Specialized Subjects

9:00～11:30, Wednesday, August 27, 2008

Instructions

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

2. This booklet contains 6 problems. The number of pages is seven excluding this cover sheet and blank pages. If you find missing or badly printed pages, ask the attendant for exchange.

3. Answer three problems. You can select any three out of the six. 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.

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Problem 1

A transmission line is modelled as in Fig. 1. The sender as well as the receiver connect identical terminal resistances Rs to the both ends of the line. The sender inputs the step voltage as shown in Fig. 2. There was energy saved neither in the capacitor nor in the inductor at t=0. Answer the following problems.

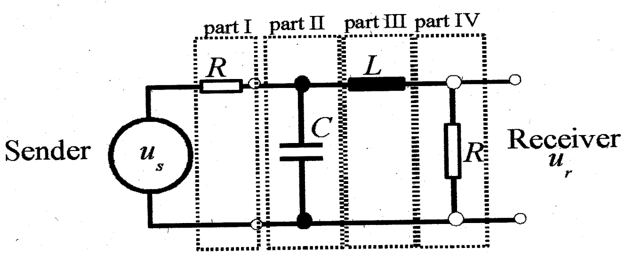


Fig. 1

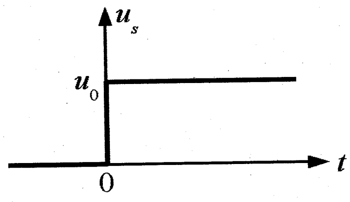


Fig. 2

(1) The F-matrix of the four terminal circuit in Fig. 3, which corresponds to the part I in Fig. 1,

is described as $\begin{pmatrix} v_2 \\ i_2 \end{pmatrix} = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v_1 \\ i_1 \end{pmatrix}$. Write the F-matrices of part II through IV in Fig. 1 in the same way using the Laplace operator s.

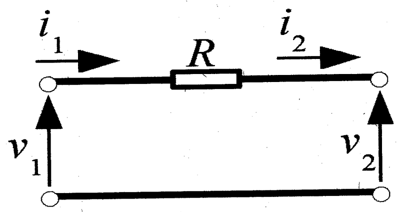


Fig. 3

(2) Using the result of (1), calculate the F-matrix F_{TOTAL} of the total transmission line, where

$\begin{pmatrix} v_r \\ i_r \end{pmatrix} = F_{\mathrm{TOTAL}} \begin{pmatrix} v_s \\ i_s \end{pmatrix}$ in Fig. 4.

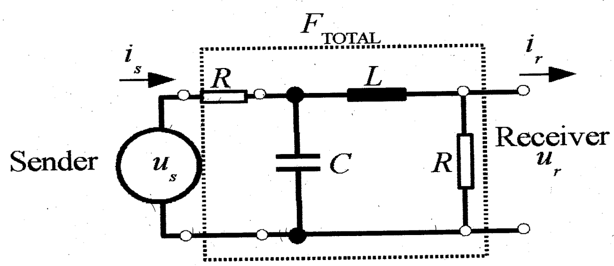


Fig. 4

(3) Using the result of (2), calculate the transfer function from sender voltage to receiver one

$G(s)=\dfrac{U_r(s)}{U_s(s)}$. Note that the terminal resistances Rs are designed as $R=\sqrt{\dfrac{L}{C}}$.

Simplify the function by putting $RC=\tau$. $U(s)$ means the Laplace transform of $u(t)$ and so on.

(4) Using the result of (3), calculate the receiver voltage $U_r(s)=G(s)\dfrac{u_0}{s}$ in the s-domain.

Decompose the receiver voltage to the partial fractions in the form of

$$\left\{\frac{A_1}{x}+\frac{A_2(x+1)}{(x+1)^2+1}+\frac{A_3}{(x+1)^2+1}\right\}u_0\tau$$ by putting $x=\tau s$.

(5) Calculate the output voltage $u_r(t)$ in the receiver end using the result of (4) and the table of Laplace transform.

