LAB – 2: DT systems applications

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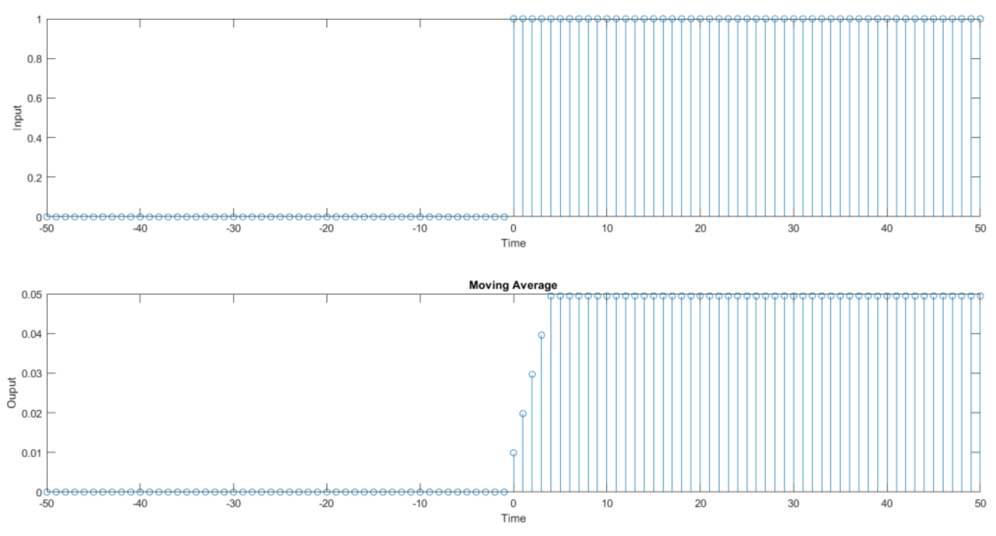
Team Name: Noicifiers

QUESTION – 2.1

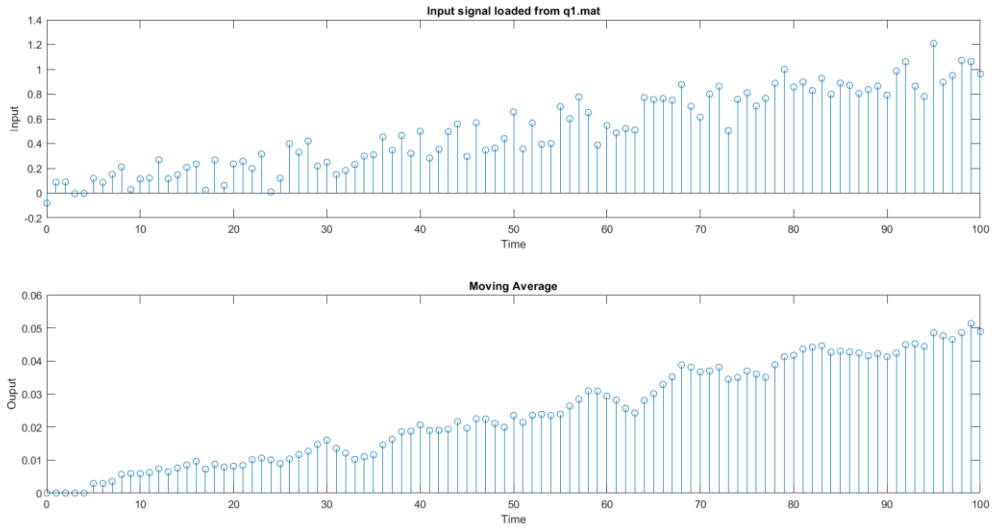
(a)

```
function y = MASystem(N, InputData)
    y = zeros(size(InputData));
    sum = 0;
    for n = 1:N
       sum = sum + InputData(n);
    end
    for n = N+1:length(InputData)
        sum = sum - InputData(n-N) + InputData(n);
        y(n) = sum;
    end
    y = y/n;
end
```

(b) Unit step Function as Input:

