PHY 307: Electronics-II

Tutorial-2

Number systems (concept notes)

Signed and Unsigned Numbers. When a fixed precision binary number is used to hold only positive values, it is said to be unsigned. The range of positive values that can be represented is [0 – (2^n -1)], where n is the number of bits used. For representing signed (negative as well as positive) numbers in binary, a part of the total range of values is used to represent positive values, and the rest of the range is used to represent negative values. There are several ways that signed numbers can be represented in binary, but the most common representation used today is called **two's complement**.

The two's complement of 10110101 can be formed by inverting the bits 11010110 and then add 1 which will result 01001011. The operation is inverting all of the bits and adding 1. In a binary number being interpreted using the two's complement representation, the high order bit of the number indicates the sign. If the sign bit is 0, the number is positive, and if the sign bit is 1, the number is negative. For positive numbers, the rest of the bits hold the true magnitude of the number. For negative numbers, the lower order bits hold the complement (or bitwise inverse) of the magnitude of the number. It is important to note that two's complement representation can only be applied to fixed precision quantities, that is, quantities where there are a set number of bits. Two's complement representation is used because it reduces the complexity of the hardware in the arithmetic-logic unit of a computer's CPU. Using a two's complement representation, all of the arithmetic operations can be performed by the same hardware whether the numbers are considered to be unsigned or signed.

ASCII Character Encoding: The ASCII (American Standard Code for Information Interchange) is a character encoding standard developed to provide a standard way for digital machines to encode characters (alphabetic characters, numeric digits, and punctuation marks). As originally designed, it was a seven-bit code. The seven bits allow the representation of 128 unique characters. All of the alphabet, numeric digits and standard English punctuation marks are encoded. The ASCII standard was later extended to an eight-bit code (which allows 256 unique code patterns) and various additional symbols were added, including characters, with diacritical marks (such as accents) used in European languages, which don't appear in English.

Binary Coded Decimal (BCD) Numbers: In this system, numbers are represented in a decimal form, however each decimal digit is encoded using a four-bit binary number. For example: The decimal number 136 would be represented in BCD as follows: 136 = 0001 0011 0110

Example 2: The following is a 16 bit number encoded in packed BCD format: 01010110 10010011

This is converted to a decimal number as follows: 0101 0110 1001 0011=5693_{10}

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(Binary numbers: Codes and arithmetic)

1. **Binary to decimal conversion:** Convert the following binary numbers to decimal,

   (i). 1110.101_2, (ii). 110011.10011,, (iii). 1010101010.1.

2. **Decimal to binary conversion:** Convert the following decimal numbers to binary,

   (i). 0.84375_{10}, (ii). 34.75_{10}, (iii). 27.1875_{10}.

3. **2s complement:**

   (i). Convert the following signed decimal numbers to their 8-bit 2s complement equivalents:

   (a) +13, (b) +110, (c) -25, (d) -90.

   (ii). Convert the following **2s** complement numbers to their signed decimal equivalents:

   (a) 01110000, (b) 00011111, (c) 11011001, (d) 11001000.

4. **BCD numbers:** (i). Convert the following BCD numbers to their decimal equivalents:

   (a) 1010 (b) 010101000011 (c) 10000110 (d) 00110010.10010100

   (ii). Convert the following decimal numbers to their 8421 BCD equivalents:

   (a) 6, (b) 13, (c) 99.9, (d) 872.8

5. **ASCII code:** Find the ASCII keyboard-encoder output if the K on the typewriter-like keyboard were pressed.

6. **Arithmetic addition in binary numbers:**

   (i). $+37_{10}+18_{10}$, (ii). $+37_{10}-18_{10}$, (iii). $-37_{10}-18_{10}$, (iv). $-37_{10}+18_{10}$.