B. Sc. in EEE, 6th Semester 03 May 2023(Morning)

Islamic University of Technology (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Electrical and Electronic Engineering

Semester Final Examination
Course Number: EEE 4601
Course Title: Signals and Systems

Summer Semester: A. Y. 2021 - 22
Time: 3 Hours
Full Marks: 150

There are 06 (six) questions. Answer all questions. Questions 5 and 6 have alternatives. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

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1. a) Classify systems. Show that for a continuous time described by the operator H to be time invariant the system operator H and the time shift operator S^{t_0} must commute with each other for all t_0. 5(CO1, PO1)

   b) Show the effect of time scaling and time shifting on the energy and power of a real signal if the signal is (i) an energy signal and (ii) a power signal. 10(CO1, PO1)

   c) Justify that the discrete time (DT) signal $x[n] = e^{j\Omega n}$ is not always periodic. Determine whether the following signals are periodic, and for those which are, find the fundamental period. 10(CO1, PO1)
      (i) $x[n] = \cos\left(\frac{8}{15}\pi n\right)$
      (ii) $x[n] = \cos\left(\frac{1}{5}\pi n\right) sin\left(\frac{1}{3}\pi n\right)$
      (iii) $x(t) = 2\sin(3t + 1) + 3\sin(4t - 1)$
      (iv) $x(t) = v(t) + v(-t)$, where $v(t) = \cos(2t)\,u(t)$
      (v) $x(t) = \sum_{k=-\infty}^{\infty}(-1)^k\,(\delta(t - 2k)$

2. a) Classify the responses of an LTI system. How are they determined? 5(CO1, PO1)

   b) The impulse response h(t) and the input x(t) of a continuous time LTI (CTLTI) system are shown in Fig. 2(a). Sketch the zero-state response (ZSR) of the system for T=4, T=2, and T=1. 10(CO1, PO1)

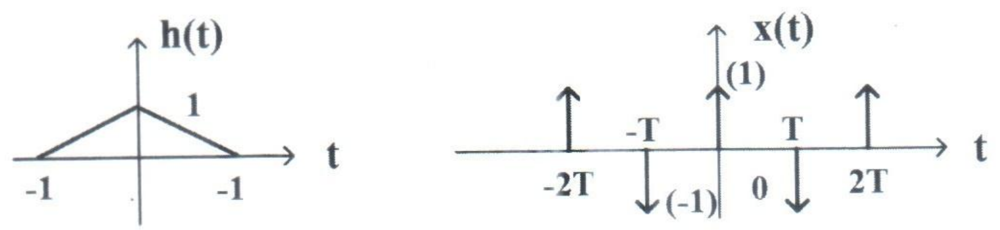

Fig. 2(a).

c) The I/O relation of a second order DT system is given as, 10(CO1, PO1)

$$y[n]-\frac{1}{9}y[n-2]=x[n]\,.$$

Find the step response for $n\geq 0$, given that $y[-1]=1\ and\ y[-2]=0$.

3. a) The coefficients of the exponential form a Fourier Series(FS) are given as, 12(CO2, PO2)

$$X[k]=\begin{cases}e^{-jk\pi/2}, & |k|<10\\ 0, & otherwise\end{cases}.$$

Determine the corresponding time domain signal. The fundamental period of the signal T=1 (s).

b) Find the DT Fourier Transform (FT) of the time domain signal depicted in Fig. 3(b). Sketch the magnitude spectrum of the signal. 13(CO2, PO2)

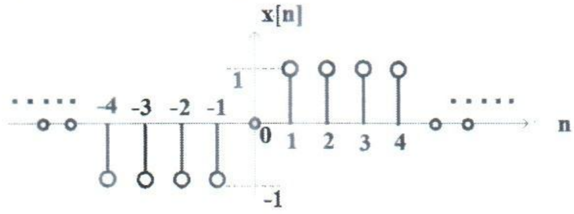

Fig. 3(b).

4. a) We may design a dc power supply by cascading a full-wave rectifier and an RC filter as depicted in Fig. 4(a). Mathematically, the full wave rectifier output can be expressed as, 13(CO2, PO2)

$$z(t)=|x(t)|.$$

The frequency response of the RC filter is given as,

$$H(j\omega)=\frac{Y(j\omega)}{Z(j\omega)}=\frac{1}{j\omega RC+1}.$$

The input $x(t)=300\cos(100\pi t)$ (V).

(i) Find the FT representation of $z(t)$.

(ii) Find the FT representation of $y(t)$.

(iii) Find the range for the time constant RC such that the first harmonic of the ripple in $y(t)$ is less than 2% of the average value.

