Sirindhorn International Institute of Technology
Thammasat University at Rangsit
School of Information, Computer and Communication Technology

ECS 371: Solution for Problem Set 1

Semester/Year: **1/2009**
Course Title: Digital Circuits
Instructor: Dr. Prapun Suksompong (prapun@siit.tu.ac.th)
Course Web Site: http://www.siit.tu.ac.th/prapun/ecs371/

Due date: June 25, 2009 (Thursday)

Please submit your homework to the instructor 3 minutes BEFORE your class starts.

Chapter 2

- 6, 9, 13, 19, 20, 22, 25, 28

6. Convert the following binary numbers to decimal:

(a) 1110 **(b)** 1010 **(c)** 11100 **(d)** 10000
(e) 10101 **(f)** 11101 **(g)** 10111 **(h)** 11111

6.
(a) $1110 = 1\times 2^3 + 1\times 2^2 + 1\times 2^1 = 8+4+2 = 14$
(b) $1010 = 1\times 2^3 + 1\times 2^1 = 8+2 = 10$
(c) $11100 = 1\times 2^4 + 1\times 2^3 + 1\times 2^2 = 16+8+4 = 28$
(d) $10000 = 1\times 2^4 = 16$
(e) $10101 = 1\times 2^4 + 1\times 2^2 + 1\times 2^0 = 16+4+1 = 21$
(f) $11101 = 1\times 2^4 + 1\times 2^3 + 1\times 2^2 + 1\times 2^0 = 16+8+4+1 = 29$
(g) $10111 = 1\times 2^4 + 1\times 2^2 + 1\times 2^1 + 1\times 2^0 = 16+4+2+1 = 23$
(h) $11111 = 1\times 2^4 + 1\times 2^3 + 1\times 2^2 + 1\times 2^1 + 1\times 2^0 = 16+8+4+2+1 = 31$

9. How many bits are required to represent the following decimal numbers?

(a) 17 **(b)** 35 **(c)** 49 **(d)** 68
(e) 81 **(f)** 114 **(g)** 132 **(h)** 205

9. (a) $(2^4 - 1) < 17 < (2^5 - 1)$; 5 bits
(b) $(2^5 - 1) < 35 < (2^6 - 1)$; 6 bits
(c) $(2^5 - 1) < 49 < (2^6 - 1)$; 6 bits
(d) $(2^6 - 1) < 68 < (2^7 - 1)$; 7 bits
(e) $(2^6 - 1) < 81 < (2^7 - 1)$; 7 bits
(f) $(2^6 - 1) < 114 < (2^7 - 1)$; 7 bits
(g) $(2^7 - 1) < 132 < (2^8 - 1)$; 8 bits
(h) $(2^7 - 1) < 205 < (2^8 - 1)$; 8 bits

13. Convert each decimal number to binary using repeated division by 2:

(a) 15 **(b)** 21 **(c)** 28 **(d)** 34
(e) 40 **(f)** 59 **(g)** 65 **(h)** 73

13. (a)
$$\frac{15}{2} = 7,\ R = 1\text{(LSB)}$$
$$\frac{7}{2} = 3,\ R = 1$$
$$\frac{3}{2} = 1,\ R = 1$$
$$\frac{1}{2} = 0,\ R = 1\text{ (MSB)}$$

(b)
$$\frac{21}{2} = 10,\ R = 1\text{ (LSB)}$$
$$\frac{10}{2} = 5,\ R = 0$$
$$\frac{5}{2} = 2,\ R = 1$$
$$\frac{2}{2} = 1,\ R = 0$$
$$\frac{1}{2} = 0,\ R = 1\text{ (MSB)}$$

(c)
$$\frac{28}{2} = 14,\ R = 0\text{ (LSB)}$$
$$\frac{14}{2} = 7,\ R = 0$$
$$\frac{7}{2} = 3,\ R = 1$$
$$\frac{3}{2} = 1,\ R = 1$$
$$\frac{1}{2} = 0,\ R = 1\text{ (MSB)}$$

(d) $\frac{34}{2} = 17, R = 0$ (LSB)
$\frac{17}{2} = 8, \quad R = 1$
$\frac{8}{2} = 4, \quad R = 0$
$\frac{4}{2} = 2, \quad R = 0$
$\frac{2}{2} = 1, \quad R = 0$
$\frac{1}{2} = 0, \quad R = 1$ (MSB)

(e) $\frac{40}{2} = 20, R = 0$ (LSB)
$\frac{20}{2} = 10, R = 0$
$\frac{10}{2} = 5, \quad R = 0$
$\frac{5}{2} = 2, \quad R = 1$
$\frac{2}{2} = 1, \quad R = 0$
$\frac{1}{2} = 0, \quad R = 1$ (MSB)

