Digital Logical Circuits Volume I

An Online Continuing Education Course for Engineers

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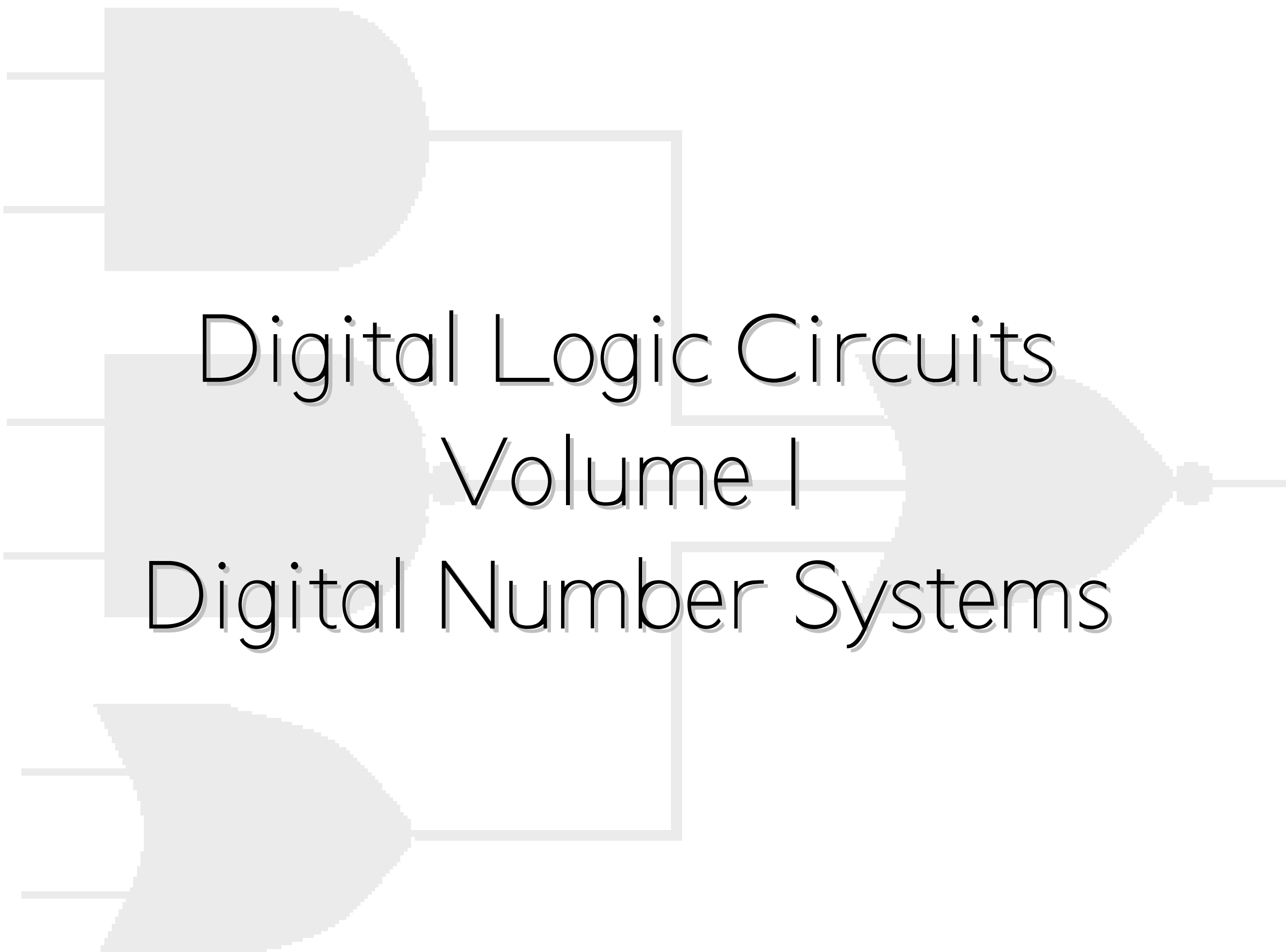
Credit: 5 Hours / 5 PDH / 5 CPD



