COMPUTER LOGIC AND DIGITAL CIRCUIT DESIGN (PHYS306/COSC330): UNIT 1.3

Jordan Hanson

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Whittier College Department of Physics and Astronomy

SUMMARY

UNIT 1.3 SUMMARY - WORKING WITH BINARY

Reading: Digital Fundamentals (DF) Ch. 2 (see Moodle)

1. Number representation
2. Binary conversions
3. Binary arithmetic
4. The floating-point system
5. Hexidecimals, Binary-Coded Decimals (BCD), Gray codes, and ASCII

Homework: exercises 1-40 Ch. 2 (DF) (two weeks)

NUMBER REPRESENTATION

Questions:

- A simple question: how many students do we have in this class?
- Una simple pregunta: ¿Cuántos estudiantes tenemos en esta clase?
- Une question simple: Combien d'étudiants est-ce que nous avons dans cette classe?

What languages do computers speak? How can we store and transmit numbers through circuits? (We cannot use voltage magnitudes).

Consider the number 37

Numbers	Expanded notation
0d37	$3 \times 10^1 + 7 \times 10^0$
0b100101	$1 \times 2^5 + 1 \times 2^2 + 1 \times 2^0$
0x25	$2 \times 16^1 + 5 \times 16^0$

Consider the number 412

Numbers	Expanded notation
• 0d412	• $4 \times 10^2 + 1 \times 10^1 + 2 \times 10^0$
• 0b110011100	• $1 \times 2^8 + 1 \times 2^7 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2$
• 0x100	• 1×16^2

Number representations - Digits, weights, and a common base

- A number is written with **digits** that have **weights**.
- A **weight** is a power of a **base**.
- At right, the **base** is ten, and the **weights** are 10^2, 10^1, and 10^0.
- The **digits** are four, one, and two.
- The digits cannot represent numbers larger than the base.

Expanded notation

- $412 =$
  $4 \times 10^2 + 1 \times 10^1 + 2 \times 10^0$

Number representations - (Aside) please use scientific notation, and here is why: digit minimization!

- Scientific notation **factors the largest weight**.
- Results in weights that are less than one.
- Weights that are less than one go to the right of the **decimal point**.
- Return here with *floating-point* representation.

Expanded notation

- $412,000,000 = 4 \times 10^8 + 1 \times 10^7 + 2 \times 10^6 + 0 \times 10^5 + 0 \times 10^4 + 0 \times 10^3 + 0 \times 10^2 + 0 \times 10^1 + 0 \times 10^0$
- $412,000,000 = 4.12 \times 10^8 = (4 \times 10^0 + 1 \times 10^{-1} + 2 \times 10^{-2}) \times 10^8$

Number representations - (Aside) please use scientific notation, and here is why: arithmetic operations with large numbers!

1. $4200 \times 4200 = (4.2 \times 10^3)^2 = (4.2)^2 \times 10^6 \approx 16 \times 10^6$
2. $\approx 17.6 \times 10^6$ if you account for the 0.2 ...

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1. $4000/3000 = 4 \times 10^3 \times \frac{1}{3} \times 10^{-3} = \frac{4}{3}$
2. $\frac{4}{3} \approx 1.33$

Expand the following numbers to expanded decimal notation:

- -10.432
- 800,000,144

Expand the following numbers to expanded binary notation:

- 10011010
- 11110000

Convert the following decimal numbers to binary notation:

- 260
- 560

Volunteer to board? - Key is explaining how you did the binary conversions

How did you do the conversions to binary? Is there a systematic what to do this?

- *Successive Approximation* - like a number puzzle (*Sum of Weights Method*)
- *Successive Division Method* - Example of an algorithm

Successive approximation technique (does this remind you of doing division in your head?) 260...$2^8 = 256$. Now we need four more...$4 = 2^2$. So $2^8 + 2^2 = 0b10000100$

What is 328 divided by 3? Ok try 100 because three times one hundred is close...

Successive Division Method

$0d412 = 0b110011100 = 2^8 + 2^7 + 2^4 + 2^3 + 2^2$

Algorithm:

1. Divide the decimal number by 2, and write down the remainder. This is the *least-significant bit* or LSB.
2. Keep dividing and recording the remainders in order, until you reach a dividend of 1.
3. $1/2 = 0r1$, so the *most-significant bit*, or MSB, is always 1.

Convert 412 to binary using the successive division method.

Convert the numbers at right to binary.

- $2^0 = 1$
- $2^1 = 2$
- $2^2 = 4$
- $2^3 = 8$
- $2^4 = 16$
- $2^5 = 32$
- $2^6 = 64$
- $2^7 = 128$

1. 93
2. 189
3. 270

Note: how many bits do you need for that last one?

Fractional.

CONCLUSION

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