Assignment 4: Fourier Series and Transform*

Signals and Systems (ELC 321)
Department of Electrical and Computer Engineering
The College of New Jersey.

Instructions:

1. The assignment questions are extracted from the Text (Signals, Systems, and Transforms, Fifth edition)
2. When using MATLAB to plot signals, scale your time or frequency axis such as to allow sufficient amount of the signal to be plotted. Use subplot to give 3 or 4 plots per page; label the axes of your plots accordingly e.g Time (sec) on the x-axis and x(t) on the y-axis; the title should be the problem number, for example 2a).
3. No submission is required for this assignment.
4. **Due Date: Not Applicable**.

Problem 1 (50 Marks)**.** *The block diagram of Figure 1 is an electronic oscillator for generating pure sinusoidal signal of a particular frequency, say ω_o. The block comprises of a square wave generator and a filter. The square wave generator can be realized using the circuit in Figure 2.*

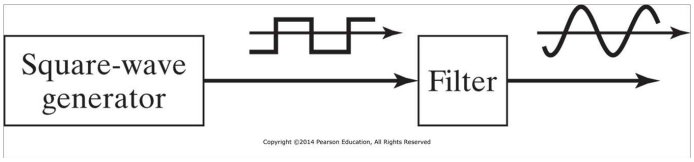

Figure 1: Square Wave Generator

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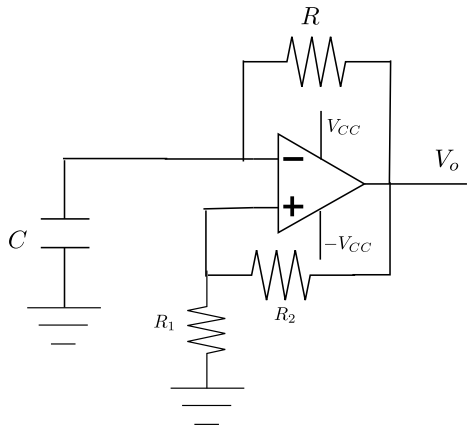

Figure 2: Square Wave Generator

a) *Simulate the square wave generator in Pspice to obtain a square wave output. Set* $V_{CC} = 5V$ *and use appropriate component values to obtain a period of 5 Secs. Include the plots of the capacitor voltage and the output voltage* V_o *in your report. Hint: The period* T *is given by the relation*

$$T = 2RC \ln\left(\frac{1+\alpha}{1-\alpha}\right) \text{ with} \tag{1}$$

$$\alpha = \frac{R_1}{R_1 + R_2} \tag{2}$$

You may fix $\ln\left(\frac{1+\alpha}{1-\alpha}\right) = 1$ *and then compute the values* R_1, R_2, R *and* C *to achieve your desired Period of 5 seconds.*

b) *Express the square-wave obtained in step* (a) *into its exponential Fourier series.*

c) *Use Matlab to plot truncated form of the Fourier series obtained in step* (b) *using the following number of harmonics:*

   (a) *3-Harmonics, i.e only include terms up to* $3\omega_o$ *in your Fourier series.*

   (b) *9-Harmonics*

   (c) *21-Harmonics, and*

   (d) *45-Harmonics*

□

Problem 2 (50 Marks)**.** *Figure 3 shows a half-wave rectifer circuit with sinusoidal signal input* $V_S(t) = Asin(\omega t)$ *as shown in Fig 4. The voltage measured across the load resistor* R_L *is shown in Fig 5 assuming ideal diode behavior.*

