**Digital Signal Processing Lab**

**Experiment:** 04 **Dt.** 31-01-2022

**Course Topics:** Applications of DFT: Studying Spectrum Signals and Filtering Unwanted signals or Noises

**Submission Deadline:**

* **MATLAB Function: 31-01-2022 before 5.40 PM (Strictly followed).**
* **Video Report: 05-02-2022 before 10.30 PM (Strictly followed).**

**Please do not copy. It is your responsibility in clarifying your doubts during the class session or after class session before coming to next lecture class.**

**Objective of this experiment:** In most signal analysis systems, the input or sensed signal contains one or more frequency components. Spectral analysis of a signal is one of the preliminary study to under the frequency characteristics of a signal. Since real-world signals can be characterized in terms of frequencies with their phases and amplitudes, an estimation of frequency components has become one of the most important signal processing tasks, including the signal/event classification, signal modelling, signal filtering and data compression. In this experiment, we study the application of DFT for determining frequency components (in particularly determining dominant frequency components, estimation fundamental components and also harmonics and also unwanted signal filtering).

**Introduction to Discrete Fourier Transform**

For a given discrete-time sequence, , the N-point DFT can be computed as

where denotes the discrete-time index and denotes the discrete Fourier transform (DFT) coefficient index. Assume that the CT signal is sampled at sampling rate of (samples per second or Hz).

For a given DFT sequence, the inverse DFT is given by

The relationship between the coefficient index or frequency bin and its associated frequency (Hz) is given by

where denotes the digital frequency of the *k*th DFT coefficient that varies from according to the minimum Nyquist sampling rate and the maximum frequency of the signal is (*B* or *W*) (Hz), which describes that a continuous time signal contains no frequency components higher than *W* (Hz). A signal with no frequency component above a certain highest frequency is known as **a bandlimited signal**.

The **frequency resolution** as the frequency step between two consecutive DFT coefficients to measure how fine the frequency domain presentation is. The frequency resolution is given by

The DFT coefficient may be a complex quantity. It is not convenient to plot DFT coefficients versus its frequency index. From the DFT coefficients, we can compute the magnitude spectrum (or amplitude spectrum or power spectrum) and phase spectrum.

**Amplitude Spectrum**: It is the plot of amplitude or magnitude versus frequency index (Hz) and can be used to visualize amplitude or magnitude of each of the frequency components that are present in the input signal or recorded signal. The amplitude spectrum as

Since the magnitude spectrum of real-valued signal is even or symmetric, we can plot one-sided amplitude spectrum by keeping the DC term at . Finally, the modified one-sided amplitude spectrum can be computed as

with doubling the amplitudes of the DFT components.

**Phase Spectrum**: It is the plot of phase or angle versus frequency index and can be used to visualize the phase value of each of the DFT components of the input discrete sequence . From the DFT sequence , the phase spectrum is given by

**Experiment- A [Deadline: 31-01-2022 before 5.40 PM (Strictly followed)]**

1. Create MATLAB function to compute N-Point DFT for a given DT sequence
2. Create MATLAB function to compute N-Point IDFT for a given DT sequence
3. Create MATLAB function to compute one-sided amplitude spectrum and phase spectrum for a given DFT sequence.

**Experiment- B [Deadline: 31-01-2022 before 5.40 PM (Strictly followed)]**

1. Write MATLAB program to remove the powerline signal having frequency of 50 Hz from the PPG and ECG signal by using the MATLAB functions which are created by you.

**Procedure for DFT Filtering approach**

1. Read the 5 second signal with a length of N (computed for a given sampling rate)
2. Compute the N-point DFT
3. Find the DFT coefficient indexes for a frequency range of 48 to 52 Hz
4. Set zero to those DFT coefficients
5. Apply IDFT to the processed DFT coefficients

**Verifying the Results**

* Sketch the time-domain original waveform, filtered waveform and error waveform
* Sketch the frequency-domain original waveform, filtered waveform and error waveform

**Experiment- B Video Report Preparation must include**

* Aim and Objective
* Theory related to the DFT and algorithms
* Source Code with Description for each of the line
* Block diagram or Flow Chart
* Results and Discussion (based on your observations)
* Conclusions