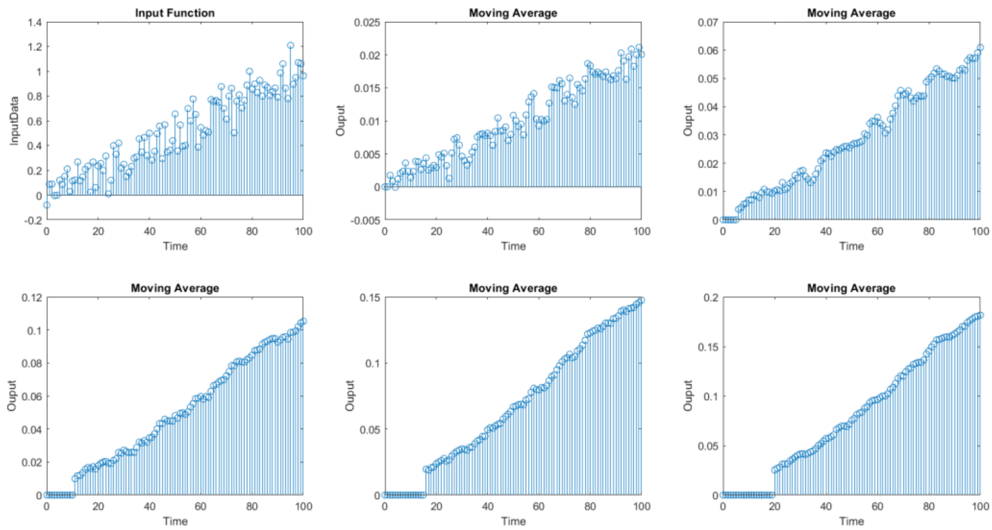


(c) Input from the file ‘q2_1.mat’



(d)

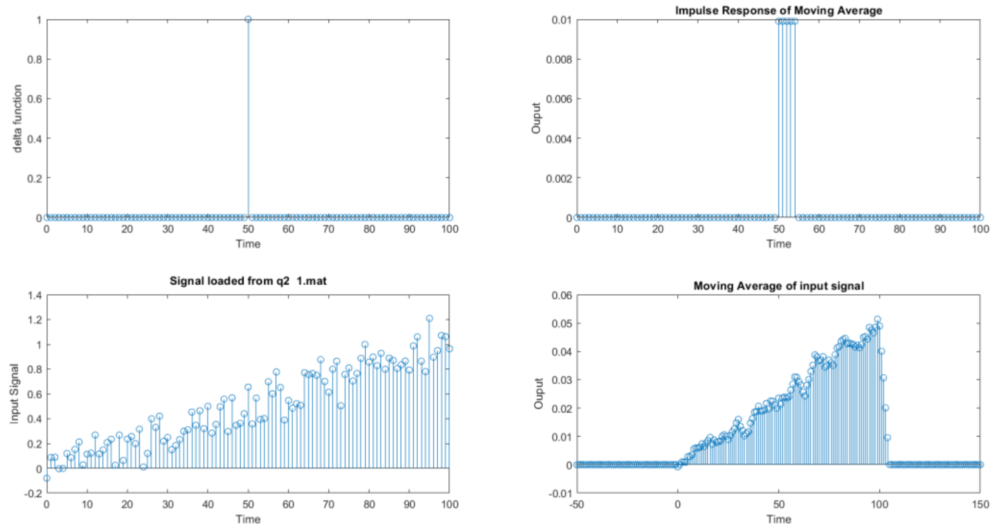
```
N_Array = [2 6 11 16 20];
```



- If N is large, the moving average does not change much as only one value changes when shifted by a unit of time.

- If N is small, a smaller number of samples are taken into consideration. Which does not give us a better understanding of the trends in the signal.
- So, the appropriate value of N would be around 7.

QUESTION – 2.1.1



Advantages of Convoluting the signal:

- Convolution involves frequency domain. So, by convolving the signal with the impulse response, we can easily understand the frequency response i.e., the behaviour of the signal at different frequencies.
- Convolution satisfies the superposition principle, which means that if you have multiple inputs, you can convolve each input's impulse response with

the corresponding input signal and then sum the results to get the overall system response.

Disadvantages of Convoluting the signal:

- Convolution involves calculating the product of each input sample with the corresponding impulse response samples and then summing these products. This operation can be computationally intensive, especially for long signals and complex impulse responses.

