DSP Assignment 1

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Problem 1. Take 20 pt three signals, one real even, one conjugate odd, one random signal and demonstrate the properties of
1.Time Shifts
2.Frequency Shifts
3.Complex Conjugate
4.Time Reversal

Solution . Defining 20 pt Signals

$$x_{\text{even}}[n] = \cos\left(\frac{2\pi n}{20}\right) \tag{1}$$

$$x_{\text{odd}}[n] = j\sin\left(\frac{2\pi n}{20}\right) \tag{2}$$

$$x_{\text{rand}}[n] = [1\ 2..20]. \tag{3}$$

1 Time Shift Property of DFT

The time shift property states that if a discrete-time signal $x[n]$ is shifted by l samples, the DFT of the shifted signal $x[n-l]$ is given by:

$$X_k = \mathcal{D}\left\{x[n-l]\right\} = X_k e^{-j\frac{2\pi}{N}kl}$$

So for the even signal

$$x_{\text{even}}[n] = \cos\left(\frac{2\pi n}{20}\right)$$

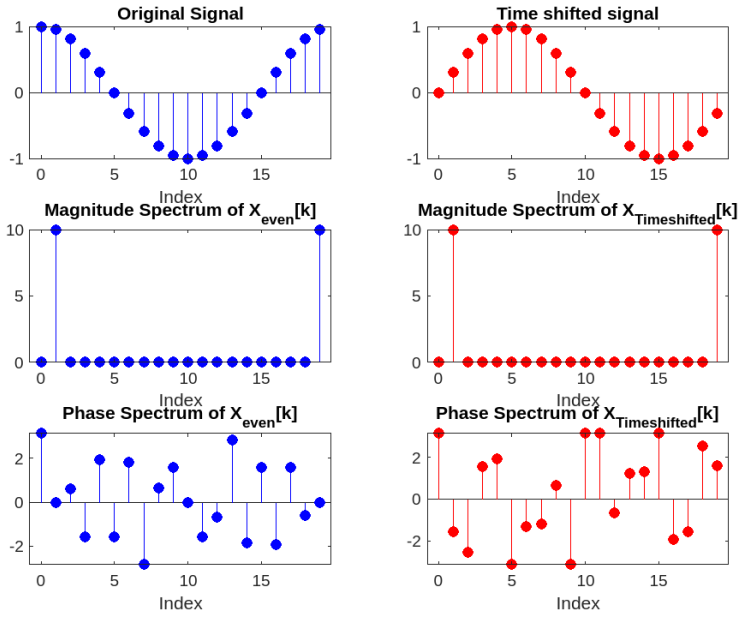

Figure 1: Matlab Plot for even signal timeshift,l=5.