Table

$f(t)$	$F(s)$
$1(t\geq 0)$	$\dfrac{1}{s}$
e^{-at}	$\dfrac{1}{s+a}$
$e^{-bt}\sin at$	$\dfrac{a}{a^2+(s+b)^2}$
$e^{-bt}\cos at$	$\dfrac{s+b}{a^2+(s+b)^2}$
te^{-at}	$\dfrac{1}{(s+a)^2}$

Problem 2

Let us consider the synchronous sequential binary logic circuit with one input A and one output Z.

Suppose A denotes single a bit binary number and the input sequence is divided per every three clock cycles. Here, each division is called an *interval*. We would like to design a sequential circuit which outputs 1 at the last clock period of the interval if and only if the interval contains one or more "1"s . Fig.1 illustrates an example of the action.

clock	1	2	3	4	5	6
input	0	0	0	1	0	1
output	0	0	0	0	0	1

Fig 1.

(1) Draw the state transition diagram for the circuit.

(2) Simplify the diagram by reducing the number of the states as many as possible.

(3) Draw the state transition table for the circuit.

(4) Draw the Karnaugh map for the circuit.

(5) Design the synchronous sequential circuit and draw it using MIL symbols (see Fig.2). Here, you can only use the following logic components: AND, OR, NOT (the number of inputs of each combinatorial logic element is less than or equal to 4), D flip flop and JK flip flop.

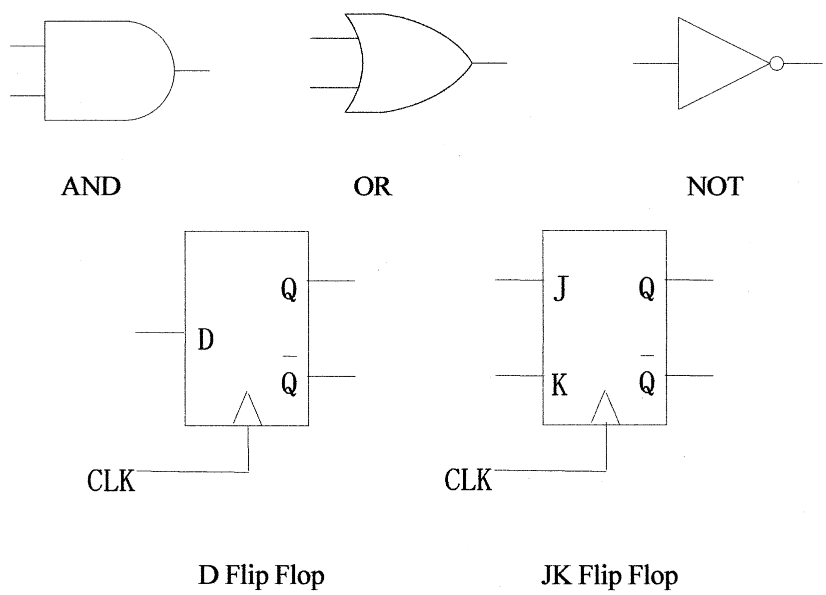


Fig. 2

Problem 3

Answer the following questions on a database management system.

(1) What are the distinctive features of relational database?

(2) Let's design the class management system at universities. Professors give classes. Each class should be managed by its name, the room-id, etc. Students can register several classes and attend them. Professors give one or more than one class. Design the schema of relational database for class management. You can introduce and define necessary attributes. For each relation, specify the key attribute(s). To simplify the problem, we assume that one class is given by one professor.

(3) Based on the schema designed in (2), express the query with SQL, which retrieves the names of the students who register the class given by the professor whose name is 'A'.

(4) In order to speed up the query given in (3), we usually introduce indexes. Explain the kinds, their structure and their features of typical indexes. Which attributes should we put indexes to reduce the execution time?

(5) Express the query with relational algebra, which retrieves the names of the students who register all the classes given by the professor whose name is 'B'.

Problem 4

Answer the following questions concerning the baseband signal $m(t)$, bandlimited to B [Hz], the Fourier transform of which is $M(f)$ shown in the figure below.

