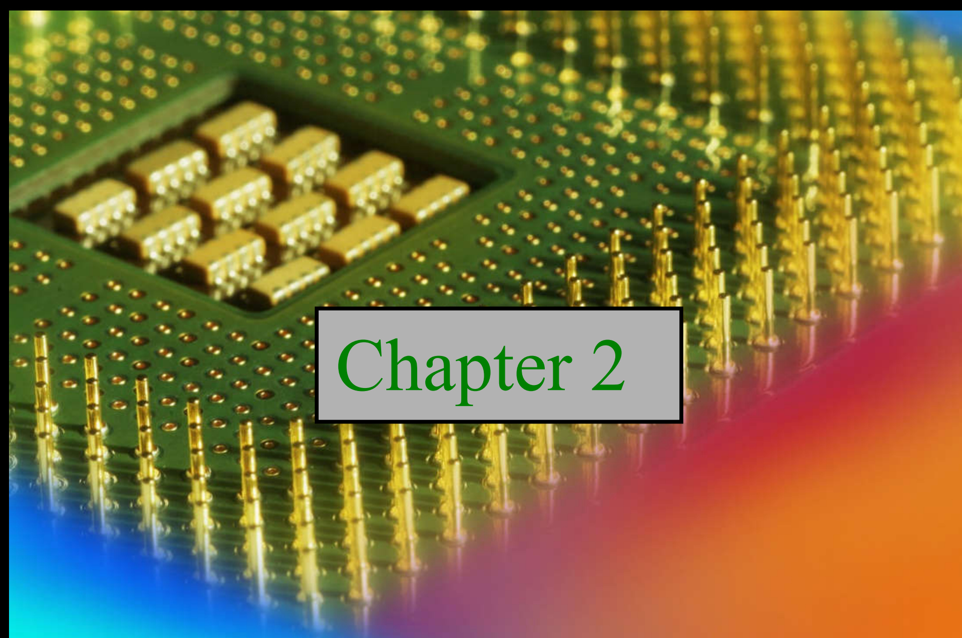
Digital Fundamentals

Tenth Edition

Floyd



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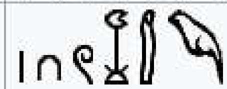
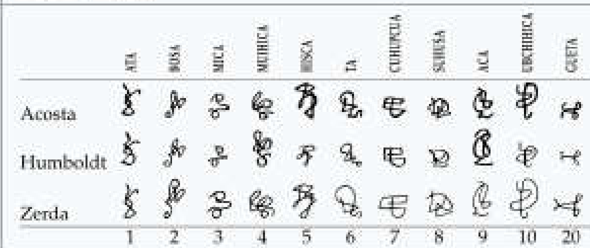
Name	Base	Sample	Approx. first appearance
Babylonian numerals	60	𒐕 𒐖 𒐗 𒐘 𒐙 𒐚 𒐛 𒐜 𒐝 𒌋	3100 BC
Egyptian numerals	10	 or 	3000 BC
Aegean numerals	10	□ □	c1500 BC
Maya numerals	20	𝋠 𝋡 𝋢 𝋣 𝋤 𝋥 𝋦 𝋧 𝋨 𝋩 𝋪 𝋫 𝋬 𝋭 𝋮 𝋯 𝋰 𝋱 𝋲 𝋳	<15th century
Muisca numerals	20		<15th century
Indian Numerals	10	Tamil 0 ௧ ௨ ௩ ௪ ௫ ௬ ௭ ௮ ௯ Devanagari 0 १ २ ३ ४ ५ ६ ७ ८ ९	750 BC – 690 BC
Chinese numerals, Japanese numerals, Korean numerals (Sino-Korean)	10	〇/零 一 二 三 四 五 六 七 八 九 十	

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Summary

Decimal Numbers

The position of each digit in a weighted number system is assigned a weight based on the **base** or **radix** of the system. The radix of decimal numbers is ten, because only ten symbols (0 through 9) are used to represent any number.

The column weights of decimal numbers are powers of ten that increase from right to left beginning with $10^0 = 1$:

$\ldots 10^5\ 10^4\ 10^3\ 10^2\ 10^1\ 10^0.$

For fractional decimal numbers, the column weights are negative powers of ten that decrease from left to right:

$10^2\ 10^1\ 10^0.\ 10^{-1}\ 10^{-2}\ 10^{-3}\ 10^{-4}\ \ldots$

https://en.wikipedia.org/wiki/List_of_numeral_systems

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Summary

Decimal Numbers

Decimal numbers can be expressed as the sum of the products of each digit times the column value for that digit. Thus, the number 9240 can be expressed as

$$(9 \times 10^3) + (2 \times 10^2) + (4 \times 10^1) + (0 \times 10^0)$$

or

$$9 \times 1{,}000 + 2 \times 100 + 4 \times 10 + 0 \times 1$$

Example

Express the number 480.52 as the sum of values of each digit.

Solution

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Summary

Binary Numbers

For digital systems, the binary number system is used. Binary has a radix of two and uses the digits 0 and 1 to represent quantities.