(f) $\frac{59}{2} = 29, \quad R = 1$ (LSB)
$\frac{29}{2} = 14, \quad R = 1$
$\frac{14}{2} = 7, \quad R = 0$
$\frac{7}{2} = 3, \quad R = 1$
$\frac{3}{2} = 1, \quad R = 1$
$\frac{1}{2} = 0, \quad R = 1$ (MSB)

(g) $\frac{65}{2} = 32, R = 1$ (LSB)
$\frac{32}{2} = 16, R = 0$
$\frac{16}{2} = 8, \quad R = 0$
$\frac{8}{2} = 4, \quad R = 0$
$\frac{4}{2} = 2, \quad R = 0$
$\frac{2}{2} = 1, \quad R = 0$
$\frac{1}{2} = 0, \quad R = 1$(MSB)

(h) $\frac{73}{2} = 36, \ R = 1$ (LSB)
$\frac{36}{2} = 18, \ R = 0$
$\frac{18}{2} = 9, \quad R = 0$
$\frac{9}{2} = 4, \quad R = 1$
$\frac{4}{2} = 2, \quad R = 0$
$\frac{2}{2} = 1, \quad R = 0$
$\frac{1}{2} = 0, \quad R = 1$ (MSB)

19. What are two ways of representing zero in 1's complement form?

19. Zero is represented in 1's complement as all 0's (for +0) or all 1's (for –0).

20. How is zero represented in 2's complement form?

20. Zero is represented by all 0's only in 2's complement.

22. Determine the 2's complement of each binary number using either method:

(a) 10 **(b)** 111 **(c)** 1001 **(d)** 1101
(e) 11100 **(f)** 10011 **(g)** 10110000 **(h)** 00111101

22. Take the 1's complement and add 1:

(a) 01 + 1 = 10
(b) 000 + 1 = 001
(c) 0110 + 1 = 0111
(d) 0010 + 1 = 0011
(e) 00011 + 1 = 00100
(f) 01100 + 1 = 01101
(g) 01001111 + 1 = 01010000
(h) 11000010 + 1 = 11000011

25. Express each decimal number as an 8-bit number in the 2's complement form:

(a) +12 **(b)** −68 **(c)** +101 **(d)** −125

25. (a) Magnitude of 12 = 1100
+12 = 00001100

(b) Magnitude of 68 = 1000100
−68 = 10111100

(c) Magnitude of 101_{10} = 1100101
$+101_{10}$ = 01100101

(d) Magnitude of 125 = 1111101
−125 = 10000011

28. Determine the decimal value of each signed binary number in the 2's complement form:

(a) 10011001 **(b)** 01110100 **(c)** 10111111

(a) $-2^7+2^4+2^3+2^0=-128+16+8+1=-103$

(b) $2^6+2^5+2^4+2^2=64+32+16+4=116$

(c) $-2^7+2^5+2^4+2^3+2^2+2^1+2^0=-65$

Alternatively, for part (a) and part (c), we could convert the number into their positive values by applying the two's complement. Then, we need to remember to put the negative sign on our final answers because we start with negative numbers.

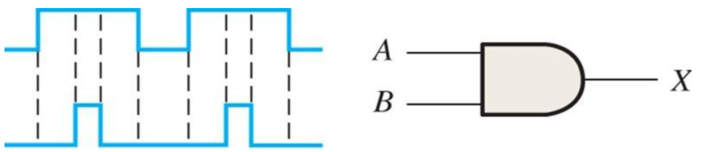
(a) 10011001 = –(1100111) = –103
(b) 01110100 = +(1110100) = +116
(c) 10111111 = –(1000001) = –65

Chapter 3

- 6, 8, 16, 20, 23

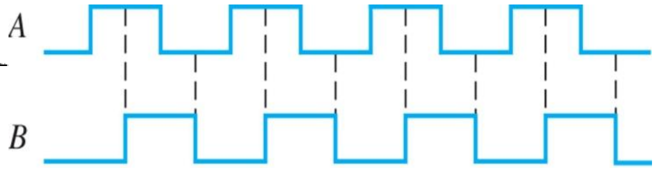
5. Determine the output, *X*, for a 2-input AND gate with the input waveforms shown in Figure 3–76. Show the proper relationship of output to inputs with a timing diagram.