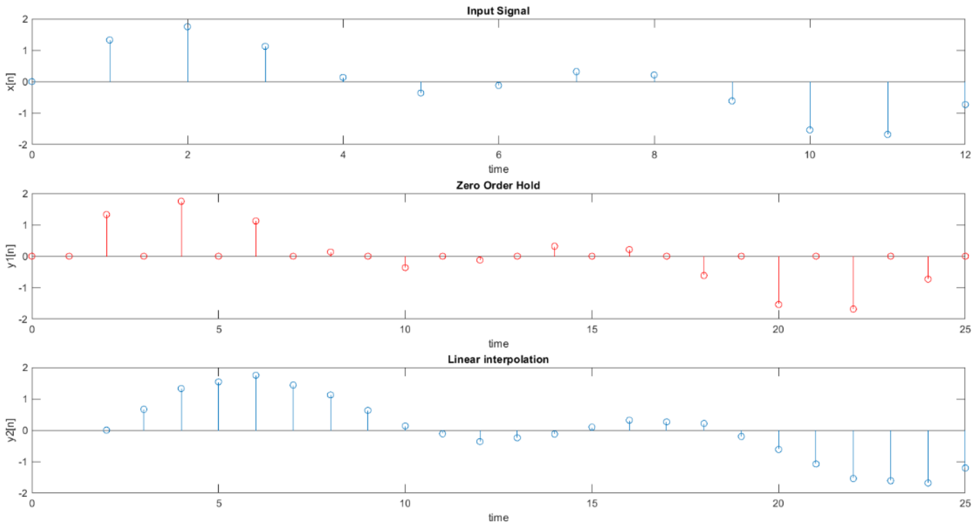
QUESTION – 2.2

(a)

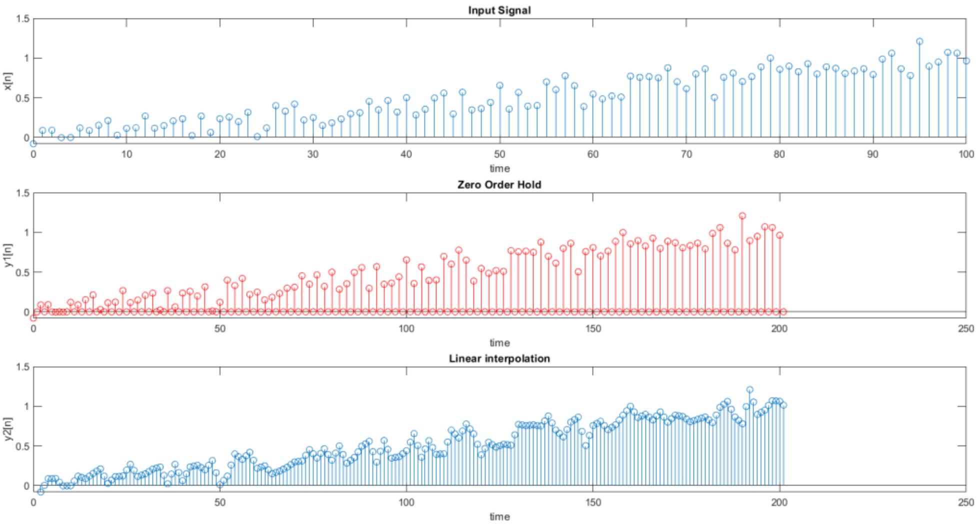
```
function y = UpSampler(M, x)
    y = zeros(1, M*length(x));
    y(1) =x(1);
    for n = 2:M*length(x)
        val = n/M;
        if val == floor(val)
            y(n-(M-1)) = x(val);
        end
    end
end
y1 = UpSampler(M, x);
y2 = interp1(M:M:M*length(x), x, t1);
```

(b)

