

Assignment 2 - ECG Filtering to Remove Noise

M.Sc., Ahmed A. Shaheen

1 Time interval selection:

- Important quantities:

$$F_s : \frac{\text{Sample}}{\text{Second}} \rightarrow \text{Sampling rate (How many samples per second)} = \frac{1}{T_s}$$

$$T_s : \frac{\text{Second}}{\text{Sample}} \rightarrow \text{Sampling interval (Period between samples)} = \frac{1}{F_s}$$

- Getting samples within a period of time:

$$\alpha * F_s \rightarrow \text{How many samples in } \alpha \text{ second}$$

For example, if $F_s = 100$, then $1 * F_s = \text{how many samples in 1 second} = 1 \times 100 = 100$ samples.

Similarly, $3 * F_s = \text{how many samples in 3 second} = 3 \times 100 = 300$ samples.

- Convert time to samples and vice versa:

$$\text{Time (Second)} \times F_s \left(\frac{\text{Sample}}{\text{Second}} \right) = \text{Samples}$$

$$\text{Sequence (Sample)} \times T_s \left(\frac{\text{Second}}{\text{Sample}} \right) = \text{Seconds}$$

- Creating time vector for $F_s = 10$ and $\text{length}(\text{Data}) = 5$:

$$t = [0 : 1 : \text{length}(\text{Data}) - 1] .* T_s; \rightarrow [0, 0.1, 0.2, 0.3, 0.4]$$

- Creating time vector for $F_s = 10$ and from time = 1 to time = 2 :

$$t = [1 : T_s : 2]; \rightarrow [1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2]$$

- If we need to select specific time duration:

$X := \text{data of size } N \times 1$, where N is the number of samples. To select the interval $[2, 5]$ seconds:

$$Y = X(2 * F_s : 5 * F_s);$$

- Creating frequency vector for one-sided FFT plot with $F_s = 20$ and $N_{fft} = \text{length}(\text{Data}) = 10$:

$$f = \text{linspace}(0, F_s/2, (N_{fft}/2) + 1); \rightarrow [0, 2, 4, 6, 8, 10]$$

2 Low-Pass filter:

$$Y(z) = H(z) \times X(z) \quad (1)$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1}{32} \times \frac{(1 - z^{-6})^2}{(1 - z^{-1})^2} \quad (2)$$

$$H(z) = \left(\frac{1}{32}\right) \times \left(\frac{1 - 2z^{-6} + z^{-12}}{1 - 2z^{-1} + z^{-2}}\right) \quad (3)$$

$$H(z) = \left(\frac{1}{32}\right) \times \left(\frac{(1)z^0 + (0)z^{-1} + (0)z^{-2} + (0)z^{-3} + (0)z^{-4} + (0)z^{-5} - 2z^{-6} + (0)z^{-7} + (0)z^{-8} + (0)z^{-9} + (0)z^{-10} + (0)z^{-11} + (1)z^{-12}}{1 - 2z^{-1} + z^{-2}}\right) \quad (4)$$

You need to keep it in the form:

$$H(z) = \frac{\left(\frac{1}{32}\right) \times [(1)z^0 + (0)z^{-1} + (0)z^{-2} + (0)z^{-3} + (0)z^{-4} + (0)z^{-5} + (-2)z^{-6} + (0)z^{-7} + (0)z^{-8} + (0)z^{-9} + (0)z^{-10} + (0)z^{-11} + (1)z^{-12}]}{(1) + (-2)z^{-1} + (1)z^{-2}} \quad (5)$$

$$b = \frac{1}{32} \times [1, 0, 0, 0, 0, 0, -2, 0, 0, 0, 0, 0, 1] \rightarrow b = \text{zeros}(1, 13); \rightarrow b(7) = (1/32) \times (-2); \quad (6)$$

$$a = [1, -2, 1] \quad (7)$$