

Classwork-4

Note: When being asked to design/create a filter, you have to at least include its frequency response.

Problem 1:

Let the sampling frequency F_s be 8 kHz, and the time vector t runs from 0 to 50 ms. Create a signal $y(t) = \cos(2\pi f_1 t) + \cos(2\pi f_2 t)$ where $f_1 = 1209 \text{ Hz}$ and $f_2 = 1336 \text{ Hz}$

- Plot $y(t)$ in both time and frequency domain.
- Design a low-pass filter to filter out f_2 , and then apply this filter to $y(t)$. Plot the result in both time and frequency domain.
- Design a high-pass filter to filter out f_1 , and then apply this filter to $y(t)$. Plot the result in both time and frequency domain.
- Design a band-pass filter to pass f_1 while reject f_2 , and then apply this filter to $y(t)$. Plot the result in both time and frequency domain.

Problem 2:

The sampling rate of the ECG signal we had from classwork-2 is 512Hz. Each impulse is one beat. The normal heart rate is between 50 and 100 beats per minute at rest

- Plot the signal versus time domain. Estimate the heart rate from the signal.
- Plot the frequency spectrum of the signal.
- Baseline Wander removal: Given that the baseline wander is usually in the range below 0.5Hz in case the patients' movements are not large. Design a high pass filter to remove those low frequency components. Apply the filter you have just designed onto the ECG signal and plot the result.

Problem 3:

Amplitude Modulation (AM): http://en.wikipedia.org/wiki/Amplitude_modulation

Amplitude modulation is a technique used in electronic communication, most commonly for transmitting information via a radio carrier wave. Amplitude modulation works by varying the strength of the transmitted signal in accordance to the information being sent. We will simply demonstrate how it works in this problem.

An AM double-side band suppressed-carrier (DSB-SC) signal is mathematically modeled:

$$AM(t) = m(t) \cdot c(t)$$

where $m(t)$ is the message to be transmitted, $c(t)$ is the carrier wave. In order to demodulate an AM signal, we multiply it with the same carrier wave, and then filter the result using a low-pass filter:

$$\text{Demod}_{AM}(t) = \text{Low_pass_filter}[AM(t) \cdot c(t)]$$

- a) Given that the sampling frequency is 500 Hz and the time vector varies from 0 to 1, create a 10-Hz sine wave. Let's call the wave we have just created the message signal. Plot the message signal versus time.
- b) Design your '*my_ammmod*' function. Use a 100-Hz carrier signal to modulate the message signal. Plot the modulated signal versus time.
- c) Plot the frequency spectrum of the message signal and the frequency spectrum of the modulated signal using any method introduced in the last classwork. What are the differences between the two plots?
- d) Design your '*my_amdemod*' function. Demodulate the modulated signal to retrieve the message signal. Plot the demodulated signal versus time and the frequency spectrum of the demodulated signal. Compare them to the plots of the message signal.