Now for odd conjugate signal,

$$x_{\text{odd}}[n] = j \sin\left(\frac{2\pi n}{20}\right)$$

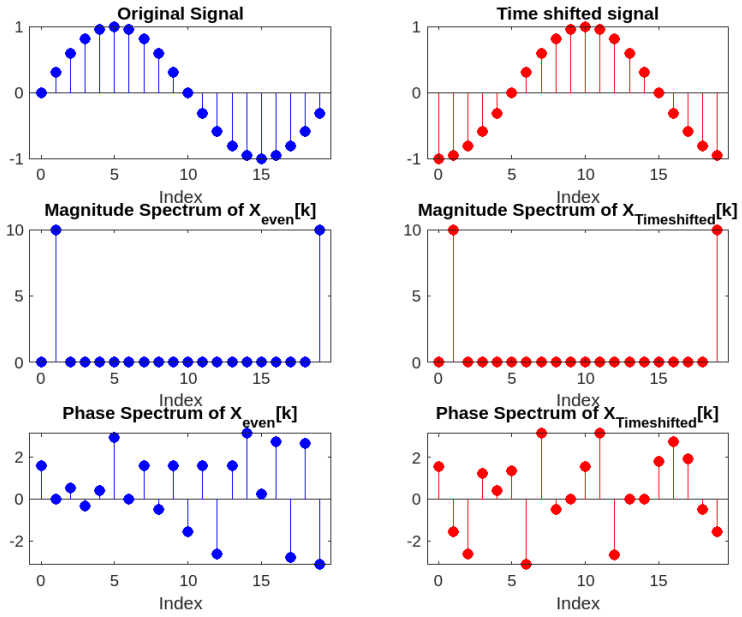

Figure 2: Timeshift plot for Odd Conjugate Signal,l=5

Now for a random signal

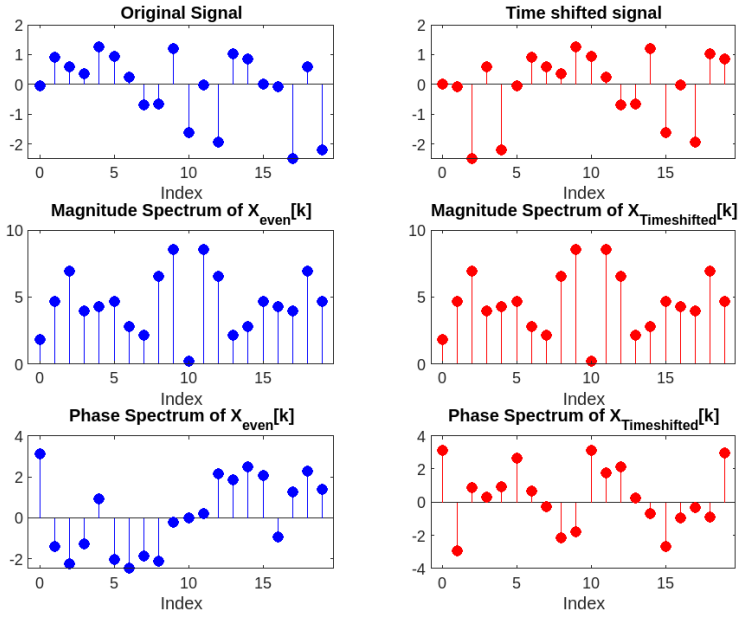

Figure 3: Timeshift Plot for a 20 pt random signal,l=5

2 Complex Conjugate

The complex conjugate property of the Discrete Fourier Transform (DFT) states that