Digital Logic Circuits
Volume I
Digital Number Systems

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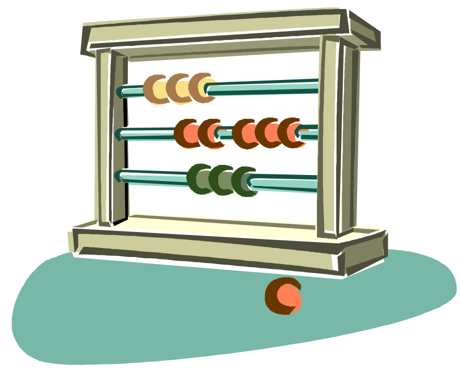
Introduction

Ever since people discovered that it was necessary to count objects, they have been looking for easier ways to count them. The abacus, developed by the Chinese, is one of the earliest known calculators. It is still in use in some parts of the world.

A Frenchman, Blaise Pascal, invented the first adding machine in 1642. Twenty years later, an Englishman, Sir Samuel Moreland, developed a more compact device that could multiply, add, and subtract. In Germany, around 1672, Gottfried Wilhelm von Leibniz perfected a machine that could perform all the basic operations (add, subtract, multiply, divide), as well as extract the square root. Modern electronic digital computers still use von Liebniz's principles.



Computers are now employed wherever repeated calculations or the processing of huge amounts of data is needed. The greatest applications are found in the military, scientific, and commercial fields. They have applications that range from mail sorting, through engineering design, to the identification and destruction of enemy targets. The advantages of digital computers include speed, accuracy, and manpower savings. Often computers are able to take over routine jobs and release personnel for more important work –work that cannot be handled by a computer.

People and computers do not normally speak the same language. Methods of translating information into forms that are understandable and usable to both are necessary. Humans generally speak in words and numbers expressed in the decimal number system, while computers only understand coded electronic pulses that represent digital information.

In this course you will learn about number systems in general and about binary, octal, and hexadecimal number systems specifically. Methods for converting numbers in the binary, octal, and hex systems to equivalent numbers in the decimal system (and vice versa) will also be described. You will see that these number systems can be easily converted to the electronic signals necessary for digital equipment.

This course is the first in a series of courses and lays out the basics needed to comprehend digital logic circuits. Subsequent courses address fundamental logic circuits and special logic circuits.

Chapter 1
Types of Number Systems

Most people only use one number system, the decimal system and some are familiar with the Roman numeral system, even though they rarely use it, except maybe to translate how many Super Bowls have occurred! In this chapter we will look at the different types of number systems.

The Decimal Number System

We all know and understand the decimal number system and therefore this course uses the decimal number system to explain other bases. The examples may seem simplistic, but they will help to understand other number systems. You should realize that these systems have certain things in common. These common terms will be defined using the decimal system as our base. Each term will be related to each number system as that number system is introduced.

Each of the number systems you will study is built around the following components: the *unit*, *number*, and *base* (radix).

Unit and Number

The terms *unit* and *number* when used with the decimal system are almost self–explanatory. By definition the unit is a single object; that is, an apple, a dollar, a day. A number is a symbol representing a unit or a quantity. The figures 0, 1, 2, and 3 through 9 are the symbols used in the decimal system. These symbols are called *Arabic numerals* or figures. Other symbols may be used for different number systems.

For example, the symbols used with the Roman numeral system are letters, for instance, "V" is the symbol for 5, "X" for 10, "M" for 1,000, and so forth. We will use Arabic numerals and letters in the number system discussions in this chapter.

Base (Radix)

The *base*, or *radix*, of a number system tells you the number of symbols used in that system. The base of any system is always expressed in decimal numbers. The base, or radix, of the decimal system is 10. This means there are 10 symbols –0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 –used in the system. A number system using three symbols –0, 1, and 2 –would be base 3; four symbols would be base 4; and so forth. Remember to count the zero or the symbol used for zero when determining the number of symbols used in a number system.