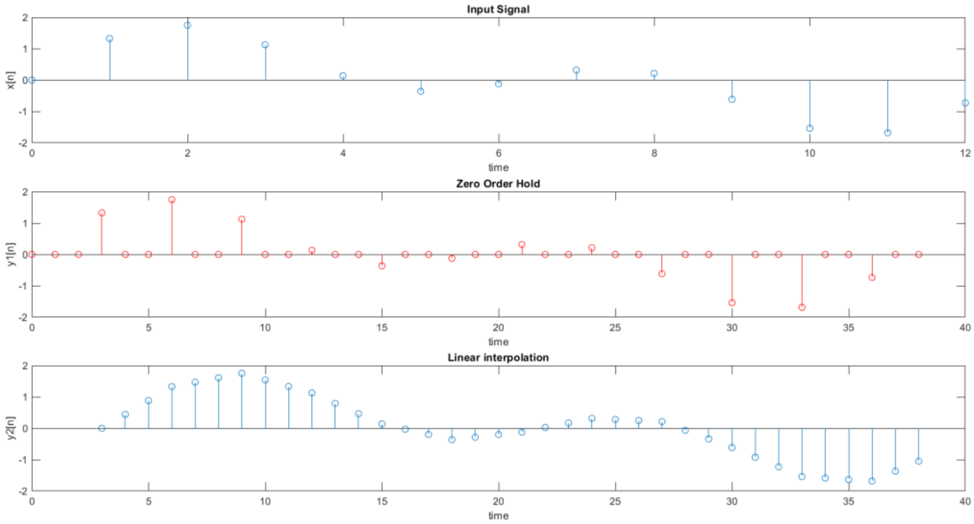
M = 2, input = q2_1



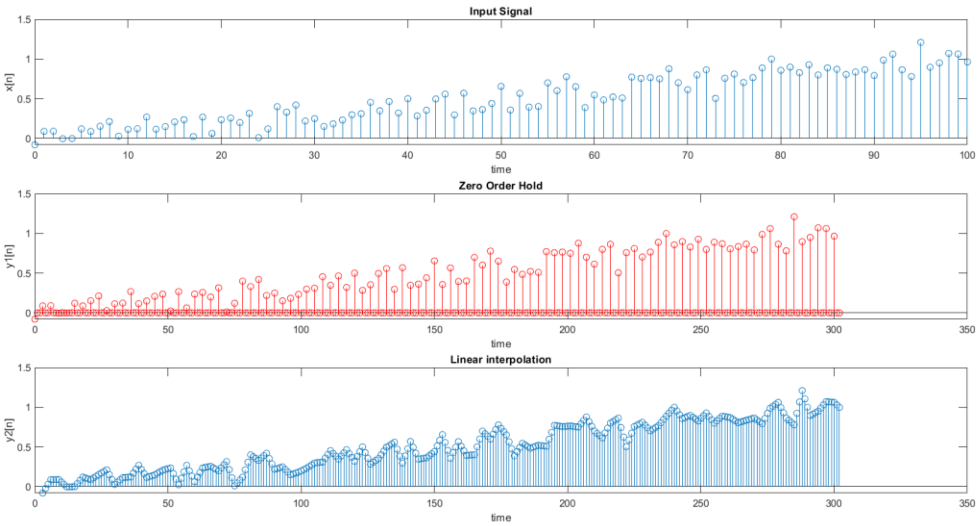
M = 2, input = q2_2



M = 3, input = q2_1



M = 3, input = q2_2

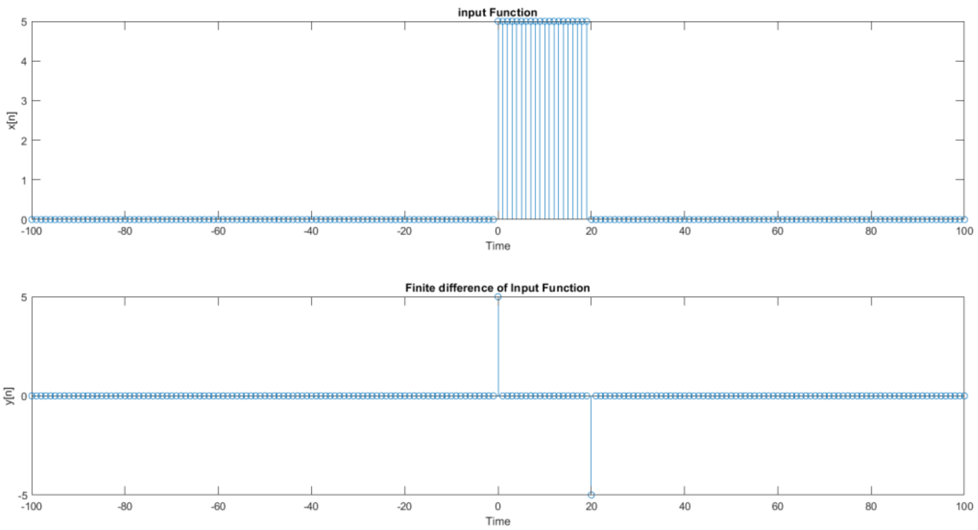


OBSERVATIONS:

