NANYANG TECHNOLOGICAL UNIVERSITY

SCHOOL OF ELECTRICAL & ELECTRONIC ENGINEERING

ACADEMIC YEAR 2014/2015 SEMESTER 2

EE2010/IM2004 SIGNALS AND SYSTEMS

TUTORIAL 1

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*Q*1.1: Determine the even and odd components of the DT function $x[n]=n+(-1)^n$. Sketch the waveforms of $x_e[n]$, $x_o[n]$, and $x[n]$.

*Q*1.2: Determine whether the following signals are energy-type or power-type signals:

(a) $x(t)=\begin{cases} e^{|t|}, & \text{for } -2 \le t \le 2, \\ 0, & \text{otherwise.} \end{cases}$

(b) $y[n]=(-1)^n$.

*Q*1.3: A sinusoidal signal $x(t)=2\sin(20\pi t)$ is passed through a half-wave rectifier circuit to produce:

$$y(t)=\begin{cases} x(t), & \text{if } x(t)>0, \\ 0, & \text{otherwise.} \end{cases}$$

(a) Sketch the waveforms of $x(t)$ and $y(t)$, respectively.
(b) Determine the energy and power levels of $x(t)$ and $y(t)$, respectively.

Answers:

$Q1.1$: $x_e[n]=(-1)^n, x_o[n]=n.$

$Q1.2$: (a) $E_x=e^4-1, P_x=0.$ (b) $E_y=\infty, P_y=1.$

$Q1.3$: (b) $E_x=\infty, P_x=2, E_y=\infty, P_y=1.$

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TUTORIAL 2

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*Q*2.1: Assume that $v(t) = \sin(2\pi f_0 t)$, sketch the following waveforms and evaluate $\int_{-\infty}^{\infty} y(t)dt.$

(a) $w(t) = v(t) \times \mathrm{rect}\left(\dfrac{t}{2T_0}\right)$, where $T_0 = 1/f_0$.

(b) $x(t) = \mathrm{sgn}(w(t))$.

(c) $y(t) = \sum_{n=-\infty}^{\infty} x(t) \times \delta(t - nT_0/4)$.

*Q*2.2: Sketch the waveforms of $x(t) = \sum_{n=-1}^{1} v(t - nT_0)$ and $y(t) = -x\left(\dfrac{t+4}{2}\right)$, where $v(t) = t[u(t) - u(t - T_0)]$ and $T_0 = 2$.

*Q*2.3: Assuming that the signal $v(t)$ is an energy-type signal and its energy is denoted as E_v, determine the energy levels of the following signals as a function of E_v.

(a) $x(t) = -3v(t)$.

(b) $y(t) = v(t-3)$.

Answers:

*Q*2.1: $\int_{-\infty}^{\infty} y(t)dt = 0.$

*Q*2.3: (a) $E_x = 9E_v$. (b) $E_y = E_v$.

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TUTORIAL 3

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*Q*3.1: Evaluate the convolution sum $y[n] = x[n] * x[n]$ where $x[n] = \begin{cases} 1, \text{ for } n = -1,0,1. \\ 0, \text{ otherwise.} \end{cases}$

*Q*3.2: For the system as shown in Figure *Q*3.2, evaluate the system output $y(t)$ where

$$x_1(t) = A\,\mathrm{rect}\left[\frac{t-1}{2}\right] - A\,\mathrm{rect}\left[\frac{t-3}{2}\right] \text{ and } x_2(t) = A\,\mathrm{rect}\left[\frac{t-2}{4}\right].$$

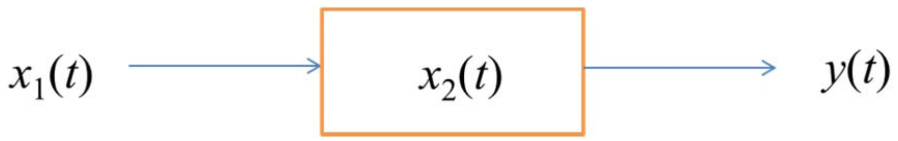

Figure *Q*3.2.

*Q*3.3: Determine the properties of the system shown in Figure *Q*3.3 in terms of linearity and time invariance.

Figure *Q*3.3.

Answers:

*Q*3.3: The system is linear but not time invariant.

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TUTORIAL 4

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*Q*4.1: Radio signals can travel through a wireless channel by more than one path, with different time delays and attenuations (known as channel fading). Consider a three-path case with a system impulse response given by

$$h(t) = \sum_{k=0}^{2} \left(\frac{1}{2}\right)^k \delta(t-3k).$$

Assume that the input signal is given by $x(t) = t \times \mathrm{rect}\left(\frac{\mathrm{t\text{ - }1}}{2}\right)$.

(a) Determine whether the system is memoryless, causal, and stable.
(b) Determine the system output $y(t)$ and sketch its waveform.
(c) Express the energy of $y(t)$ as a function of the energy of $x(t)$.

*Q*4.2: Evaluate the step response of the system with impulse response given by $h(t) = 2e^{-2|t|}$.

*Q*4.3: (a) Find the equivalent impulse response $h[n]$ of the overall system as shown in Figure *Q*4.3, where $h_1[n] = \delta[n-4], h_2[n] = \delta[n-2]$, and $h_3[n] = \delta[n+1]$.

(b) Determine whether the overall system is memoryless, causal, and stable.
(c) Determine the step response of the overall system.

