Introduction to Computer Science: Review Questions I

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1 Digital Systems

Question 1

Electrical and electronic systems could be classified as (i) an analog system, (ii) a digital system or (iii) a mixed analog-digital system. Give at least one exemplar system for each of these systems.

Question 2

In the lecture, it has been introduced six common logic gates which could be used for digital system implementation.

(a) State the six logic gates which have been introduced in the lecture materials and state their truth tables.

(b) In general sense, what electronic components are these logic gates made of?

(c) Design a NOT gate by using NAND gate only.

(d) Design an AND gate by using two NAND gates.

(e) Design an XOR gate by using NOT gates and AND gates only.

(f) Design an XOR gate by using NAND gates only.

Question 3

A logic gate is essentially an electronic circuit. An input to a logic gate is physically an electrical signal. Low (resp. high) voltage is defined as the signal for '0' (resp. '1').

(a) In computer industry, what voltage is defined for '0' and what voltage is defined for '1'?

(b) Is the above standard the only standard for '0' and '1'?

(c) To make the electronic circuit perform as a logic gate, voltage has to be supplied to the circuit. In principle, is the supply voltage higher than the level of 'high' voltage for '1'?

(d) Suppose that input voltages have been fed to a logic gate, the logic gate will definitely not response simultaneously. There is a time lag for the output voltage to rise/drop to its correct level. What is the technical term describing this response rate?

Question 4

Let A, B and C be the inputs of a digital logic circuit. X and Y be the outputs.

(a) Suppose the logical operation of the circuit is given by

$$\begin{aligned} X &= A + BC, \\ Y &= AB + C. \end{aligned}$$

What is the truth table of this logic circuit?

(b) Suppose the logical operation of the circuit is given by

$$\begin{aligned} X &= (A + B)\bar{C}, \\ Y &= A\bar{B} + \bar{A}C. \end{aligned}$$

What is the truth table of this logic circuit?

2 Number Representation

Question 5

In the following questions, the numbers are represented in 8-bit unsigned integer format.

(a) What are the bases for a binary number with eight digits?

(b) What is the value of '10000000' in decimal form?

(c) What is the value of '10101001' in decimal form?

(d) What is the value of '11011011' in decimal form?

(e) What is the value of '00101010' in decimal form?

(f) What is the value of '11111111' in decimal form?

Question 6

In the following questions, the numbers are represented in 16-bit unsigned integer format.

(a) What are the bases for a binary number with sixteen digits?

(b) What is the value of '1000000000000000' in decimal form?

(c) What is the value of '1111111111111111' in decimal form?

(d) What is the smallest number (in decimal form) of a binary number in 16-bit unsigned integer format?

(e) What is the largest number (in decimal form) of a binary number in 16-bit unsigned integer format?

Question 7

In the following questions, the numbers are represented in 16-bit signed-magnitude integer format.

`sxxxxxxxxxxxxxxx`

(a) What are the bases for a binary number with sixteen digits?

(b) What is the value of '1000000000000000' in decimal form?

(c) What is the value of '1111111111111111' in decimal form?

Question 8

(a) What is the smallest number (in decimal form) of a binary number in 16-bit unsigned integer format?

(b) What is the second smallest number (in decimal form) of a binary number in 16-bit unsigned integer format?

(c) What is the largest number (in decimal form) of a binary number in 16-bit unsigned integer format?

(d) What is the smallest number (in decimal form) of a binary number in 16-bit unsigned fixed point format, in which the decimal point is located in between the 12^{th} and 13^{th} digits?

(e) What is the second smallest number (in decimal form) of a binary number in 16-bit unsigned fixed point format, in which the decimal point is located in between the 12^{th} and 13^{th} digits?

(f) What is the precision error (in decimal form) of a binary number in 16-bit unsigned fixed point format, in which the decimal point is located in between the 12^{th} and 13^{th} digits?

Question 9

To represent a number in binary, there are many different representation formats.

(a) What are they?

(b) Represent 18_{10} in an 8-bit unsigned integer format, i.e. its decimal point is located after the last bit.

(c) Represent 18_{10} in an 8-bit signed integer format, i.e. its decimal point is located after the last bit.

