Signal Processing Lab Report 6

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1 Linear Convolution

1.1 Part a

Linear Convolution: Perform convolution of $x[n]$ with each unit pulse:

$$y_1[n] = x[n] * h_1[n], \quad y_2[n] = x[n] * h_2[n]$$

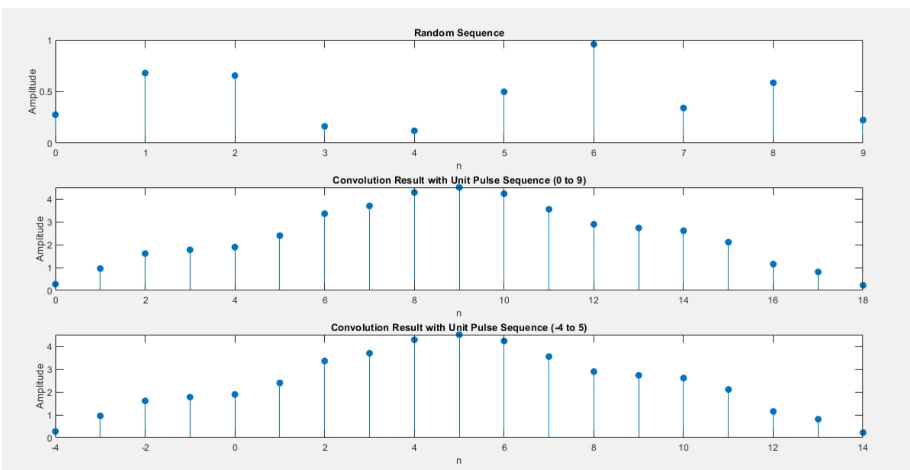

Figure 1.1: Result of convolution with the given 2 signals

1.2 Part b

Convolving the unit pulse with itself (length 4) results in a triangular sequence of length 7:

$$y[n] = [1, 2, 3, 4, 3, 2, 1]$$

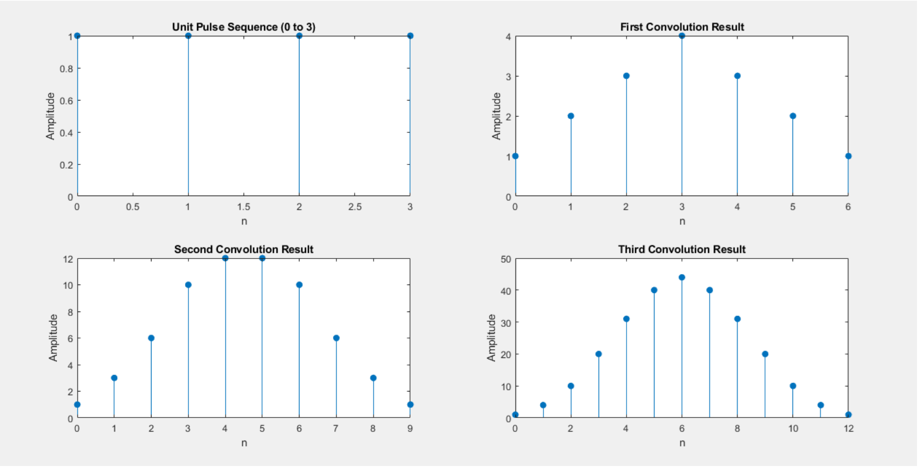

Figure 1.2: Required Convolution plots

1.3 Part c

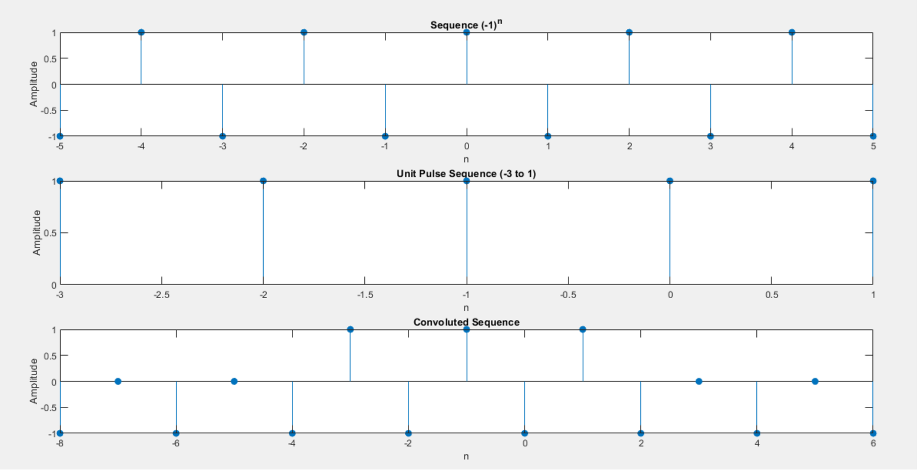

Figure 1.3: Signals and their convolution plots

1.4 Part d

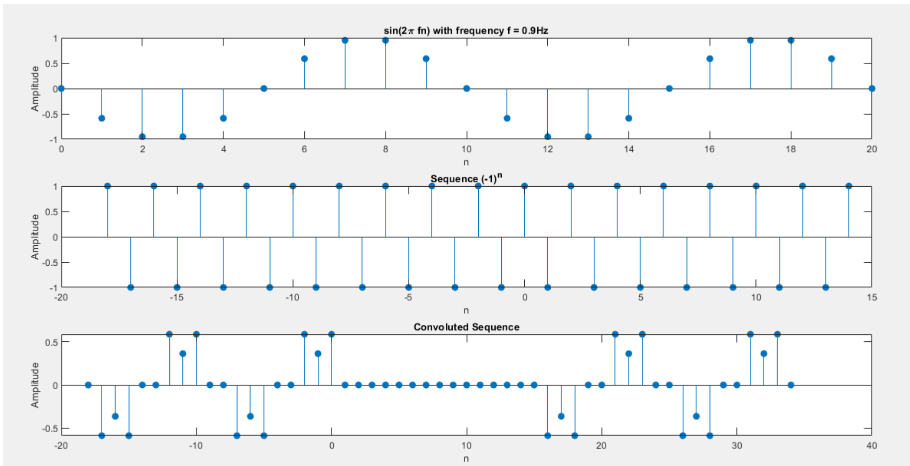

Figure 1.4: Convolution plots of the 2 given signals

2 Circular Convolution

Suppose we consider two finite length Discrete signals x[n] and h[n] of length N_1 and N_2 .

Linear Convolution

Linear convolution of two finite-length sequences $x[n]$ and $h[n]$ produces a sequence whose length is $L = N_1 + N_2 - 1$ respectively.

The linear convolution sum is given by:

$$y_{\text{linear}}[n] = \sum_{k=0}^{N_1-1} x[k]h[n-k]$$

for $n = 0, 1, 2, \ldots, N_1 + N_2 - 2$.

Linear convolution is widely used in systems where the complete response of one signal to another is required. The operation considers all shifts of the signals and does not assume any periodicity. This means that the boundaries are treated without any overlap, and the result reflects the full signal extension.

Circular Convolution

Circular convolution assumes that both signals are periodic, and is defined as:

$$y[n] = (x \circledast h)[n] = \sum_{k=0}^{N-1} x[k] \cdot h[(n-k) \mod N] \tag{1}$$

Here, N is the length of the sequences, and the result of the circular convolution will always have the same length as the input sequences, i.e., N. The Length will be Maximum length of the signal. N = $\max(N_1, N_2)$.

Circular convolution is primarily used when dealing with periodic signals, especially in the context of the discrete Fourier transform. Unlike linear convolution, circular convolution "wraps around" the signals, causing potential overlap at the boundaries. This makes it ideal for operations in the frequency domain or for processing periodic data.

Boundary Handling

- **Linear Convolution:** The operation does not assume periodicity, so the signals are shifted and extended naturally, without any boundary overlap.
- **Circular Convolution:** The operation wraps around the signals at the boundaries, effectively folding them over. This may cause unintended overlaps at the edges, which are not present in linear convolution.

