Specialized Subjects

9:00～11:30, Tuesday, August 21, 2012

Instructions

1. Do not open this booklet before permission is given.

2. This booklet contains 5 problems. The number of pages is six excluding this cover sheet and blank pages. If you find missing or badly printed pages, ask the attendant for exchange.

3. <u>Answer three problems</u>. You can select any three out of the five. Your answer to each problem should be written on a separate sheet. You may use the reverse side of the sheet if necessary.

4. Fill the top parts of all your three answer sheets as instructed below. Before submitting your answer sheets, make sure that the top parts are correctly filled.

専 門 科 目

| 第　　問 |

↑
Write the Problem No.

| 受験番号 |　|　|　|　|

↑
Write the Examinee No.

5. The three answer sheets must be submitted at the end of the examination, even if they are blank ones.

6. You must answer either in Japanese or in English.

7. This booklet and the preparation sheet must be returned at the end of the examination.

8. This English translation is informal but provided for the convenience of applicants. Japanese version is the formal one.

blank page

Problem 1

Figure 1 shows the circuit consisting of the capacitance C_1, capacitance C_2, resistance R, and switch S. Voltages of C_1 and C_2 are V_1 and V_2, respectively at $t = 0$, when S is on. Answer the following questions. Assume that $V_1 \geq V_2$.

(1) Find the voltage of C_1 when $t \to \infty$.

(2) Find the current $i(t)$ of the circuit and the voltage $v_1(t)$ of C_1.

(3) Find the total of energy consumed by R after sufficient time from $t = 0$. Show that it is equal to the decrease of potential energy stored in C_1 and C_2 at $t = 0$.

(4) Energy decreases even when $R = 0$. How does this energy decrease occur?

(5) Suppose the resistance having the non-linear characteristics shown in Fig. 2, and reaching the operating point $v(t) = V_b$ at $t = t_0$. Assume $V_1 - V_2 \geq V_b$. Show an equivalent circuit without non-linear elements for $0 \leq t \leq t_0$.

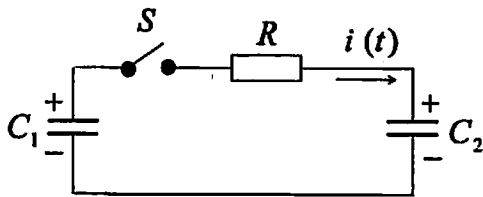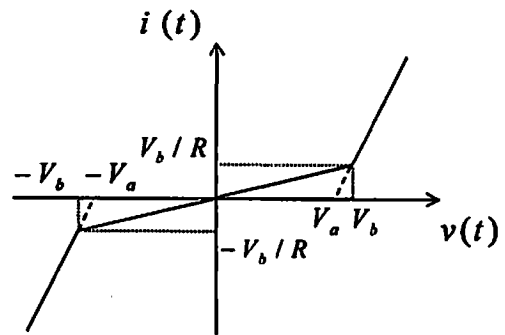(6) Find t_0. Also find the voltage $v_1(t_0)$ of C_1 at $t = t_0$.

Fig. 1

Fig. 2

Problem 2

Let us design a binary digital synchronous sequential circuit which outputs 6, 1, 0, 2, and 5 in this order. After outputting 5, it continuously generates 6, 1, 0, 2, and 5 periodically. Here, you can only use the following logic components: AND, OR, NOT, NAND, NOR, D flip flop and JK flip flop.

(1) Describe what a sequential circuit is within 10 words.

(2) For preparation, design a synchronous mod-8 binary counter and draw it using MIL symbols (see the Fig. below).

(3) Using (2), design a synchronous mod-5 binary counter and draw it using MIL symbols. Simplify the circuit as far as possible.

