ECE 348: Digital Signal Processing Lab, Spring 2023

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**General Instructions: Please submit a written report in the pdf format within 2 weeks of your lab session. The report must describe the purposes of the experiments, the methods used, including all graphs and Matlab code. The reports must be uploaded to Canvas within the allotted time frame.**

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## LAB – 1

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**Problem 1** (CP 2.15)**.** Write a computer program that computes and plots the overall impulse response $h(n)$ of the system shown in Fig. CP 2.15 for $0 \le n \le 99$. The system and $\mathcal{T}_1, \mathcal{T}_2, \mathcal{T}_3$, and $\mathcal{T}_4$ are specified by

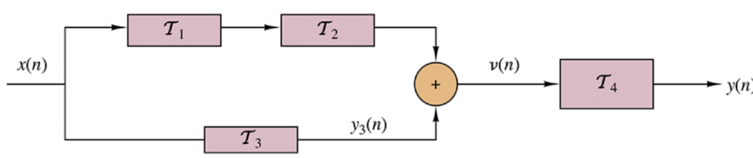
(a) $\mathcal{T}_1$: $h_1(n) = \{\underset{\uparrow}{1}, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}\}$

(b) $\mathcal{T}_2$: $h_2(n) = \{\underset{\uparrow}{1}, 1, 1, 1, 1\}$

(c) $\mathcal{T}_3$: $y_3(n) = \frac{1}{4}x(n) + \frac{1}{2}x(n-1) + \frac{1}{4}x(n-2)$

(d) $\mathcal{T}_4$: $y_4(n) = 0.9y(n-1) - 0.81y(n-2) + v(n) + v(n-1)$

**Figure CP2.15**




**Problem 2** (CP 2.16 TIME DELAY ESTIMATION IN RADAR)**.** Let $x_a(t)$ be the transmitted signal and $y_a(t)$ be the received signal in a radar system, where

$$y_a(t) = ax_a(t - t_d) + v_a(t)$$

and $v_a(t)$ is additive random noise. The signals $x_a(t)$ and $y_a(t)$ are sampled in the receiver and are processed digitally to determine the time delay and hence the distance of the object. The resulting discrete-time signals are

$$x(n) = x_a(nT)$$

$$\begin{aligned} y(n) = y_a(nT) &= ax_a(nT - DT) + v_a(nT) \\ &\triangleq ax(n - D) + v(n) \end{aligned}$$

(a) Explain how we can measure the delay $D$ by computing the crosscorrelation $r_{xy}(l)$.

(b) Let $x(n)$ be the 13-point Barker sequence

$$x(n) = \{+1, +1, +1, +1, +1, -1, -1, +1, +1, -1, +1, -1, +1\}$$

and $v(n)$ be a Gaussian random sequence with zero mean and variance $\sigma^2 = 0.01$. Write a program that generates the sequence $y(n)$, $0 \le n \le 199$ and for $a = 0.9$ and $D = 20$. Plot the signals $x(n), y(n), 0 \le n \le 199$.

(c) Compute and plot the crosscorrelation $r_{xy}(l)$, $0 \le l \le 59$. Use the plot to estimate the value of the delay $D$.

(d) Repeat parts (b) and (c) for $\sigma^2 = 0.1$ and $\sigma^2 = 1$.

**Problem 3** (CP 2.8)**.** An LTI system is described by the difference equation

$$y(n) = \tfrac{1}{2}y(n-1) - \tfrac{1}{4}y(n-2) + x(n) + 2x(n-1) + x(n-3)$$

(a) Compute and plot the impulse response of the system for $0 \le n \le 100$. Determine the stability of the system from the impulse response.

(b) If the input to this system is

$$x(n) = [10 + 2cos(0.3\pi n) + 5sin(0.6\pi n)]u(n)$$

compute and plot the response $y(n)$ over $0 \le n \le 200$.