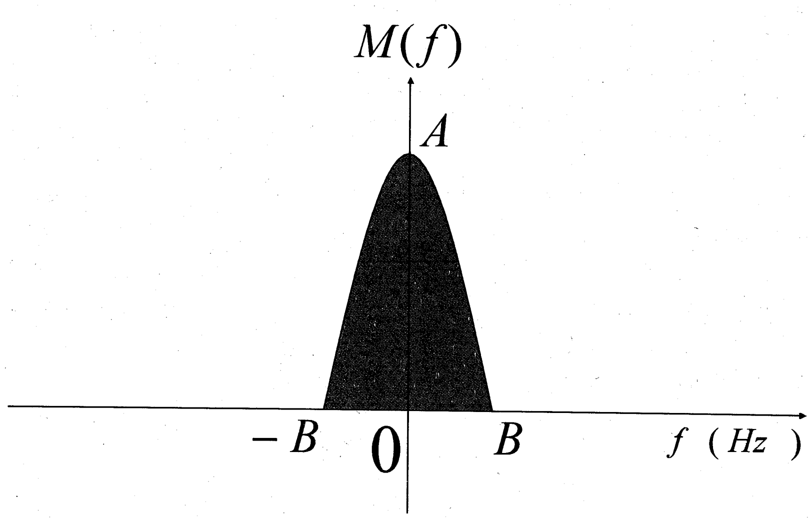
(1) Assume the amplitude modulation of the carrier $\cos(2\pi f_C t)$, with carrier frequency $f_C > 2B$ [Hz], by $m(t)$. Draw the Fourier transform $X(f)$ of the modulated signal $x(t) = m(t)\cos(2\pi f_C t)$.

(2) Draw the Fourier transform $Y(f)$ of a signal $y(t) = \sum_{n=-\infty}^{\infty} m(nT_S)\delta(t - nT_S)$, obtained by sampling $m(t)$ by a sampling rate $f_S > 2B$ [Hz], where $T_S f_S = 1$ and $\delta(t)$ is the delta function or unit impulse function defined as $\delta(t) = 0 \ (t \neq 0), \int_{-\infty}^{\infty} \delta(t)dt = 1$.

(3) Explain "Aliasing Distortion" in Sampling Theorem in short (a few lines of words). You may use illustrations.

(4) Draw the Fourier transform $Z(f)$ of a signal $z(t) = \sum_{n=-\infty}^{\infty} x(nT_C)\delta(t - nT_C)$, obtained by sampling $x(t)$ with a sampling rate $f_S = f_C$ [Hz], where $T_C f_C = 1$.

(5) What kind of ideal filter is required to get $m(t)$ from $z(t)$?



Problem 5

Mobile phone carriers are intensively competing by offering attractive rate plans. Let us compare them by using a simple model where each subscriber makes a phone call according to a Poisson process and the duration of each call is short enough.

(1) Briefly explain Poisson process.

(2) Assume that a subscriber makes λ calls per one month on average. Show the probability $P_k(t)$, where this subscriber makes k calls per t months. For simplicity, we assume that every month consists of the same number of days.

(3) Show that the time interval between the calls from a subscriber follows an exponential distribution by using the result of (2).

(4) Calculate $\sum_{k=0}^{\infty} P_k(t)$ and $\sum_{k=0}^{\infty} kP_k(t)$. You have only to show the results.

(5) Let us compare the following three rate plans.

Bargain Plan (by provider D) :The basic rate is ¥900 per month up to 10 calls regardless of the duration of calls. For 11 calls or more, the additional rate is ¥100 per call regardless of the duration of calls.

Plain Plan (by provider A): The basic rate is ¥200 per month, but no free call is included. The additional rate is ¥70 per call regardless of the duration of calls.

Yellow Plan (by provider S): The rate is flat rate of ¥1000 per month regardless of the duration of calls and the number of calls.

Show the most favorable plan for a subscriber who makes 10 calls per one month on average. Use $10^{10} \times \exp(-10)/10! = 0.125$, if necessary.