(4) Using (3) as a black box, design the synchronous sequential circuit producing 6, 1, 0, 2, and 5 periodically and draw it using MIL symbols. Simplify the circuit as far as possible, using Karnaugh Map.
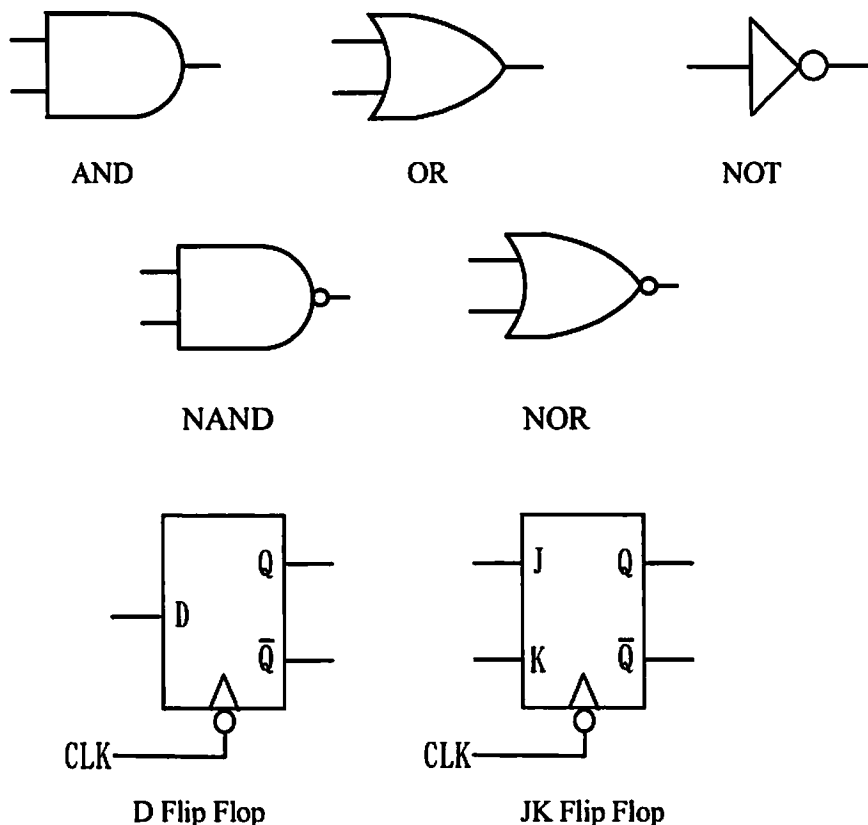
AND   OR   NOT

NAND   NOR

D Flip Flop   JK Flip Flop

Fig.

Problem 3

Answer the following questions about directed graphs. In this problem, assume that directed graphs do not include self loops or duplicated edges.

(1) Depict the directed graph in Figure 1 by an adjacency matrix representation, and an adjacency list representation. Use the list representation in Figure 2 for the adjacency list representation.

(2) Answer which representation uses more memory space for the directed graph in Figure 1, when we use the same memory space for each element in the adjacency matrix, each vertex label in the adjacency list, and each pointer in the adjacency list.

(3) Consider a directed graph whose number of vertices is fixed to N. Answer the number of edges with which both representations require the same size of memory space. When the directed graph satisfies this condition, explain with reason whether the graph is weakly connected or not. A directed graph is said to be weakly connected if it is connected when we ignore the direction of edges.

(4) The following pseudo code performs depth-first search (DFS) of a given directed graph G composed of a set of vertices V and a set of directed edges E. Depict a search tree when we start DFS from the vertex 0 of the graph in Figure 1.

```
Traverse(Graph G)
    foreach v ∈ V { v.setMark(UNVISITED) }
    foreach v ∈ V { if (v.getMark() == UNVISITED) DFS(G, v) }
DFS(Graph G, Vertex v)
    v.setMark(VISITED)
    foreach (v, w) ∈ E {
        if (w.getMark() == UNVISITED) DFS(G, w)
    }
```

