CE203/SC301 Tutorial 2: Measurement System - Filters

1) Figure Q1 shows a simple op-amp high pass filter (HPF). It is proposed to use the filter to pass all signals above 1KHz, with a passband gain of 26db. The Op-amp has a gain-bandwidth product of 1MHz.

(a) Design a suitable HPF based on the given filter topology.
(b) Sketch the frequency response of the filter. (Hint: consider the limited gain-bandwidth product of the Op-amp). How does this HPF perform relative to an ideal HPF ?
(c) Estimate the input impedance of the filter at 25KHz.
(d) Design another suitable HPF based passive RC network and sketch the frequency response. Contrast the responses from the two filters.

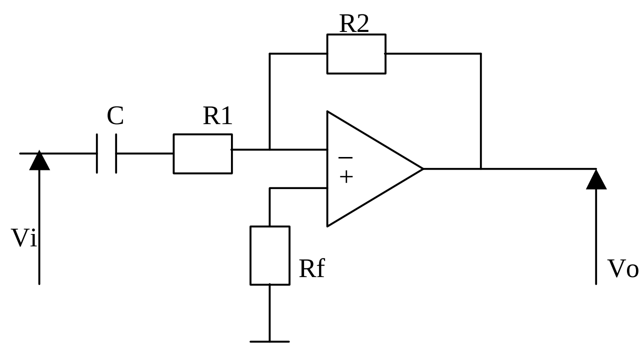

Figure Q1

2) In biomedical measurement system that measures the "electrical wave pattern" of a patient. The signal called EEG (Electroenocephalogram) has a magnitude of 50μV at a frequency range of 0.5 to 25 Hz is needed in the data analysis of the neural pattern. Disturbances (noise interferences) from the muscles called EMG (Electronyogram) with an amplitude of 100μV at 100Hz-3000Hz as well as from EMI (Electromagnetic interference) with a noise level if 10mV at 50Hz are present in the measurement system. To effectively retrieve the required signal, EEG, the noise should be reduced to a magnitude of not more than 1μV. The feasibility of applying low pass filtering to condition the signal for analysis has to be investigated.

(a) Use 1μV as the reference, sketch the signal and noise spectrum.
(b) Hence, establish the required attenuation necessary to achieve the required signal conditioning.
(c) Determine the order of the filter needed.
(d) How would you reduce the order of the LPF needed?
(e) Design a suitable Butterworth LPF to meet the requirement using the equal component value Sallen-Key topology. What is the magnitude of the passband EEG signal at the output of the filter.