Problem 6

Let us consider the N-point Discrete Fourier Transform (DFT) as shown in the following.

$$X(k)=\sum_{n=0}^{N-1} x(n) W_N^{kn} \quad (k=0,1,2,\cdots,N-1)$$

Here, $W_N = e^{-j\frac{2\pi}{N}}$ and $N=2^c$ (c is a positive integer).

(1) Consider that we divide the sequence $x(n)$ into two parts depending on whether the suffix is odd or even. Prove that the following equation holds in such a case.

$$X(k)=\sum_{r=0}^{\frac{N}{2}-1} x(2r) W_{\frac{N}{2}}^{rk} + W_N^{k} \sum_{r=0}^{\frac{N}{2}-1} x(2r+1) W_{\frac{N}{2}}^{rk} \quad \left(r=0,1,2,\cdots,\frac{N}{2}\right)$$

(2) Draw a signal flow graph of the decimation-in-time Fast Fourier Transform (FFT) for the case of N=4 based on (1).

(3) Consider that we divide the sequence $x(n)$ into two parts: $x(0), x(1), \cdots, x(N/2 - 1)$ and $x(N/2), x(N/2+1), \cdots, x(N-1)$. Prove that the following equation holds in such a case.

$$X(k)=\sum_{n=0}^{\frac{N}{2}-1} x(n) W_N^{nk} + W_N^{\frac{Nk}{2}} \sum_{n=0}^{\frac{N}{2}-1} x\left(n+\frac{N}{2}\right) W_N^{nk}$$

(4) Draw a signal flow graph of the decimation-in-frequency FFT for the case of N=4 based on (3).

(5) Derive the numbers of multiplication required for the original DFT, the decimation-in-time FFT, and the decimation-in-frequency FFT, respectively. You can assume that W_N^k is given in advance.

第 1 問 正誤表 **(Errata)**

（日　英　2 箇所ずつ）　F 行列定義の左右のベクトルの添字逆転

(1) 図 1 の part I に相当する図 3 で，四端子回路として左から右への信号の伝達を

誤 $\begin{pmatrix} v_2 \\ i_2 \end{pmatrix} = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v_1 \\ i_1 \end{pmatrix}$　　正 $\begin{pmatrix} v_1 \\ i_1 \end{pmatrix} = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v_2 \\ i_2 \end{pmatrix}$

と F 行列を用いて表すことができる．これに倣い，part II から part IV のそれぞれの F 行列をラプラス演算子 s を用いて書け．

(2) (1)の結果を用い誤 $\begin{pmatrix} v_r \\ i_r \end{pmatrix} = F_{\mathrm{TOTAL}} \begin{pmatrix} v_s \\ i_s \end{pmatrix}$ 正 $\begin{pmatrix} v_s \\ i_s \end{pmatrix} = F_{\mathrm{TOTAL}} \begin{pmatrix} v_r \\ i_r \end{pmatrix}$ として，図 4 に示すこの線路全体の F 行列 F_{TOTAL} を計算せよ．

Fig. 2

(1) The F-matrix of the four terminal circuit in Fig. 3, which corresponds to the part I in Fig. 1, is described as . Write the F-matrices of part II through IV in Fig. 1 in the same way using the Laplace operator s.

replace $\begin{pmatrix} v_2 \\ i_2 \end{pmatrix} = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v_1 \\ i_1 \end{pmatrix}$ with $\begin{pmatrix} v_1 \\ i_1 \end{pmatrix} = \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix} \begin{pmatrix} v_2 \\ i_2 \end{pmatrix}$

(2) Using the result of (1), calculate the F-matrix F_{TOTAL} of the total transmission line, where

replace $\begin{pmatrix} v_r \\ i_r \end{pmatrix} = F_{\mathrm{TOTAL}} \begin{pmatrix} v_s \\ i_s \end{pmatrix}$ with $\begin{pmatrix} v_s \\ i_s \end{pmatrix} = F_{\mathrm{TOTAL}} \begin{pmatrix} v_r \\ i_r \end{pmatrix}$ in Fig. 4.

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