$$\mathcal{D}\{x^*[n]\} = X^*[N-k]$$

So For an Even real signal,

$$x_{\text{even}}[n] = \cos\left(\frac{2\pi n}{20}\right)$$

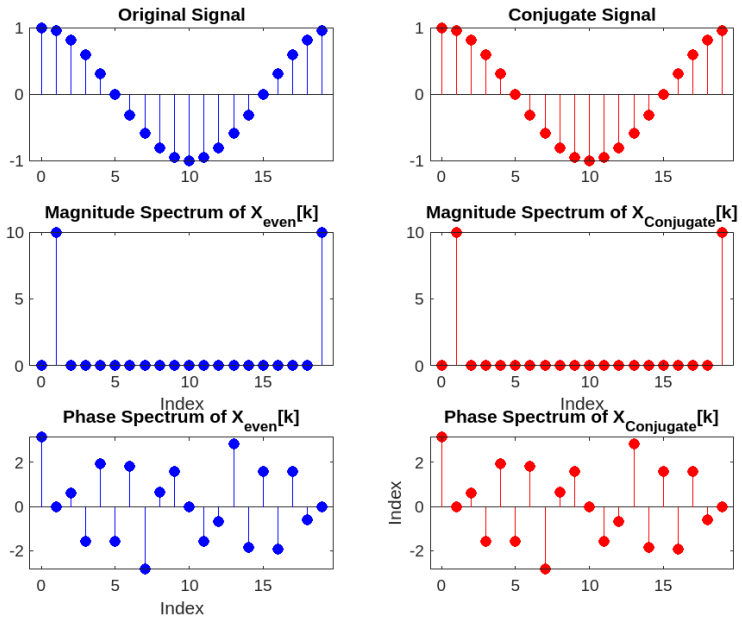

Figure 4: conjugate for even signal

For an odd Conjugate Signal, Now for odd conjugate signal,

$$x_{\text{odd}}[n] = j\sin\left(\frac{2\pi n}{20}\right)$$

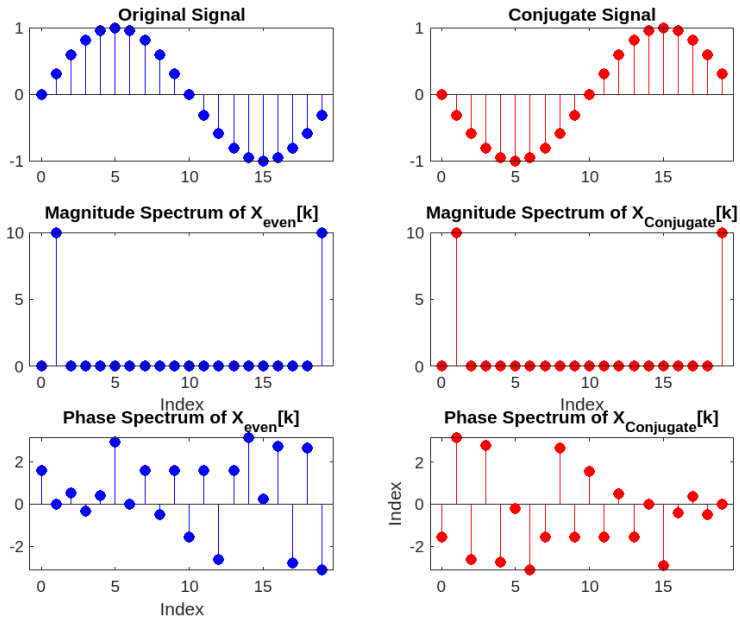

Figure 5: Conjugate Plot for odd Conjugate.

And for a Random signal.

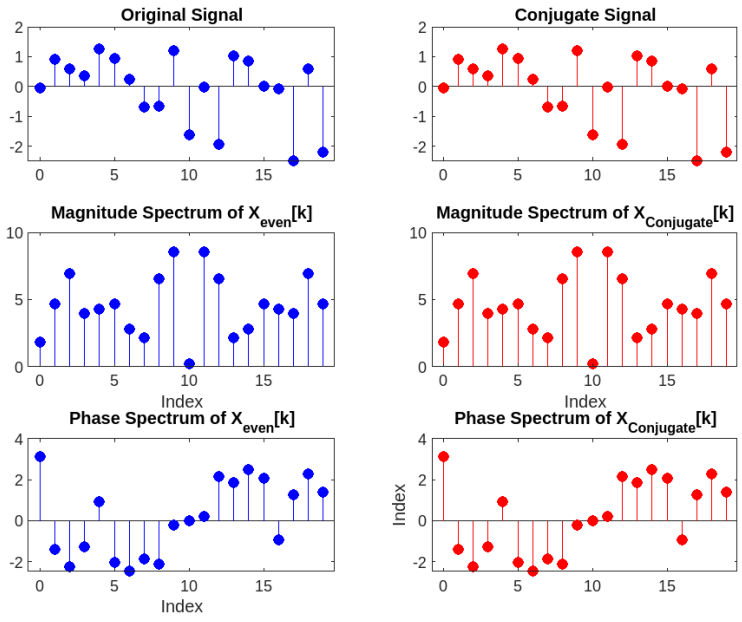

Figure 6: Conjugate Plot for Random Signal.

3 Time Reversal Property of DFT

The time reversal property ofDFT states that the DFT of a time-reversed signal is the complex conjugate of the DFT of the original signal, but with a reversal of the frequency indices

$$\mathcal{D}\{x[-n]\} = X^*[N-k]$$

So For An Even real signal,

$$x_{\text{even}}[n] = \cos\left(\frac{2\pi n}{20}\right)$$

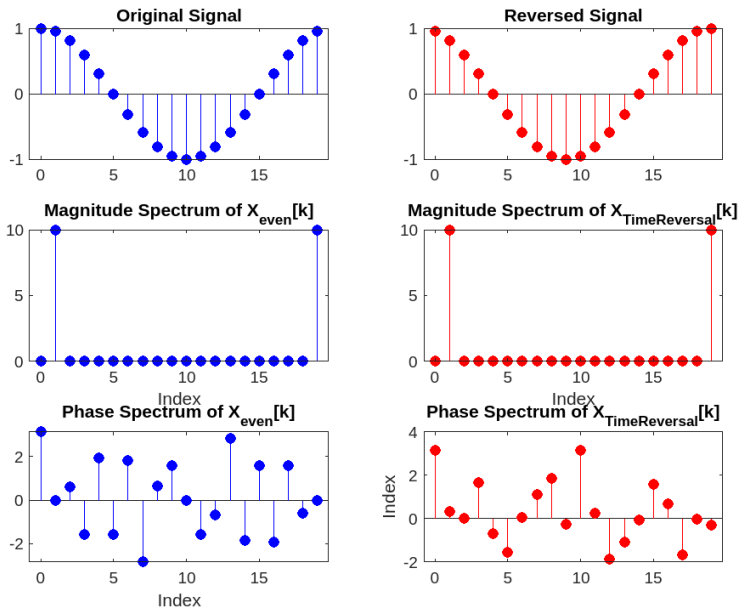

Figure 7: Time Reversal Plot of Even signal.