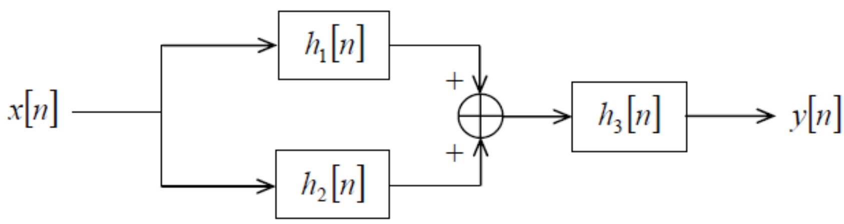

Figure *Q*4.3.

Answers:

$Q4.1$: (a) The system is not memoryless, it is causal and stable. (b) $E_y = \frac{21}{16}E_x$.

$$Q4.2: s(t) = \begin{cases} 2 - e^{-2t}, & \text{for } t \ge 0, \\ e^{2t}, & \text{for } t < 0. \end{cases}$$

$Q4.3$: (a) $h[n] = \delta[n-1] + \delta[n-3]$. (b) The system is not memoryless, it is causal and stable.

(c) $s[n] = u[n-1] + u[n-3]$.

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TUTORIAL 5

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*Q*5.1: Show that the cross-correlation function between any energy-type signal $x[n]$ and the delta function $\delta[n]$ is equal to $x[-m]$.

*Q*5.2: Find the cross-correlation function between the two signals $x[n] = \text{rect}\left(\frac{\text{n}}{2}\right)$ and $y[n] = \delta[n-1]$.

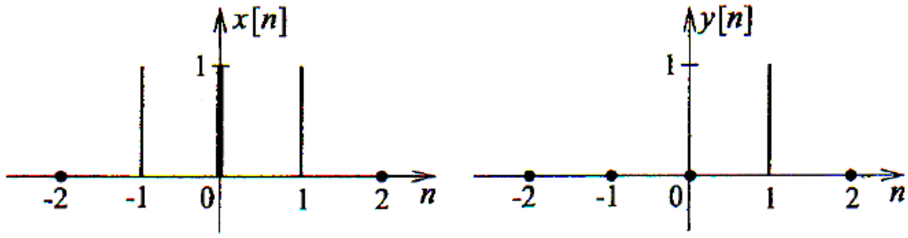

Figure *Q*5.2.

*Q*5.3: Consider two complex-valued signals given by $x(t) = 3e^{j20\pi t}$ and $y(t) = 4e^{j40\pi t}$.

(a) Sketch the amplitude plots of $x(t)$ and $y(t)$, respectively.
(b) Determine the power levels of $x(t)$ and $y(t)$, respectively.
(c) Find the cross-correlation function of $x(t)$ and $y(t)$.
(d) Comment on the result obtained in part (c).

Answers:

$Q5.3$: (b) $P_x = 9, P_y = 16.$ (c) $R_{xy}(\tau) = 0.$

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TUTORIAL 12

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*Q*12.1: A sinusoidal signal $p(t) = \sin(200\pi t)$ is passed through a full-wave rectifier circuit to produce the output signal *m*(*t*) given by

$$m(t) = \begin{cases} p(t), \text{ if } p(t) \geq 0, \\ -p(t), \text{ otherwise.} \end{cases}$$

The signal *m*(*t*) is then modulated by the conventional AM to produce the AM signal

$$x_{AM}(t) = [1 + 2m(t)]\cos(2000\pi t).$$

(a) Sketch the waveform of *m*(*t*) and determine the power level of *m*(*t*).
(b) Sketch the waveform of $x_{AM}(t)$.

*Q*12.2: A message signal *m*(*t*) is modulated by a conventional AM scheme to produce

$$x_{AM}(t) = 2[1 + 0.5m(t)]\cos(2000\pi t).$$

The amplitude spectrum of *m*(*t*) is given by

$$M(f) = \begin{cases} 1 - |0.01f|, \text{for } -100\text{Hz} \leq f \leq 100\text{Hz}, \\ 0, \quad \text{otherwise.} \end{cases}$$

(a) Sketch the amplitude spectrum of $x_{AM}(t)$.
(b) Determine the bandwidths of $m(t)$ and $x_{AM}(t)$, respectively.

*Q*12.3: Two messages signals $m_1(t)$ and $m_2(t)$ are to be transmitted over a wireless channel simultaneously using the conventional AM with frequency-division multiplexing (FDM). The spectral of $m_1(t)$ and $m_2(t)$ are shown in Figure *Q*12.3. Determine the minimum separation between the two carrier frequencies and the minimum bandwidth required to transmit these two signals simultaneously without interfering with each other.

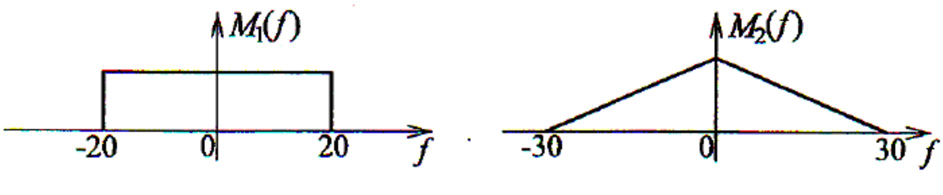

Figure *Q*12.3.

Answers:

$Q12.2$: (b) $B_m = 100$ Hz, $B_{x_{AM}} = 200$ Hz.

$Q12.3$: $\Delta f = 50$ Hz, $W = 100$ Hz.