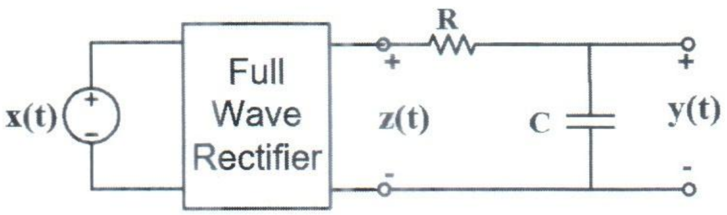

Fig. 4(a).

b) Consider the system depicted in Fig. 4(b). The FT $X(j\omega)$ of the input signal $x(t)$ is shown. Sketch the spectrum of z(t) and y(t) for the given $w(t)$. 12(CO2, PO2)

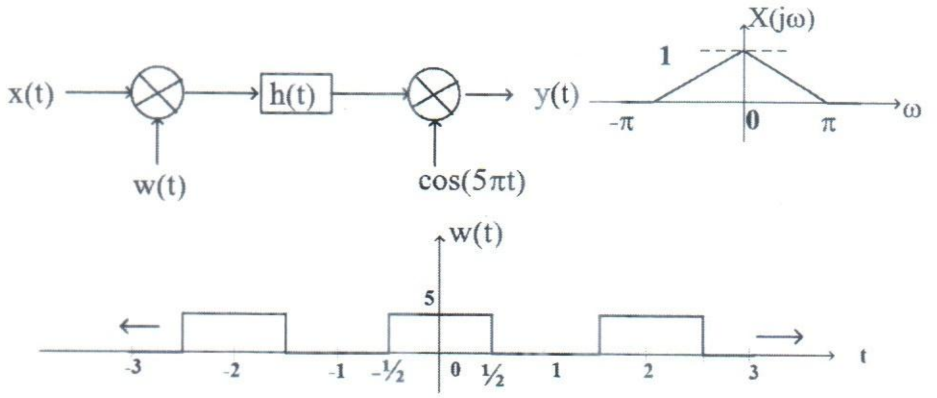

Fig.4(b).

5. a) Use Laplace Transform (LT) technique on the circuit of Fig. 5(a) to find $i(t)$ at $t = 1.5\ ms$, for $i_s(t)$ equals (i) $\delta(t)$ and (ii) $u(t)$. 12(CO2, PO2)

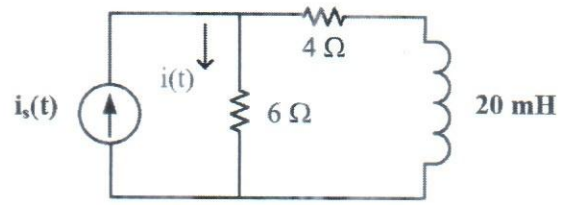

Fig. 5(a).

b) (i) Find the time domain signal corresponding to the spectrum, 7+6(CO2, PO2)

$$X(j\omega) = \begin{cases} 4\cos(\omega), & |\omega| < \pi \\ 0, & |\omega| > \pi \end{cases}.$$

(ii)Use the FT properties to find the FT of the output of an LTI system given as,

$$y(t) = \frac{d}{dt}\{(e^{-4(t-1)}u(t-1)) * (e^{-2t}u(t-3))\}.$$

OR(Question 5)

a) Find the output as indicated in Fig. 5(a-OR) using LT. 13(CO2, PO2)

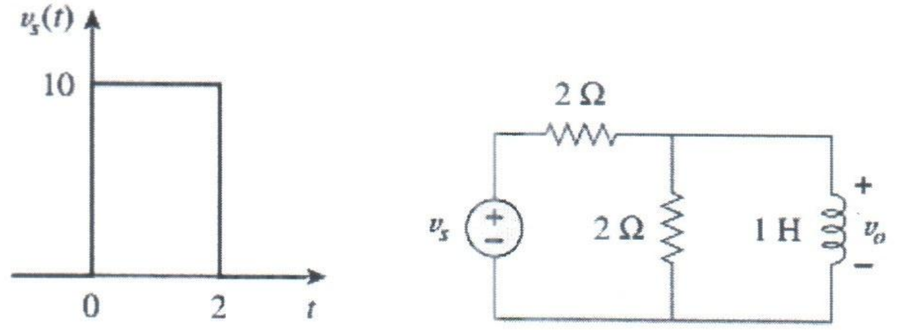

Fig. 5(a-OR).

b) Find and sketch the frequency response of the systems described by the following impulse responses. Characterize each system as lowpass, bandpass, or high pass. 12(CO2, PO2)

$$h(t) = \delta(t) - 2e^{-2t}u(t)$$
$$h[n] = \frac{1}{8}\left(\frac{7}{8}\right)^n u[n]$$

6. a) From the time domain I/O relation of the Op Amp circuit of Fig. 6(a) use LT to find the output v_o and hence i_o for $v_i(t) = u(t)$. Assume $v(0_-) = 1\text{V}$. 12(CO3, PO3)

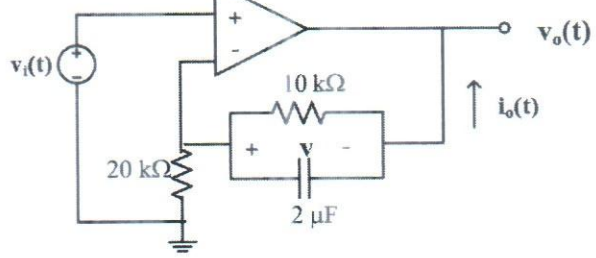

Fig. 6(a).

