Lab 1.5.4: Converting Numbers Overview

Estimated Time: 25 Minutes

Objective

Upon completion of this lab, you will be able to identify the *places* in binary and decimal numbers and know the value of each. Also, you will work with powers of 10 and relate them to decimal places as well as work with powers of 2 and relate them to binary places. Finally, you will manually convert between simple binary numbers and decimal numbers and describe the differences between binary and decimal number systems.

Equipment

This is a written lab exercise.

Scenario

Having sharp skills in number systems will aid you in your career as an IT professional. With the ability to convert numbers without the use of a calculator, you will be able to solve problems that may arise quickly and easily.

Procedures

This lab will help you learn to work with the binary number system. You will convert binary numbers (Base 2) to decimal numbers (Base 10) and then from decimal to binary. Computers and networking equipment, such as routers, use binary numbers, a series of BITS (short for Binary Digits) that are either ON (a binary 1) or OFF (a binary 0). They are encoded internally in the PC on microchips and on the computer motherboard's bus as electrical voltages. Understanding binary numbers and how they relate to decimal numbers is critical to understanding how computers work internally.

Step 1

The decimal number system is based on powers of 10. This exercise will help you develop and understand how the decimal number system is constructed. With Base 10, the right-most *place* has a value of 1 (as with Base 2). Each place moving to the left is valued 10 times more. 10 to the zero power is one ($10^0 = 1$), 10 to the first power is 10 ($10^1 = 10$), 10 to the second power is 100 ($10^2 = 10 \times 10 = 100$), 10 to the third power is 1000 ($10^3 = 1000$), and so on. Just multiply the number in each place with the value of each place (for example, $400 = 4 \times 10^2 = 4 \times 100$). Remember that any number (other than 0) to the zero power is 1.

The following chart shows how the decimal number system represents the number 352,481. This will help in understanding the binary number system.

Exponent	10^5	10^4	10^3	10^2	10^1	10^0
Expanded	100000	10000	1000	100	10	1
Numeral	3	5	2	4	8	1
	3 x 100,000	**5 x 10,000**	**2 x 1,000**	**4 x 100**	**8 x 10**	**1 x 1**

The number 352,481, if read from left to right in expanded decimal form, is (3 x 100,000) + (5 x 10,000) + (2 x 1,000) + (4 x 100) + (8 x 10) + (1 x 1), for a total of 352,481 (a six-digit number).

Here is another way to look at it that makes it easier to add up the decimal number values:

Position of digit (from right)	**Value of bit position (10^X or ten to the power of)**	**Number value from 0 to 9**	**Calculation**	**Decimal Value**
1st Decimal Digit	10^0 or 1	1	1 x 1	1
2nd Decimal Digit	10^1 or 10	8	8 x 10	80
3rd Decimal Digit	10^2 or 100	4	4 x 100	400
4th Decimal Digit	10^3 or 1,000	2	2 x 1,000	2,000
5th Decimal Digit	10^4 or 10,000	5	5 x 10,000	52,000
6th Decimal Digit	10^5 or 100,000	3	3 x 100,000	300,000
Decimal Value (Total of 6 digits)				**352,481**

Step 2

Binary means "two" and each digit in a binary number can only have two values (zero or one). Binary numbers are key to understanding how computers work. The value of each binary digit, or bit, is based on powers of two.

This exercise will help develop an understanding of powers of 2, which is what all computers and data communications use. With Base 2, the right-most place has a value of 1 as with Base 10. Each place moving to the left is valued 2 times more. 2 to the zero power is one ($2^0 = 1$), 2 to the first power is 2 ($2^1 = 2$), 2 to the second power is 4 ($2^2 = 4$), 2 to the third power is 8 ($2^3 = 2$), and so on. Just multiply the number in each place (either a 0 or a 1) by the value of each place (for example, $8 = 2^3 = 1 \times 8$) and add up the total. Remember that any number (except 0) to the zero power is 1.

Binary Number Conversion Example

The following table shows the detailed calculations (starting from the right side) to convert the binary number 10011100 into a decimal number.

Position of digit (from right)	**Value of bit position (two to the power of)**	**Is bit a One (on) or a Zero (off)**	**Calculation**	**Decimal Value**
1st Binary Digit	$2^0 = 1$	0	0 x 1	0
2nd Binary Digit	$2^1 = 2$	0	0 x 2	0
3rd Binary Digit	$2^2 = 4$	1	1 x 4	4
4th Binary Digit	$2^3 = 8$	1	1 x 8	8
5th Binary Digit	$2^4 = 16$	1	1 x 16	16
6th Binary Digit	$2^5 = 32$	0	0 x 32	0
7th Binary Digit	$2^6 = 64$	0	0 x 64	0

8^{th} Binary Digit	$2^7 = 128$	1	1 x 128	128
Decimal Value. (Sum total of 8 bits)				**156**

Step 3

Look at the binary number bit status. If there is a 1 in a given position add the value shown. If there is a 0 in a given position then do not add it.

Solve for the decimal value.

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary Number Bit	1	0	0	1	1	1	0	0

Decimal Value: ____

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status	1	1	1	0	0	0	1	1

Decimal Value: ____

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status	0	1	1	1	0	0	0	0

Decimal Value: ____

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status	1	1	0	1	1	0	1	0

Decimal Value: ____

Step 4

Convert the decimal values of 209, 114, 58, and 165 to their binary equivalents. To do this, look at the decimal value and then subtract binary values starting from 128 (the highest value binary bit for these number). If the number is larger than 128 then put a one in the 128 (or 2^7) column. Subtract 128 from the number and then see if there is 64 or greater left over. If there is, put a one there. Otherwise, put a zero and see if there is 32 or greater left over. Continue until all 8 bits are defined as either a zero or a one.

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status								

Binary Value of 209: ____

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status								

Binary Value of 114: ____

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status								

Binary Value of 58: ____

Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Bit Position	8	7	6	5	4	3	2	1
Value	128	64	32	16	8	4	2	1
Binary number bit status								

Binary Value of 165: ____

Step 5

Check your answers by converting the numbers back.

Troubleshooting

Learning how to calculate binary numbers without the use of a calculator is an important skill in the IT Industry. The ability to perform number conversions can save time especially in the field where calculators are not always available.

Reflection

Using the system that you have learned to solve decimal to binary conversion, convert the decimal number 255 to binary?

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