

EE 341 – Homework Chapter 4

4.2 For the functions

$$\Phi_1(t) = e^{-2|t|} \quad \text{and} \quad \Phi_2(t) = 1 - Ke^{-4|t|}$$

Determine the value of K such that the functions are orthogonal over the interval $[-\infty, \infty]$.

4.5 The Haar functions are very popular in signal processing and wavelet applications. These functions are generated using a scale parameter (m) and a translation parameter (n). Let the mother Haar function (m=n=0) be defined as follows:

$$H_{0,0}(t) = \begin{cases} 1 & 0 \leq t \leq 0.5 \\ -1 & 0.5 \leq t \leq 1 \\ 0 & \text{o.w.} \end{cases}$$

The other Haar functions, at scale m and with translation n, are defined using the mother Haar functions as follows:

$$H_{m,n}(t) = H_{0,0}(2^m t - n), \quad n = 0, 1, \dots, (2^m - 1)$$

The Haar functions for m=0,1,2 are shown in Fig. P4.5.

Show that the Haar wavelet functions $\{H_{m,n}(t), m=0,1,2,\dots, n=0,1,2,\dots, (2^m-1)\}$ form a set of orthogonal functions over the interval $[0,1]$ by proving the following:

$$\int_0^1 H_{m,n}(t) H_{p,q}(t) dt = \begin{cases} 2^{-m} & m = p, n = q \\ 0 & \text{o.w.} \end{cases}$$

4.24 The impulse response of an LTIC system is given by

$$h(t) = e^{-2|t|}$$

- (a) Based on the Eq. (4.73), calculate the T.F. $H(\omega)$ of the LTIC system.
- (b) The plot of magnitude $|H(\omega)|$ with respect to ω is referred to as the magnitude spectrum of the LTIC system. Plot the magnitude spectrum of the LTIC system for the range $(-\infty < \omega < \infty)$.
- (c) Calculate the output response $y(t)$ of the LTIC system if the impulse train shown in Fig. 4.7 is applied as an input to the LTIC system.

4.27 Consider the following periodic functions represented as CTFS:

- (i) $x_1(t) = \frac{7}{\pi} \sum_{m=0}^{\infty} \frac{1}{2m+1} \sin [8\pi(2m+1)t];$

(ii) $x_2(t) = 1.5 + \sum_{m=0}^{\infty} \frac{1}{4m+1} \cos [2\pi(4m + 1)t]$.

- (a) Determine the fundamental period $x(t)$.
- (b) Determine if $x(t)$ is an even signal or an odd signal.
- (c) Using the `ictfs.m` function provided in the CD, calculate and plot the functions in the time interval $-1 \leq t \leq 1$. [Hint: You may calculate $x(t)$ for $t = [-1:0.01:1]$. The MATLAB “plot” function give a smooth interpolated plot.]
- (d) From the plot in step ©, determine the period of $x(t)$. Does it match your answer to part (a)?