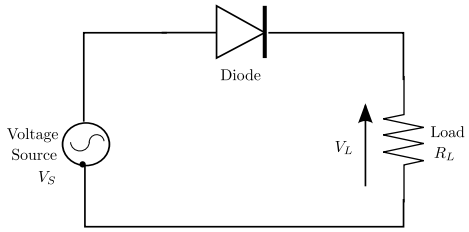

Figure 3: Half-wave Rectifier Circuit

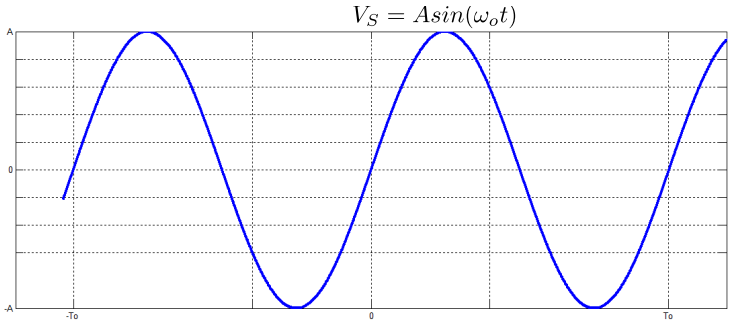

Figure 4: Sinusoidal Input

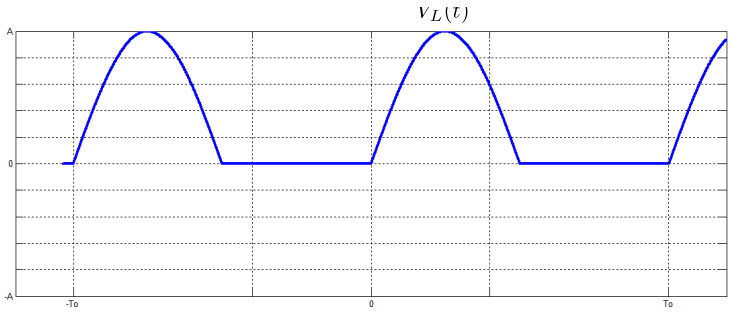

Figure 5: Half-wave rectified Signal

a) Determine the period T_o of both the input and output signals shown in Figs 4 and 5.

b) Express the input sinusoidal signal as an exponential Fourier series.

c) Express the half-wave rectfied signal of Fig. 5 as an exponential Fourier series. Deduce the average value of the half-wave rectified signal.

□

Problem 3 (50 Marks)**.** *The pulsed sinusoid of Figure 6 is formed by multiplying a sinusoidal signal $x(t)$ of Fig. 7 by a rectangular pulse of Fig. 8*

sometimes called a window. This pulsed-waveform has many applications expecially in electronic communication systems and in detection systems such as radar and sonar.

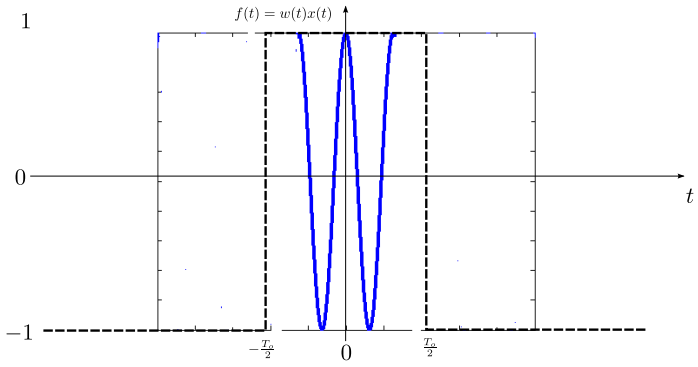

Figure 6: Pulsed Cosine waveform

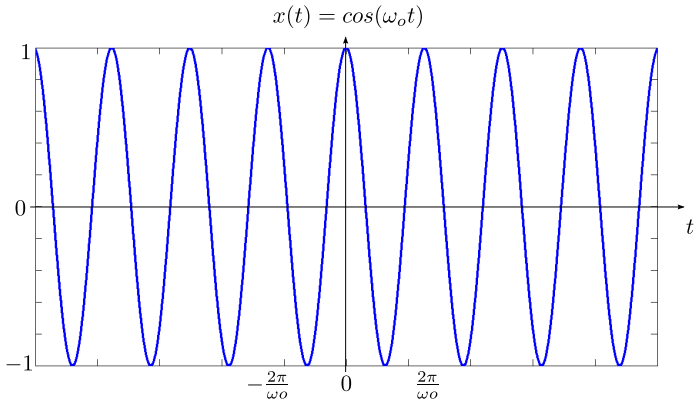

Figure 7: Cosine waveform

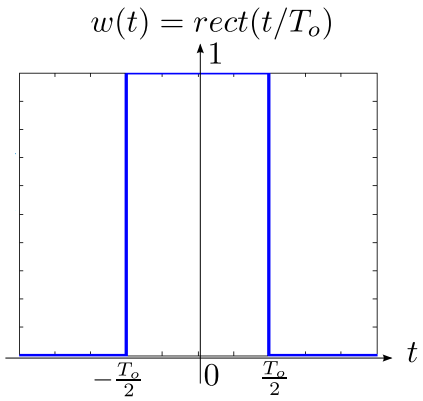

Figure 8: Rectangular Pulse

a) Determine the Fourier tranform of the cosine waveform $x(t) = cos(\omega_o t)$ *shown in Fig. 7 and plot its magnitude spectrum.*

b) Find the Fourier transform of the rectangular pulse of Fig. 8 and plot its magnitude spectrum using Matlab

c) Determine the Fourier tranform of the pulsed cosine waveform of Fig.6 and plot the magnitude spectrum using Matlab.

□