FIGURE 3–76



6. Repeat Problem 5 for the waveforms in Figure 3–77.

FIGURE 3–77



6. See Figure 3-5.

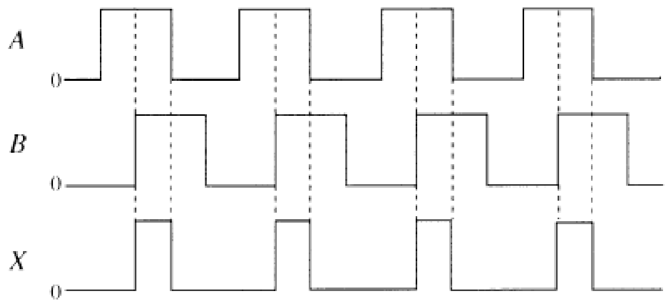
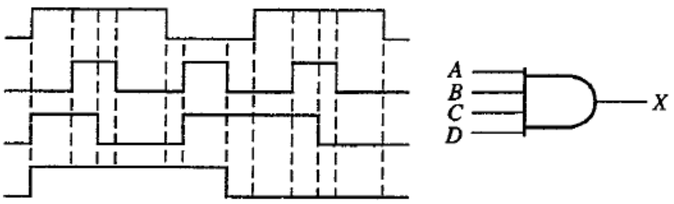


FIGURE 3-5

8. The input waveforms applied to a 4-input AND gate are as indicated in Figure 3–79. Show the output waveform in proper relation to the inputs with a timing diagram.

FIGURE 3–79



8. See Figure 3-7.

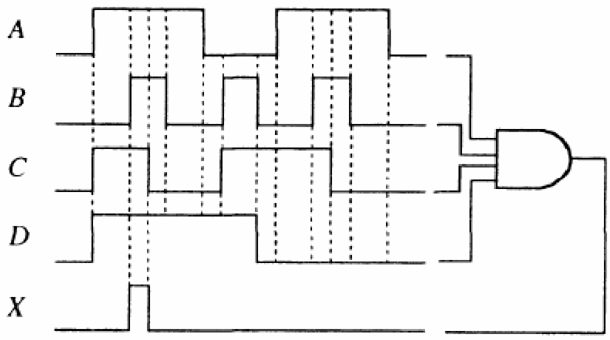
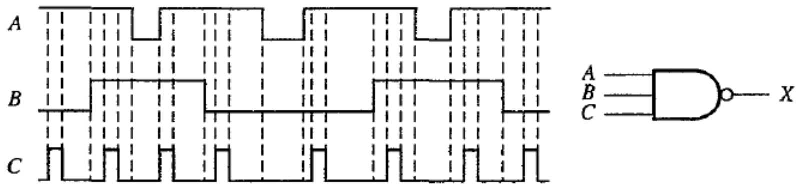


FIGURE 3-7

16. Determine the gate output for the input waveforms in Figure 3–82 and draw the timing diagram.

FIGURE 3–82



16. See Figure 3-14.

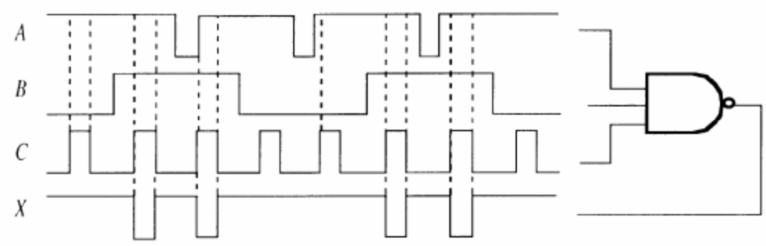
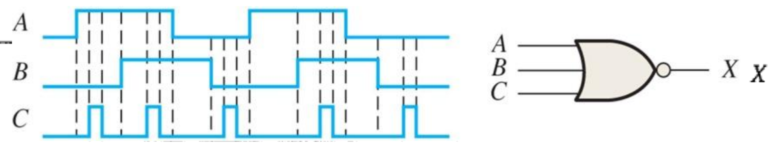


FIGURE 3-14

20. Determine the output waveform in Figure 3–85 and draw the timing diagram.

FIGURE 3–85



20. See Figure 3-18.

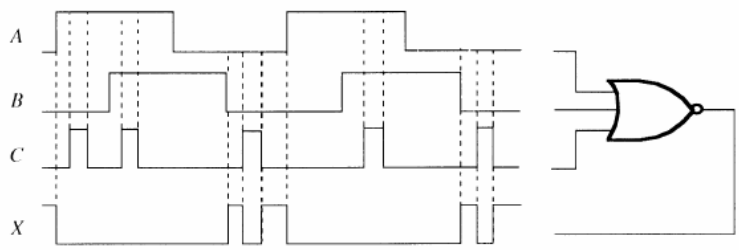


FIGURE 3-18

23. How does an exclusive-OR gate differ from an OR gate in its logical operation?

23. The output of the XOR gate is HIGH only when one input is HIGH. The output of the OR gate is HIGH any time one or more inputs are HIGH.