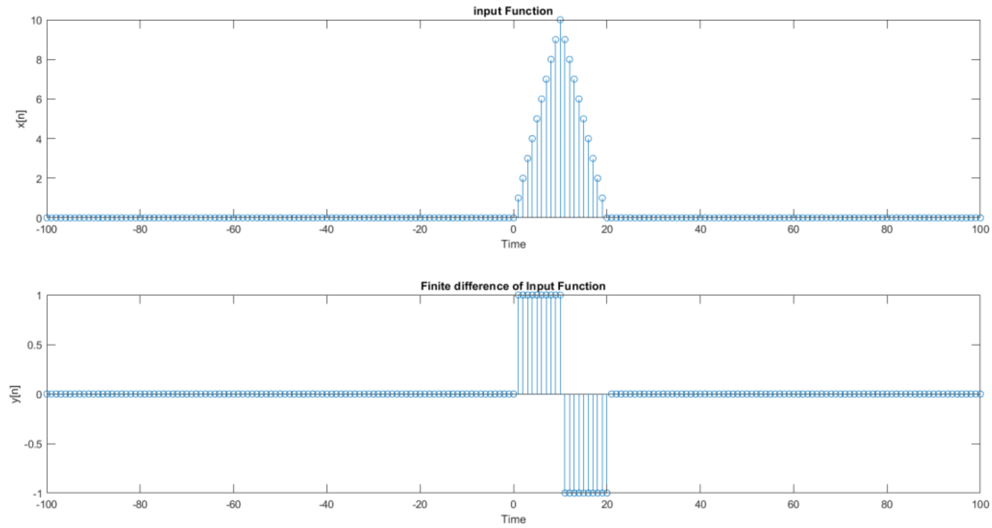
- For, zero Order hold, the plot gets scaled along the x-axis and the values present are only at multiples of M (corresponding values from the input).
- For Linear interpolation, the plot gets scaled by M along the x-axis. The corresponding values from the input are at multiples of M. interp1() function interpolates the graph for non–multiple values of M on x–axis.
- For M = 2, the graph scales by 2 along the x–axis.
- For M = 3, the graph scales by 3 along the x-axis.

QUESTION – 2.3

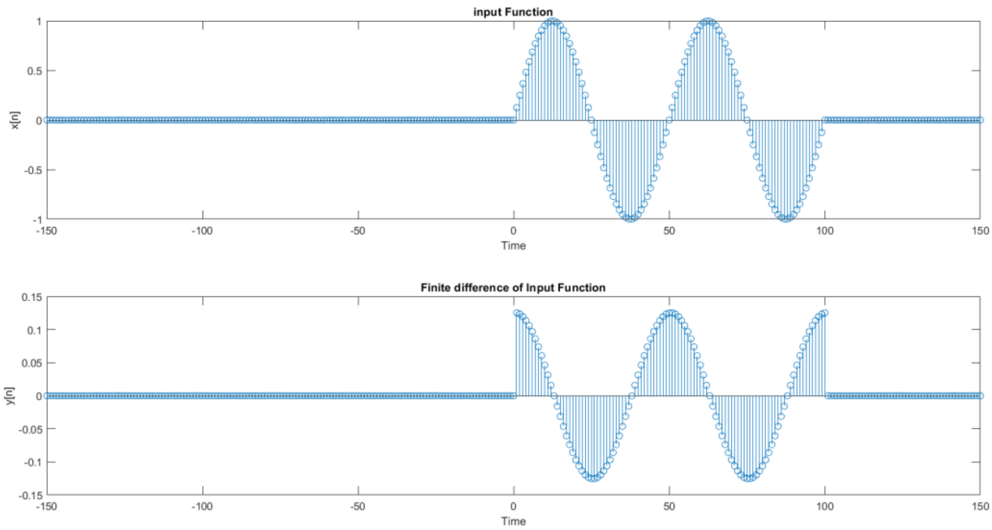
(a)



