# Project Two: Bio-Signal Amplifier

In the course, you have become familiar with ECG and EEG signals. In this project, we aim to design amplifiers for these two signals. Any modeling software can be used, but it is recommended to use NI MultiSim software. Any operational amplifier can be used.

**ECG Amplifier:**

To sample the cardiac signal digitally, it is necessary to have an analog amplifier in the first stage. The amplitude of the heart signal is in the range of a few millivolts, and it cannot be sampled using conventional ADCs; therefore, a suitable amplifier is required. Design an amplifier with the following specifications:

- Gain: 1000 to 5000 (Adjustable)
- Bandwidth: 0.1 – 100 Hz
- Input Impedance ≥ 1 MΩ

To simplify the modeling of the signal, you can use a sine wave with an amplitude of 1 to 5 millivolts and a frequency of 1 to 10 Hz. This wave does not resemble the actual heart wave, but it is easier to use. Note that the heart rate can reach up to 120 beats per minute, which is equivalent to 2 Hz, but cardiac signals have faster fluctuations that require an amplifier with a higher bandwidth. To add real-world conditions to the desired signal, add a wave with a frequency of 50 Hz and an amplitude equivalent to 50% of the main signal amplitude, along with a high-frequency noise (1 MHz) with an amplitude equivalent to 50% of the main signal amplitude. To combine these signals, you can use summing amplifier circuits.

Ensure that the two interfering factors do not exist in the amplified signal. If you use a notch filter to eliminate the city power frequency, it will receive a score. If you use a suitable low-pass filter, you will lose some bandwidth of the amplifier. The higher the order of the low-pass filter, the less your main signal will be affected.

**EEG Amplifier:**

The EEG signal has an amplitude of approximately 10 to 100 microvolts, which requires a higher gain amplifier. Design an amplifier with the following specifications:

- Gain: 10,000 to 50,000 (Adjustable)
- Bandwidth: 0.1 – 200 Hz
- Input Impedance ≥ 5 MