Indian Institute of Technology Bombay

Department of Electrical Engineering

Handout 8 EE 229 Signal Processing

Tutorial 5 Oct 20, 2020

Question 1) Under the assumption that Parseval's relation applies, find the energy $\int_{\mathbb{R}} |x(t)|^2 dt$, when $x(t) = \delta(t - \tau)$.

Question 2) Consider the digital signals

$$x[0] = 7, x[1] = 3, x[2] = 6, x[3] = 4, x[4] = 1, x[5] = 3 \text{ and}$$
$$h[0] = 4, h[1] = 2, h[2] = 2.$$

Take the remaining indices to contain zeroes.

(a) Find $x[n] * h[n]$ and $x[n] \circledast h[n]$. Which one has more entries.

(b) Is $x[n] \circledast h[n]$ same as $h[n] \circledast x[n]$?

(c) Find a signal $u[n]$ s.t. $u[n] * h[n] = x[n] \circledast h[n]$ for $0 \le n \le N - 1$. (**Cyclic Prefix in 4G**).

(d) Express $x[n] \circledast h[n]$ as a matrix vector product.

Question 3) Suppose a signal $x(t)$ is sampled at β samples per second by multiplying with $\sum_n \delta(t + \frac{n}{\beta})$ to obtain the digital samples $x[n], n \in \mathbb{Z}$. Let the signal $x(\frac{t}{\beta})$ be sampled at every integer instant to obtain $y[n]$.

(a) Compare the respective DTFTs of $x[n]$ and $y[n]$.

(b) What is the highest frequency content of the samples $x[n]$.

Question 4) The signal $\cos(2\pi 9000t)$ is sampled at 10 kilo samples per second to obtain $x[n]$. From the samples we wish to generate a 9 kHz waveform by filtering. Suggest a possible Block 1 in the figure below, to obtain a suitable discrete time signal, which will then give the shown output when filtered using $h(t)$. You have to also specify an appropriate $h(t)$.