(b)

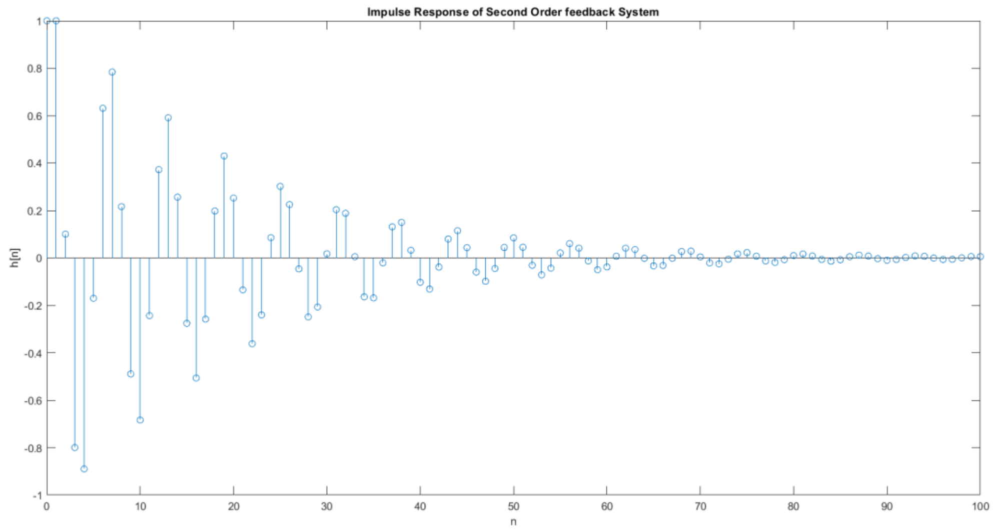

input Function
x[n]
Time
Finite difference of Input Function
y[n]
Time

(c)

