FIJI NATIONAL UNIVERSITY

Final Examination

College	Engineering, Science & Technollogy
School	Electrical & Electronics Engineering
Programme	EADEE, BENG
Semester	II
Year	2013
Unit Code	EEE610
Unit Title	Electrical Engineering Modeling
Date of Examination	November 1
Time	9am
Venue	B314
Duration	3 Hours *(extra 10 mins allowed to read the paper)*
Maximum Marks	100

Instructions

1. Create a folder on the desktop by the name "EEE610 Exam". Open MATLAB and change the current directory to the folder created. This is your working folder. Create a new M-File by your ID number. Example if your ID number is 2009001687, the filename should be **s2009001687.m**. Write your student ID number at the top of the M-File as a comment.
2. There are six (6) questions. Attempt all questions in the M-File. Use cell mode to separate the questions.
3. Use a **figure** command to start a new plot. After completing all the questions, publish the M-File in PDF.

Question 1 *(10 Marks)*

(a) An ideal diode blocks the flow of current in the direction opposite that of the diodes arrow symbol. It can be used to make a half wave rectifier as shown in Fig. 1. For the ideal diode, the voltage V_L across the load R_L is given by (6)

$$V_L = \begin{cases} V_S & \text{if } V_S > 0.7 \\ 0 & \text{if } V_S \leq 0.7 \end{cases} \tag{1}$$

Suppose the supply voltage is

$$V_S(t) = 6e^{-\frac{t}{3}} \sin(\pi t) \tag{2}$$

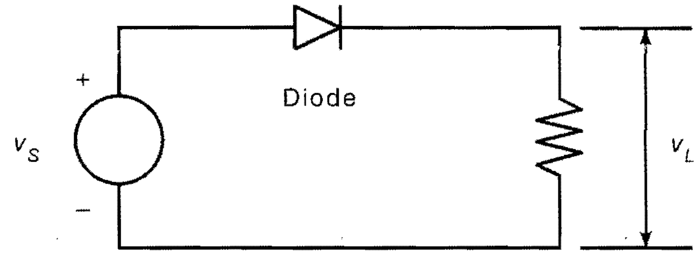

Figure 1: Ideal diode circuit

where time t is in seconds. Plot the voltage V_L versus t and V_S versus t for $0 \leq t \leq 10s$.

(b) Create a vector of 1000 random numbers from a Normal distribution with mean 2 and standard deviation 5. After you generate the vector, verify that the sample mean and standard deviation of the vector are close to 2 and 5 respectively. (4)

Question 2 *(20 Marks)*

The electric potential field V at a point, due to two charged particles, is given in (3).

$$V = \frac{1}{4\pi\epsilon_o}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right) \tag{3}$$

where q_1 and q_2 are the charges of the particles in coulombs (C), r_1 and r_2 are the distances of the charges from the point (in meters), and ϵ_o is the permittivity of free space, whose value is $\epsilon_o = 8.854 \times 10^{-12} C^2/(Nm^2)$. Suppose the charges are $q_1 = 2 \times 10^{-10}C$ and $q_2 = 4 \times 10^{-10}C$. Their respective locations in the xy plane are (0.3, 0) and (-0.3, 0) m. Plot the electric potential field on a three-dimensional surface plot with V plotted on the z-axis over the ranges $-0.25 \leq x \leq 0.25m$ and $-0.25 \leq y \leq 0.25m$. Create the plot in two ways:

(a) by using the **surf** function and (10)

(b) by using the **meshc** function (10)

Question 3 (*10 Marks*)

Consider the following system of linear equations. This system can be expressed in the form $\mathbf{Ax} = \mathbf{b}$.

$$\begin{aligned} 7x + 9y - 9z &= 22 \\ 3x + 2y - 4z &= 12 \\ x + 5y - z &= -2 \end{aligned}$$

(a) Compute the ranks of $\mathbf{A}$ and $[\mathbf{A}\ \mathbf{b}]$. (2)

(b) Based on the result from part (a) above propose a method to solve the above system of linear equations to determine at least one solution if it can be found. (8)

Question 4 (*20 Marks*)

A certain electric circuit has a resistor and a capacitor. The capacitor is initially charged to 100V. When the power supply is detached, the capacitor voltage decays with time as the following data table shows.

Time(s)	Voltage(V)
0.0	100
0.5	62
1.0	38
1.5	21
2.0	13
2.5	7
3.0	4
3.5	2
4.0	3

(a) Find a functional description of the capacitor voltage V as a function of time t. (10)

(b) Plot the function and the data on the same plot with labels and legend. (5)

(c) Determine the quality of the curve by computing J, S and r^2 shown in the equation (5) in (4)

$$J = \sum_{i=1}^{m} (f(x_i) - y_i)^2$$
$$S = \sum_{i=1}^{m} (y_i - \bar{y})^2$$
$$r^2 = 1 - \frac{J}{S} \tag{4}$$

where m is the number of data points.

Question 5 *(20 Marks)*

The differential equation model for the RC circuit shown in Fig. 2 is given in (5). For $RC = 0.1s$, answer the following questions.

$$RC\dot{v}_o + v_o = v_i \tag{5}$$

(a) Create a function for $\dot{v}_o$ with the definition `[vdot] = rccircuit(t, v)`, to solve the differential equation for $v_i = 1V$, $v_o(0) = 0$ and $0 \leq t \leq 1$s using ode solver **ode45**. Plot v_o versus t and label the plot. (10)

(b) Convert the differential equation model into a transfer function model (zero initial conditions). Plot the linear simulation result with a $50Hz$ full wave rectified input voltage v_i given by the equation in (6), where $0 \leq t \leq 0.4$s. (10)

$$v_i = |\sin \omega t| \tag{6}$$

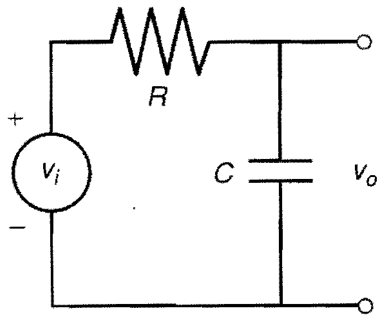

Figure 2: RC circuit

Question 6 *(20 Marks)*

The model of a series RLC circuit is given in (7). The component values are; $R = 500\Omega$,

$C = 1\mu F$ and $L = 0.2H$. The input is a voltage source v connected to the circuit and the output is the capacitor voltage y.

$$\ddot{y} + \frac{R}{L}\dot{y} + \frac{1}{LC}y = \frac{1}{LC}v \tag{7}$$

(a) Determine a state space representation of the RLC circuit model above, which would be in the form shown in (8). Determine the matrices A, B, C and D. (5)

$$\begin{aligned} \dot{\mathbf{x}} &= Ax + Bu \\ y &= Cx + Du \end{aligned} \tag{8}$$

(b) Using the state space model in part (a) above;
  i. Plot the free or initial response of the system where $y(0) = 1$ and $\dot{y}(0) = 0$. (5)
  ii. Plot the response where v is a square pulse of period 0.01s from $0 \leq t \leq 0.02$s where $y(0) = 2$ and $\dot{y}(0) = 0$. (5)

(c) Express the above system into continuous time transfer function form (zero initial conditions). Generate a **step** response of the system. From the step response figure determine: (5)
  i. Peak Response
  ii. Settling Time
  iii. Rise Time
  iv. Steady State Value

The End
Happy Holidays!