 2
  - Digits are referred to as bits

Number Systems

- Octal
  - Base: 8
  - Symbols: 0 – 7
  - Value of positions is based on powers of 8

Number System

- Decimal
  - Base: 10
  - Symbols: 0 – 9
  - Value of positions is based on powers of 10

Number System

- Hexadecimal (hex for short)
  - Base: 16
  - Symbols
    - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
    - A, B, C, D, E, F
  - Used as a shorthand for binary numbers
  - Value of positions is based on powers of 16

Number System: conversion

- Given a number ***a*** in base **N**, find the equivalent number ***b*** in base **M**…
- Value of ***a*** must be equal to value of ***b***

Number System: conversion

- Decimal to Binary: 21
- Binary to Decimal: 1101
- Decimal to Octal: 41
- Octal to Decimal: 235
- Binary to Octal: 111011
- Octal to Binary: 12

Number System: conversion

- Decimal to Hex: 47
- Hex to Decimal: BAD
- Binary to Hex: 101011
- Hex to Binary: 21

Number System: conversion

Decimal	Binary	Octal	Hexadecimal
00	00000	00	00
01	00001	01	01
02	00010	02	02
03	00011	03	03
04	00100	04	04
05	00101	05	05
06	00110	06	06
07	00111	07	07
08	01000	10	08
09	01001	11	09
10	01010	12	0A

Number System: conversion

Decimal	Binary	Octal	Hexadecimal
11	01011	13	0B
12	01100	14	0C
13	01101	15	0D
14	01110	16	0E
15	01111	17	0F
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14

Useful Information

- To determine how many binary digits a binary number representation of a value needs, use

  $\log_2 (X) + 1$

  X is the value

  Consider the integer part only

- With n digits, 2^n unique numbers (from **0 to** 2^n-1) can be represented

Reference

- Mano, M. M. and M. D. Ciletti. Digital design, fourth edition. Prentice Hall.