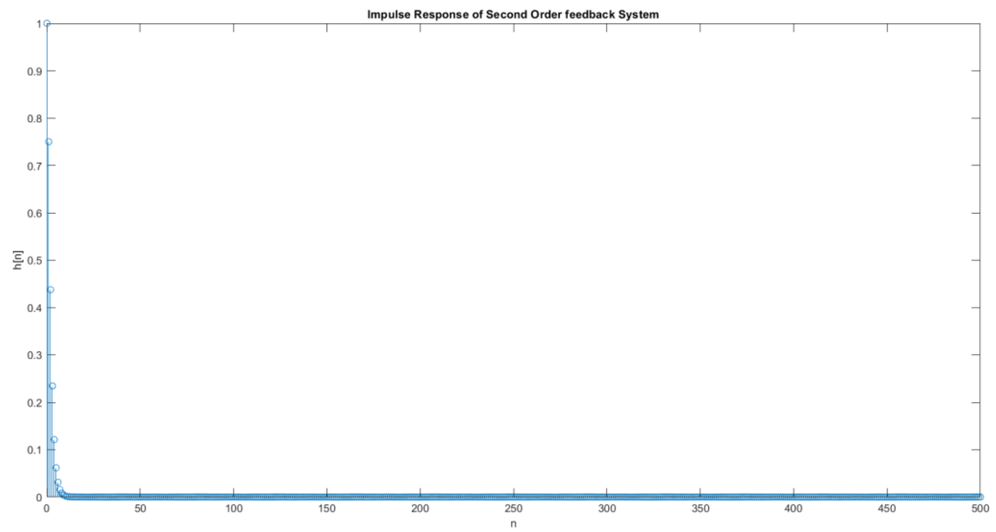

input Function
x[n]
Time
Finite difference of Input Function
y[n]
Time

QUESTION – 2.4.1

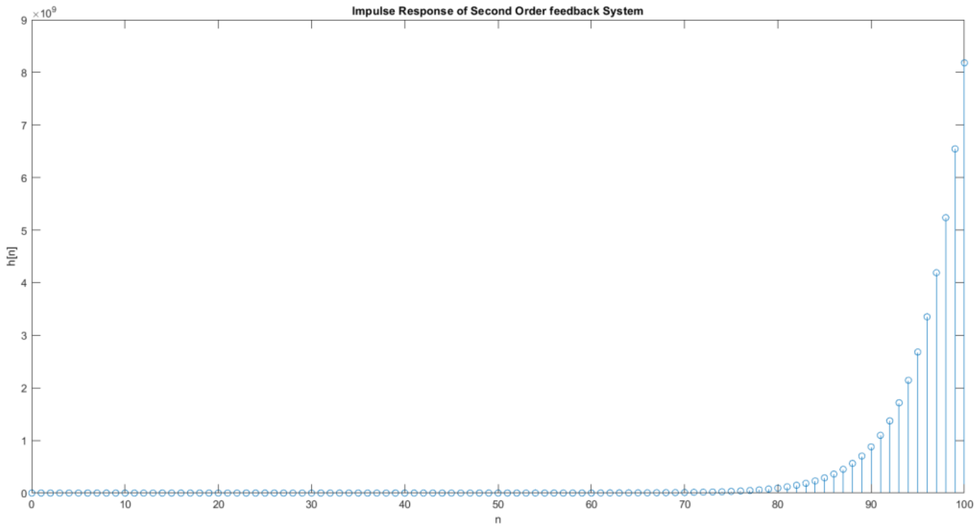
(a) α =-1 and β = 0.9



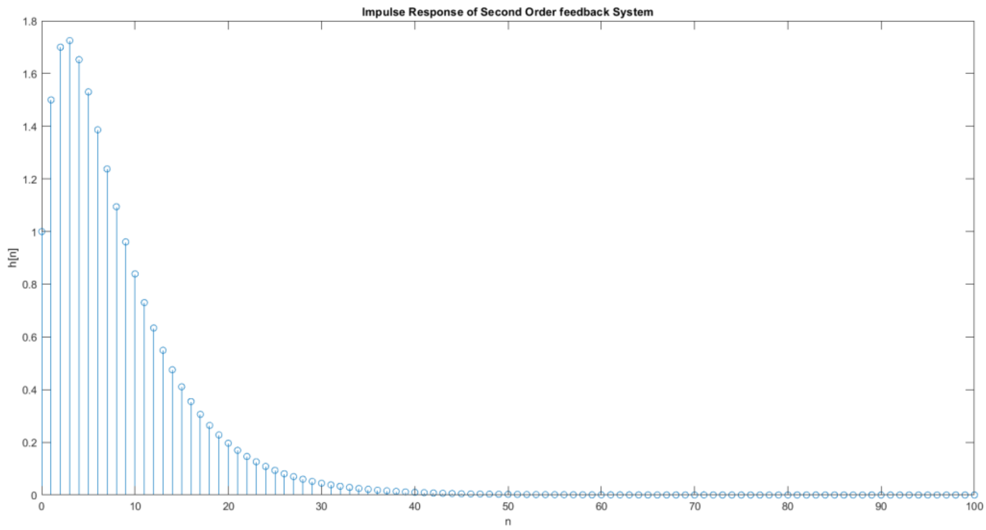
(b) α = -0.75 and β = 0.125



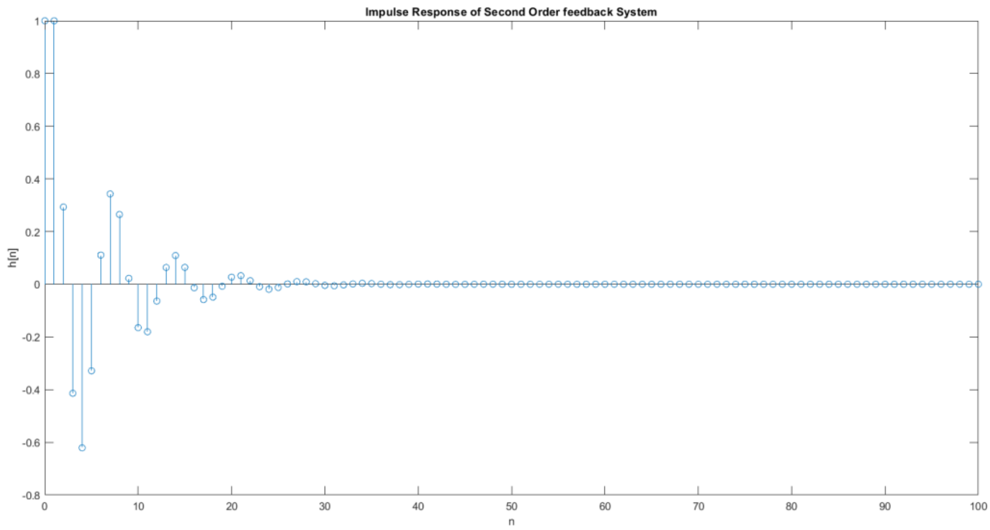
(c) α = -1.75 and β = 0.625



(d) α = -1.75 and β = 0.55



(e) $\alpha = -1$ and $\beta = 0.707$



An explanation for selecting those values of α and β

$$y[n] + \alpha y[n-1] + \beta y[n-2] = x[n]$$

$$\Rightarrow Y + R\alpha Y + \beta R^2 Y = X$$

$$\Rightarrow Y(1 + R\alpha + R^2\beta) = X$$

$$\Rightarrow \boxed{Y = \frac{1}{R^2\beta + R\alpha + 1} X}$$

$$\frac{1}{R^2\beta + R\alpha + 1} = \frac{1}{(R-a)(R-b)} = \frac{1}{(a-b)}\left[\frac{1}{R-a} - \frac{1}{R-b}\right]$$

$$= \frac{1}{(a-b)}\left[\frac{-1}{a}\left[1 + \frac{R}{a} + \frac{R^2}{a^2} + \cdots \infty\right] + \frac{1}{b}\left[1 + \frac{R}{b} + \frac{R^2}{b^2} + \cdots \infty\right]\right]$$

$$= \frac{1}{a-b}\left[\frac{1}{b} + \frac{R}{b^2} + \frac{R^2}{b^3} + \cdots \infty + \left(\frac{-1}{a}\right) + \left(\frac{-R}{a^2}\right) + \cdots \infty\right]$$

$$= \frac{1}{a-b}\left[\left(\frac{1}{b} - \frac{1}{a}\right) + \left(\frac{R}{b^2} - \frac{R}{a^2}\right) + \cdots + \left(\frac{R^n}{b^{n+1}} - \frac{R^n}{a^{n+1}}\right) + \cdots \infty\right]$$