(5) We call a directed path in a directed graph as a directed cycle when its first and last vertices are the same. Write an algorithm in pseudo code that finds a directed cycle in a given graph if it exists, and output a set of vertices in the cycle.
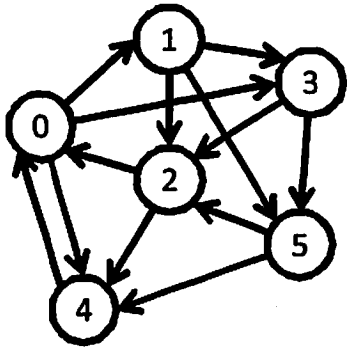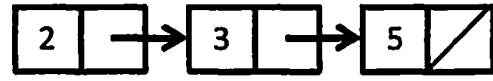
Fig. 1

Fig. 2

Problem 4

In a radio communication system where multiple wireless terminals access to the same access point, the throughput of the system decreases when many terminals are connected to it simultaneously. To avoid it, we try to limit the maximum number of simultaneously connected terminals.

(1) Briefly describe the reason why such deterioration of the throughput occurs.

(2) In places such as an airport terminal where there is generally enough number of terminals, we can assume the origination of connection occurs in a Poisson manner. Let us assume that the origination of connection occurs in a Poisson manner with the origination rate of 2 [1/hour] and that the distribution of the connecting time abides by exponential distribution with the average connecting time of 1 [hour]. Show the probability distribution of the number of simultaneously connected terminals and its average when we do not limit the maximum number of simultaneously connected terminals.

(3) Now in (2), let us limit the maximum number of simultaneously connected terminals to three. Calculate the probability where a connection fails.

(4) In places such as an indoor conference room, we have to assume the number of terminals is finite. Let us assume that each terminal is either in connected state or in not-connected state in a repeated manner. Also assume that the duration of connected state and that of not-connected state both abide by exponential distribution with the average duration time of 1 [hour] . Further, if a connection fails, assume that the terminal repeats the not-connected state where the duration of the state abides by the aforementioned exponential distribution again. Assuming that we do not limit the maximum number of simultaneously connected terminals, show the probability where a terminal is in connected state. Further, derive the probability distribution of the number of simultaneously connected terminals and its average when the number of terminals is four. Also, show the average is the same with the average derived in (2).

(5) In (4), show the probability where a connection fails when the maximum number of simultaneously connected terminals is limited to four. Similarly in (4), calculate the probability where a connection fails when the maximum number of simultaneously connected terminals is limited to three. Explain the reason why this probability is smaller than the probability derived in (3).

(6) When the number of connected terminals is large, it is desirable to install an additional access point. Briefly describe the points to be considered using the terms "channel" and "interference".

Problem 5

Consider a machine flashes one of Red (R), Green (G) and Blue (B) light bulbs at regular time interval. The sequence of flashes has characteristics below.

- Right after R, either R or G flashes with probability of 0.8 and 0.2, respectively.
- Right after G, either G or B flashes with probability of 0.9 and 0.1, respectively.
- Right after B, either B or R flashes with probability of 0.9 and 0.1, respectively.

The light flash of this machine is considered as the source of information S. Answer the questions below.

(1) The source of information S is a first order markov source. Show its state transition diagram.

(2) Obtain the steady state probabilities of flashes of R, G and B, respectively.

(3) The flash sequence from the source S can be efficiently encoded and transmitted. Assuming two consecutive flashes are assigned binary codes consisting of 0 and 1, design the most efficient code and obtain the average code length per one flash.

(4) Taking into account that the same color tends to continue, the nine groups of flashes shown below are assigned binary codes. Design the most efficient codes and obtain the average code length per one flash.

RG, RRG, RRR, GB, GGB, GGG, BR, BBR, BBB

(5) What is the minimum average code length for the source S ?

(Use $\log_2 3 = 1.58$ $\log_2 5 = 2.32$, if necessary.)

blank page