For an odd Conjugate Signal,

$$x_{\text{odd}}[n] = j \sin\left(\frac{2\pi n}{20}\right)$$

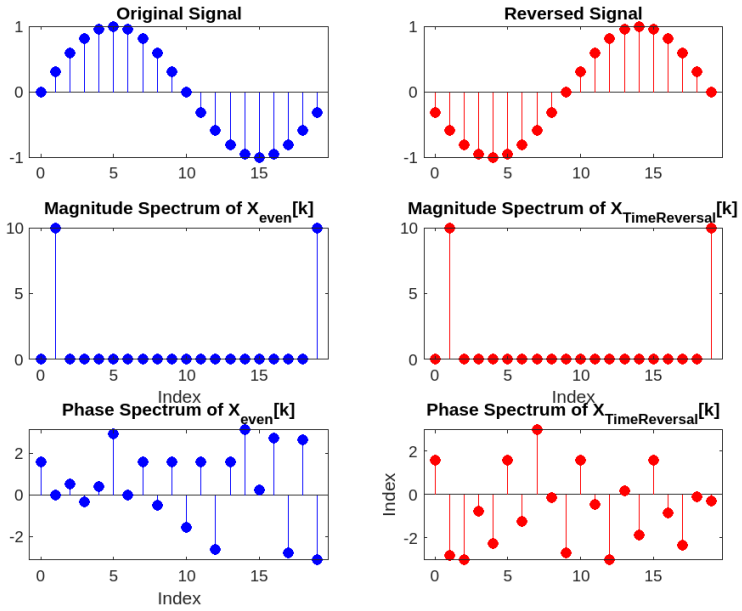

Figure 8: Reversal Plot for odd Conjugate.

For a random signal,

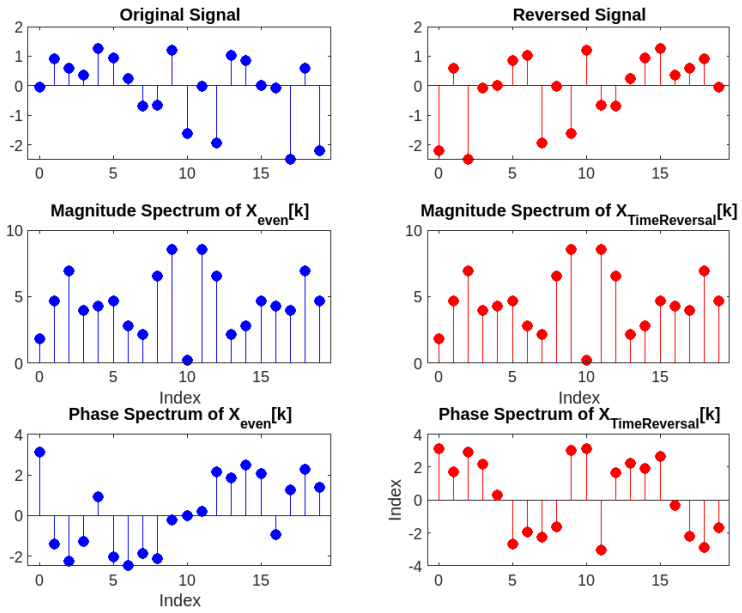

Figure 9: Reversal Plot for Random Signal

4 Frequency Shifts

The frequency shift property states that multiplying a signal by a complex exponential in the time domain results in a shift in the frequency domain.