General Term:-

$$T_n = \frac{1}{a-b}\left[\frac{1}{b^{n+1}} - \frac{1}{a^{n+1}}\right] R^n$$

(b) Monotonically decaying:-

as $n \uparrow$, $T_n \downarrow$ $\Rightarrow b > a$

$\Rightarrow \left.\begin{matrix} b = 4 \\ a = 2 \end{matrix}\right\} x^2 - 6x + 8$

$$\Rightarrow \underbrace{0.125}_{\beta} x^2 + \underbrace{(-0.75)}_{\alpha} x + 1$$

(c) **diverges monotonically**

as $n\uparrow$, $T_n \uparrow$ $\Rightarrow$ one root is > 1

other root is < 1

$\Rightarrow a = 2$

$b = 0.8$

$\Rightarrow (x-2)(x-0.8) = x^2 - 2.8x + 1.6 = 0$

$\Rightarrow \cancel{x^2 - (2.8)x + 1/8 = 0}$

$\Rightarrow \cancel{5x^2 + (-10.2)x + 1 = 0}$

$\beta \quad \alpha$

$\Rightarrow \underset{\beta}{(0.625)}x^2 - \underset{\alpha}{1.75}x + 1 = 0$

(e) **Oscillate for all n:**

roots must be complex

$a, b = \frac{1 \pm i}{\sqrt{2}}$

$\Rightarrow \left(x - \left(\frac{1-i}{\sqrt{2}}\right)\right)\left(x - \left(\frac{1+i}{\sqrt{2}}\right)\right)$

$\Rightarrow x^2 - \sqrt{2}x + \sqrt{2} = 0$

$\Rightarrow \underset{\beta}{(1/\sqrt{2})}x^2 + \underset{\alpha}{(-1)}x + 1 = 0$

(d) $h[n]$ should grow initially and decay as $n \to \infty$

$\rightarrow$ α should be -ve.

$\rightarrow$ $|\alpha| > \beta$

$\rightarrow$ β should be +ve

so that after initial growth, β dominates and $h[n]$ decreases.