The base of a number system is indicated by a subscript (decimal number) following the value of the number. The following are examples of numerical values in different bases with the subscript to indicate the base:

7592

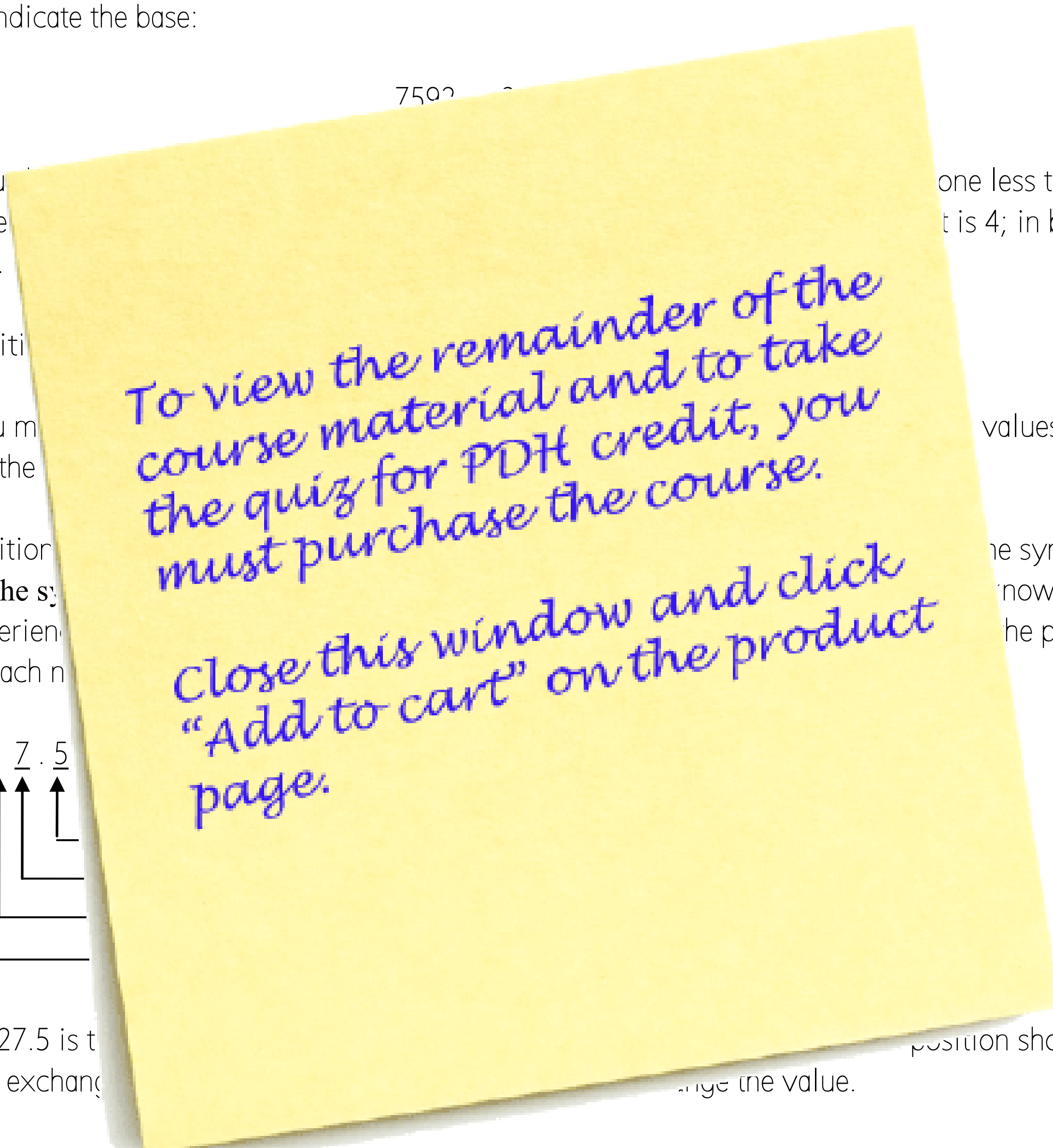
You ... one less than the base ... t is 4; in base–3 it is 2.

Positi...

You m... values. They are the ...

Position... he symbol but **by the sy**... now from experien... he position of each n...

4 2 7 . 5



If 427.5 is t... position shown. If you exchang... nge the value.

Each position in the positional notation system represents a power of the base, or radix. A *power* is the number of times a base is multiplied by itself. The power is written above and to the right of the base and is called an *exponent*. Examine the following base–10 line graph,