$$\mathcal{D}\left\{x[n]e^{-jk_0\frac{2\pi n}{N}}\right\} = X(k-k_0)$$

So For An Even real signal,

$$x_{\text{even}}[n] = \cos\left(\frac{2\pi n}{20}\right)$$

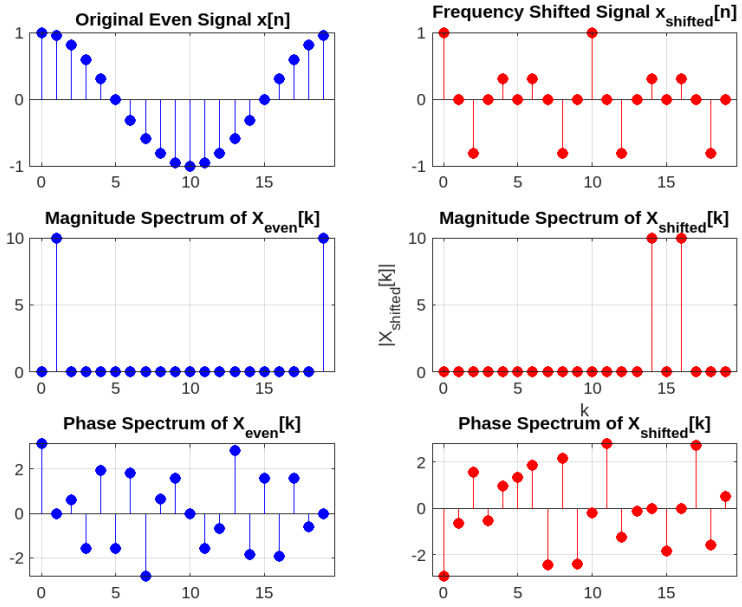

Figure 10: Frequency Shift Plot of Even signal.

For an odd Conjugate Signal,

$$x_{\text{odd}}[n] = j \sin\left(\frac{2\pi n}{20}\right)$$

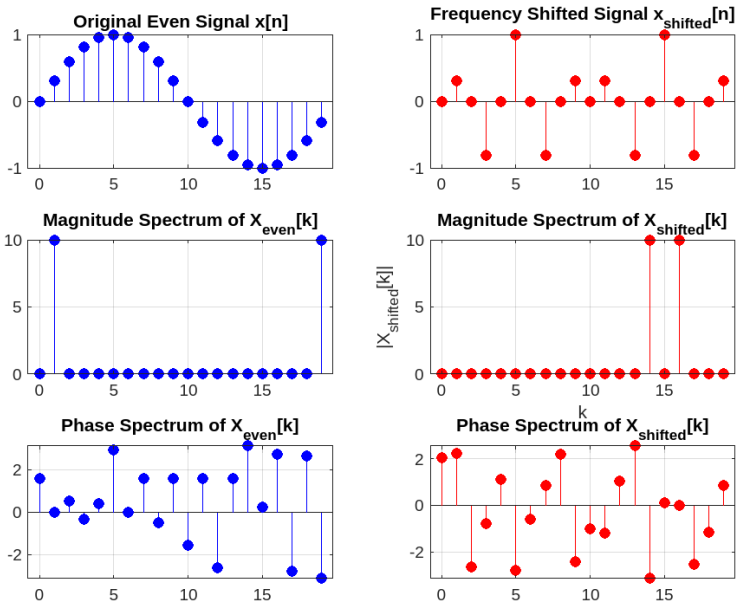

Figure 11: Frequency shift Plot for odd Conjugate.

For a random signal,

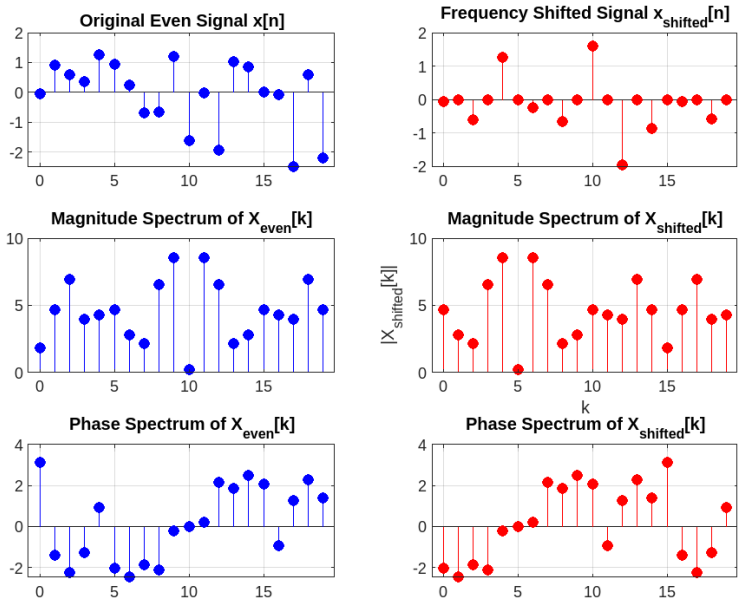

Figure 12: Frequency shift Plot for Random Signal