The column weights of binary numbers are powers of two that increase from right to left beginning with $2^0 = 1$:

$$\ldots 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0.$$

For fractional binary numbers, the column weights are negative powers of two that decrease from left to right:

$$2^2\ 2^1\ 2^0.\ 2^{-1}\ 2^{-2}\ 2^{-3}\ 2^{-4}\ \ldots$$

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Summary

Binary Numbers

The column weights of binary numbers are powers of two that increase from right to left beginning with $2^0 = 1$:

$\ldots 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0.$

Example Express the number 7 as the sum of values of each digit in binary system.

Solution

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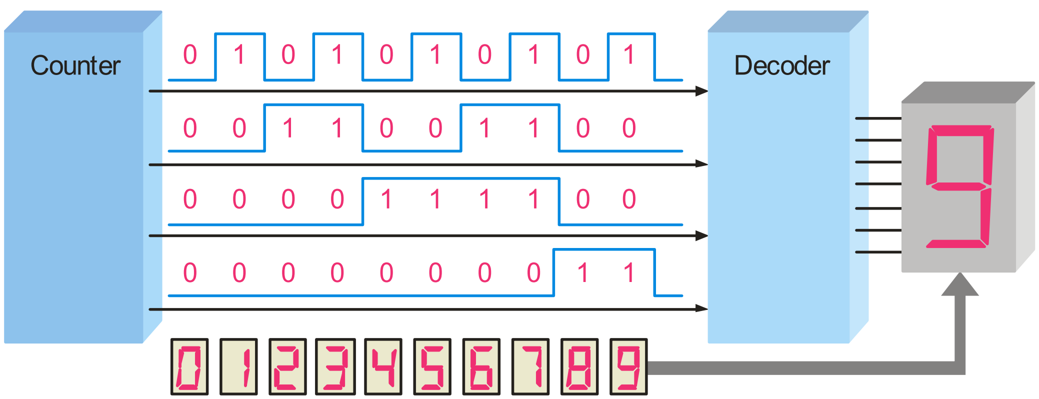
Summary

Binary Numbers

A binary counting sequence for numbers from zero to fifteen is shown.

Notice the pattern of zeros and ones in each column.

Digital counters frequently have this same pattern of digits:



Decimal Number	Binary Number
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0
11	1 0 1 1
12	1 1 0 0
13	1 1 0 1
14	1 1 1 0
15	1 1 1 1

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Summary

Binary Conversions

The decimal equivalent of a binary number can be determined by adding the column values of all of the bits that are 1 and discarding all of the bits that are 0.

Example Convert the binary number 100101.01 to decimal.

Solution Start by writing the column weights; then add the weights that correspond to each 1 in the number.

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Summary

Binary Conversions

You can convert a decimal whole number to binary by reversing the procedure. Write the decimal weight of each column and place 1's in the columns that sum to the decimal number.

Example Convert the decimal number 49 to binary.

Solution The column weights double in each position to the right. Write down column weights until the last number is larger than the one you want to convert.

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Summary

Binary Conversions

You can convert a decimal fraction to binary by repeatedly multiplying the fractional results of successive multiplications by 2. The carries form the binary number.

Example Convert the decimal fraction 0.188 to binary by repeatedly multiplying the fractional results by 2.

Solution

0.188 x 2 = 0.376	carry = 0	MSB
0.376 x 2 = 0.752	carry = 0	
0.752 x 2 = 1.504	carry = 1	
0.504 x 2 = 1.008	carry = 1	
0.008 x 2 = 0.016	carry = 0	

Answer = .00110 (for five significant digits)

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Summary

Binary Conversions

You can convert decimal to any other base by repeatedly dividing by the base. For binary, repeatedly divide by 2:

Example Convert the decimal number 49 to binary by repeatedly dividing by 2.

Solution You can do this by "reverse division" and the answer will read from left to right. Put quotients to the left and remainders on top.

Answer: 1 1 0 0 0 1 ← remainder

0 1 3 6 12 24 49 ⟨ 2

Continue until the last quotient is 0

Quotient

Decimal number

base

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Summary

Binary Addition

The rules for binary addition are

$0 + 0 = 0$	Sum = 0, carry = 0
$0 + 1 = 1$	Sum = 1, carry = 0
$1 + 0 = 1$	Sum = 1, carry = 0
$1 + 1 = 10$	Sum = 0, carry = 1

When an input carry = 1 due to a previous result,
example: 10101 + 10111 = 101100

$1 + 1 = 10$	Sum = **0**, carry = 1
$1 + 1 + 0 = 10$	Sum = **0**, carry = 1
$1 + 1 + 1 = 11$	Sum = **1**, carry = 1
$1 + 0 + 0 = 01$	Sum = **1**, carry = 0
$0 + 1 + 1 = 10$	Sum = **0**, carry = 1

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Binary Addition

Example Add the binary numbers 00111 and 10101 and show the equivalent decimal addition.

Solution

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Summary

Binary Subtraction

The rules for binary subtraction are

$$0 - 0 = 0$$
$$1 - 1 = 0$$
$$1 - 0 = 1$$
$$10 - 1 = 1 \text{ with a borrow of } 1$$

Example Subtract the binary number 00111 from 10101 and show the equivalent decimal subtraction.

Solution

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