(d) Represent -18_{10} in an 8-bit signed integer format, i.e. its decimal point is located after the last bit.

(e) Represent -18_{10} in an 8-bit 2's compliment format, i.e. its decimal point is located after the last bit.

(f) Represent 18_{10} in an 8-bit unsigned number format. Its decimal point is located in between the sixth and seventh bits.

(g) Represent 18_{10} in an 8-bit signed number format. Its decimal point is located in between the sixth and seventh bits.

(h) Represent -18_{10} in an 8-bit signed number format. Its decimal point is located in between the sixth and seventh bits.

(i) Represent -18_{10} in an 8-bit 2's compliment format. Its decimal point is located in between the sixth and seventh bits.

Question 10

For a binary number is represented by the following signed 8-bit fixed point format.

`sxxxx.xxx`

The first bit is the signed bit : '0' for positive numbers and '1' for negative numbers. The decimal point is located in between the fifth and the sixth bits. What are the decimal points of the following binary numbers?

(a) 00011100.

(b) 10011100.

(c) 10011001.

(d) 00111101.

(e) 11111111.

(f) 01111111.

3 Arithmetic

Question 11

Full adder is an important digital circuit for performing addition of two single-bit binary numbers. To make a full adder, half adders have to be used.

(a) With an aid of a diagram, draw the digital circuit design for a half adder.

(b) State the truth table for a half adder.

(c) With an aid of a diagram, draw the digital circuit design for a full adder.

(d) State the truth table for a full adder.

(e) By using full adders as building blocks, draw the digital circuit for addition of two 3-bit unsigned integers.

(f) To add two decimal (resp. binary) numbers, we need to add the numbers digit by digit starting from right to left. Why?

Question 12

(a) What is the advantage of representing a negative number in 2's compliment format?

(b) How does a processor perform multiplication of two unsigned integers, say 0011×0010?

(c) How does a processor perform division of two unsigned integers, say $0110 \div 0010$?

Question 13

In this question, the binary number is represented in of 16-bit 2's complement integer format.

(a) Convert 20_{10} into binary number.

(b) Represent -12_{10} 2'S complement.

(c) Show the steps of obtaining the value of $20_{10} - 12_{10}$.

Question 14

In this question, the binary number is represented in of 16-bit 2's complement integer format.

(a) Convert 58_{10} into binary number.

(b) Represent -78_{10} 2'S complement.

(c) Show the steps of obtaining the value of $58_{10} - 78_{10}$.

(d) Convert the answer in (c) in sign-magnitude form.

4 Text Representation

Question 15

To store a text document in memory, each character in the document has to be represented in binary code (equivalently format).

(a) Which coding scheme is now the *de facto* format used for character representation?

(b) How many bits a character is represented under such scheme?

(c) In this *de facto* coding scheme, what languages their characters can be represented?

(d) For Asian languages, like Chinese and Japanese, other coding schemes have been designed. For these coding schemes, how many bits a character is represented?

(e) In the ASCII code table, there are many strange characters like codes from number 128 to 159. Why do we need to have these characters?

(f) In the ASCII code table, what is the purpose to have the strange characters from code number 176 to code number 178?

Question 16

In accordance with the default format for character representation, convert the following sequences of characters in binary.

(a) `John.`

(b) `Sum.`

(c) `101`

(d) `1 0 1`

The number of characters in (a) is five. The number of characters in (b) is four. The number of characters in (c) is three. The number of characters in (d) is five, in which two of them are 'space'.

Question 17

`johnsum.txt` is a text file located at the root directory `C:>`. By typing the command below, the content of the file is shown.

```
C:>type johnsum.txt
John Sum. 1 0 1.
C:>
```

(a) How many characters are stored in the file?

(b) What are the binary codes for the first four characters?

(c) What is the binary code for the last character?

(d) What is the binary code for the 10^{th} character?

Question 18

`johnsum.txt` is a text file located at the root directory `C:>`. By typing the command below, the content of the file is shown.

```
C:>type johnsum.txt
John Sum.
1 0 1.
C:>
```

(a) How many characters are stored in the file?

(b) What are the binary codes for the first four characters?

(c) What is the binary code for the last character?

(d) What is the binary code for the 10^{th} character?