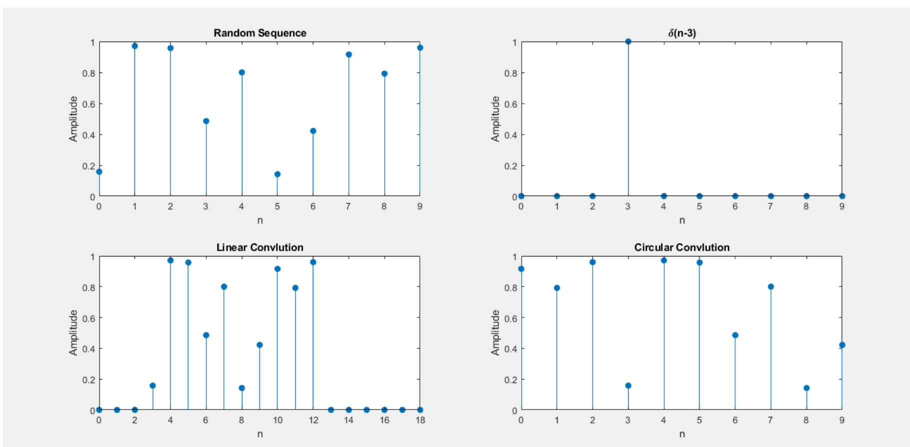

Figure 2.1: Result of convolution for set of Random signal

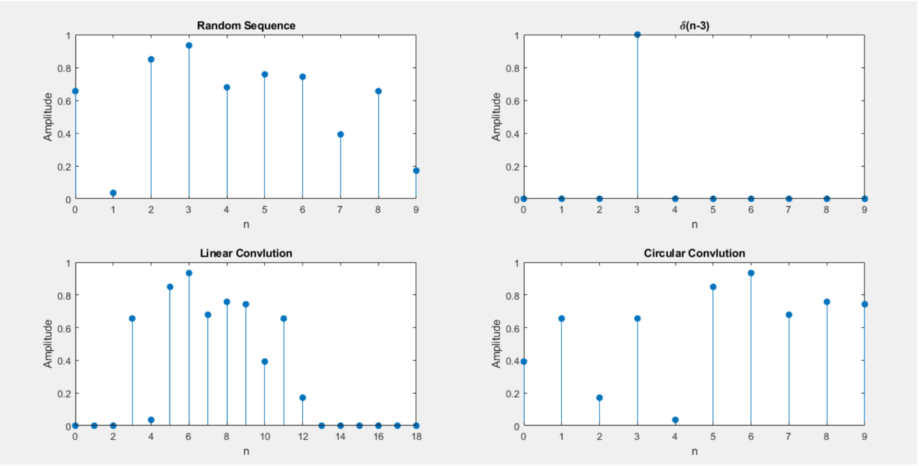

Figure 2.2: Result of convolution for set of Random signal

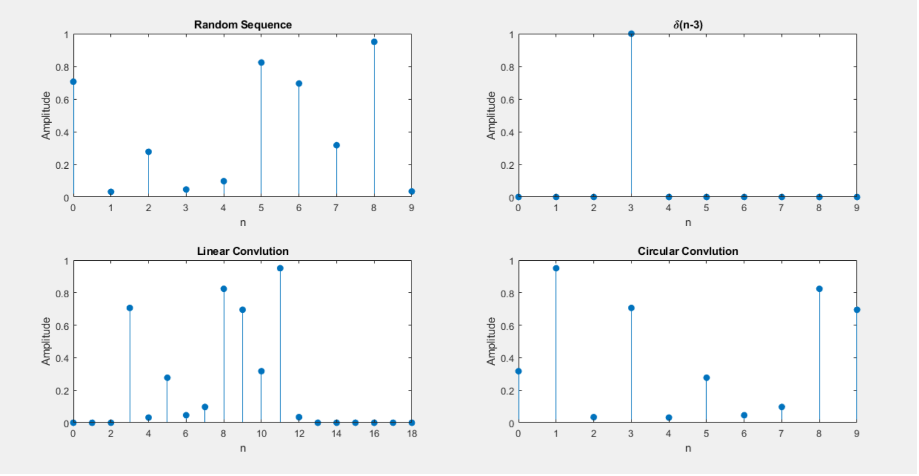

Figure 2.3: Result of convolution for set of Random signal