b) Fig. 6(b) below shows an automobile ignition system and its simplified circuit model. Suppose the switch(point) has been closed for a long time. At $t = 0$, the switch opens, and a high voltage will momentarily occur at the output terminals, causing the spark plug to fire. Find approximately the maximum voltage appearing across the spark plug and the time at which it occurs. 13(CO3, PO3)

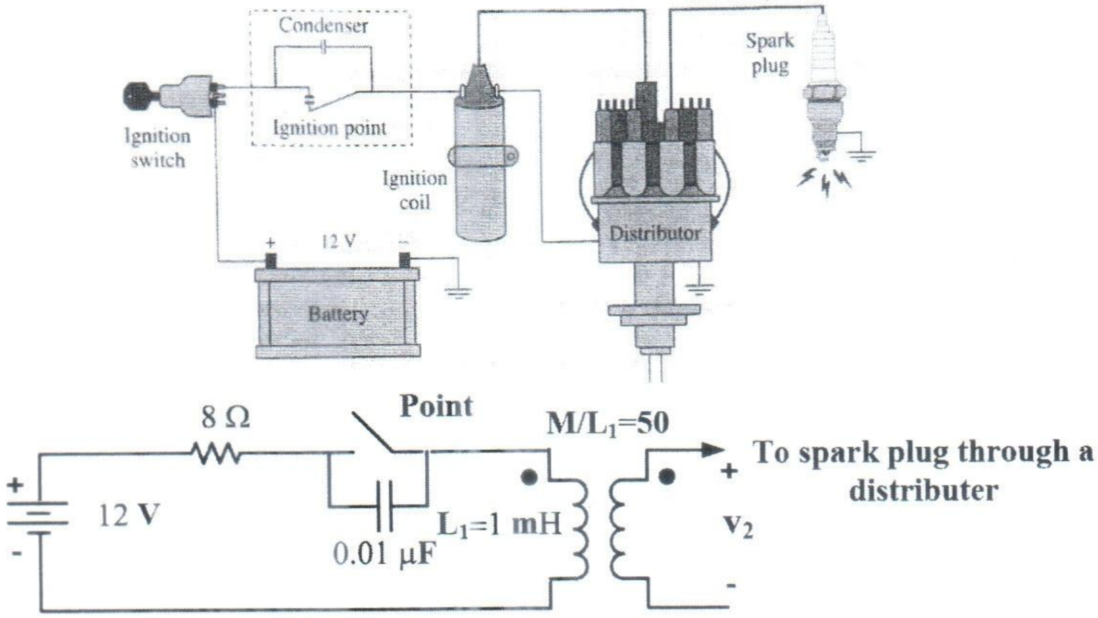

Fig. 6(b).

OR(Question 6)

a) Fig. 6(a-OR) shows a circuit in the time domain. An incorrect analysis of this circuit in the S-domain for $t > 0$ indicates that $I_L(S) = \frac{S+2}{S^2+S+5}$ and $V_C(S) = \frac{-20(S+2)}{S^2+S+5}$. 12(CO3, PO3)

(i) Use the initial and final value theorems to find the error in the analysis.

(ii) Correct the error and find $v_C(t)$.

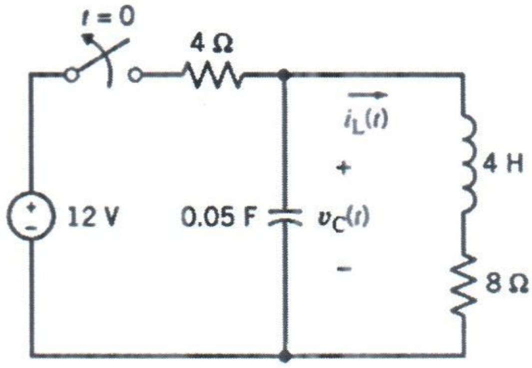

Fig.6(a-OR).

b) Sketch the S-domain circuit of Fig. 6(b-OR) for $t > 0$ and find $v(t)$. 13(CO3, PO3)

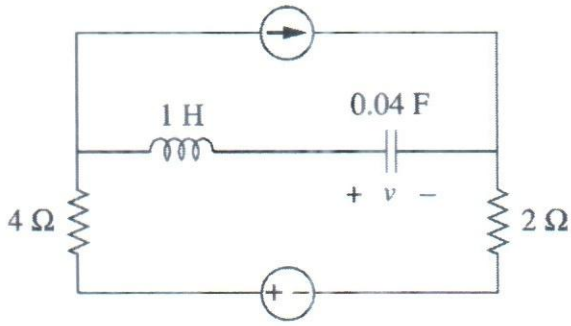

Fig. 6(b-OR).