Reading: Class notes

Download the file `ecg_signals.mat` and scripts from the GitHub. Load it into `python` through the `load_ecg_signals` method defined in the `load_ecg.py` file. This is an Electrocardiogram (ECG) data trace. This data file contains two signals: one with and one without noise. The noisy one, as sensor signals often do, has noise of 60Hz (the frequency of 120V AC power). In this problem, you will design a notch filter to eliminate this noise and produce a clean signal.

1. For the `ecg_noisy` signal, assuming a sample frequency of 300 Hz:
   (a) Plot the signal in the time domain. The signal should be 2 seconds in duration.
   (b) Plot the fast fourier transform (FFT) result and identify the contribution of the 60 Hz noise.
2. Use the `filter_design_tool.py` to design a 60 Hz digital notch filter to eliminate the electrical noise and produce a clean ECG signal.
   (a) Design criteria for the filter: bandpass frequencies of 50 Hz and 70 Hz, bandstop frequencies of 55 Hz and 65 Hz, and a bandstop amplitude of at least -40 dB.
   (b) What type of filter do you select? What is the order of the filter? Write down the filter as a transfer function $H(z)$.
3. Filter the noisy ECG signal using the filter you designed in problem 2 (copy the filter code into the file `problem2.py`), and plot the filtered result together with the clean ECG signal (run the `problem3.py`).
   (a) Use the `signal.lfilter` method from the `scipy` package. Do you see any phase shift in the filtered signal compared to the clean signal?
   (b) Use the `signal.filtfilt` method from the `scipy` package. Do you still see any phase shift in the filtered signal compared to the clean signal or has the phase shift gone away?
   (c) Plot the FFT of the filtered signals (from both 3.(a) and 3.(b)) and compare to the original FFT result. Did the 60 Hz peak change?
4. Did we need to use a notch filter? Could we have gotten by with a low-pass filter? If so, design a suitable low-pass filter and compare the results with that filter to the bandstop/notch filter.