Introduction
Number Systems and Conversion

Objectives

1. Introduction
   The first part of this unit introduces the material to be studied later. In addition to getting an overview of the material in the first part of the course, you should be able to explain
   a. The difference between analog and digital systems and why digital systems are capable of greater accuracy
   b. The difference between combinational and sequential circuits
   c. Why two-valued signals and binary numbers are commonly used in digital systems

2. Number systems and conversion
   When you complete this unit, you should be able to solve the following types of problems:
   a. Given a positive integer, fraction, or mixed number in any base (2 through 16); convert to any other base. Justify the procedure used by using a power series expansion for the number.
   b. Add, subtract, multiply, and divide positive binary numbers. Explain the addition and subtraction process in terms of carries and borrows.
   c. Write negative binary numbers in sign and magnitude, 1's complement, and 2's complement forms. Add signed binary numbers using 1's complement and 2's complement arithmetic. Justify the methods used. State when an overflow occurs.
   d. Represent a decimal number in binary-coded-decimal (BCD), 6-3-1-1 code, excess-3 code, etc. Given a set of weights, construct a weighted code.

Study Guide

1. Study Section 1.1, *Digital Systems and Switching Circuits*, and answer the following study questions:

   (a) What is the basic difference between analog and digital systems?

   (b) Why are digital systems capable of greater accuracy than analog systems?

   (c) Explain the difference between combinational and sequential switching circuits.

   (d) What common characteristic do most switching devices used in digital systems have?

   (e) Why are binary numbers used in digital systems?

2. Study Section 1.2, *Number Systems and Conversion*. Answer the following study questions as you go along:

   (a) Is the first remainder obtained in the division method for base conversion the most or least significant digit?

   (b) Work through all of the examples in the text as you encounter them and make sure that you understand all of the steps.

   (c) An easy method for conversion between binary and hexadecimal is illustrated in Equation (1-1). Why should you start forming the groups of four bits at the binary point instead of the left end of the number?

   (d) Why is it impossible to convert a decimal number to binary on a digit-by-digit basis as can be done for hexadecimal?

(e) Complete the following conversion table.

Binary (base 2)	Octal (base 8)	Decimal (base 10)	Hexadecimal (base 16)
0	0	0	0
1			
10			
11			
100			
101			
110			
111			
1000			
1001			
1010			
1011			
1100			
1101			
1110			
1111			
10000	20	16	10

(f) Work Problems 1.1, 1.2, 1.3, and 1.4.

3. Study Section 1.3, *Binary Arithmetic.*

(a) Make sure that you can follow all of the examples, especially the propagation of borrows in the subtraction process.

(b) To make sure that you understand the borrowing process, work out a detailed analysis in terms of powers of 2 for the following example:

$$\begin{array}{r} 1100 \\ -\ 101 \\ \hline 111 \end{array}$$

4. Work Problems 1.5, 1.6, and 1.17(a).

5. Study Section 1.4, *Representation of Negative Numbers.*

(a) In digital systems, why are 1's complement and 2's complement commonly used to represent negative numbers instead of sign and magnitude?

(b) State two different ways of forming the 1's complement of an n-bit binary number.

(c) State three different ways of forming the 2's complement of an n-bit binary number.

(d) If the word length is $n = 4$ bits (including sign), what decimal number does 1000_2 represent in sign and magnitude?
In 2's complement?
In 1's complement?

(e) Given a negative number represented in 2's complement, how do you find its magnitude?

Given a negative number represented in 1's complement, how do you find its magnitude?

(f) If the word length is 6 bits (including sign), what decimal number does 100000_2 represent in sign and magnitude?

In 2's complement?

In 1's complement?

(g) What is meant by an overflow? How can you tell that an overflow has occurred when performing 1's or 2's complement addition?

Does a carry out of the last bit position indicate that an overflow has occurred?