

Notes for ECE 27000 - Introduction to Digital System Design

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Course Description

An introduction to digital system design, with an emphasis on practical design techniques and circuit implementation.

Number Systems

In daily life, we primarily interact with the familiar base-10 numbers. However, when interaction with digital systems, we must also concern ourselves with base-2, base-8, base-16, and other bases which are friendly to binary states. Unless completely unambiguous, the base of a number is written as a right subscript such as 144_{10} for base-10 or 1001_2 for base-2.

For binary numbers, each digit represents a power of two. To convert a binary number to decimal, you sum the products of each binary digit with its corresponding power of two. For example, the binary number 1001 is calculated as

$$2^3 \times 1 + 2^2 \times 0 + 2^1 \times 0 + 2^0 \times 1 = 8 + 0 + 0 + 1 \quad (1)$$

$$= 9_{10} \quad (2)$$

To convert from hexadecimal to decimal, each digit represents a power of sixteen. For instance, the hexadecimal number f1 is calculated as

$$15 \times 16 + 1 \times 16 = 240 + 1 \quad (3)$$

$$= 241_{10} \quad (4)$$

where f represents the decimal value 15. When converting to another base, reverse the process by dividing the decimal number by the target base, recording the remainder, and repeating with the quotient until it reaches zero. The remainders give you the digits of the number in the new base, read in reverse order.

To convert a decimal number into binary, for example, you repeatedly divide the number by 2 and record the remainders. For the decimal number 9, dividing by 2 gives a quotient of 4 and a remainder of 1. Dividing 4 by 2 gives a quotient of 2 and a remainder of 0. Dividing 2 by 2 gives a quotient of 1 and a remainder of 0, and finally, dividing 1 by 2 gives a quotient of 0 and a remainder of 1. Reading the remainders from bottom to top, the binary representation of 9 is 1001.

In SystemVerilog, numbers are written in format `[size]'[base][number]`, for example:

- `4'b1001` // binary, 9 in decimal, bit width 4 bits
- `8'hf1` // hex, equals 241, bit width 8 bits
- `3'o3` // octal, 3, bit width 3 bits
- `32'b1001_1101_0101_1111` // binary, 40255, bit width 32 bits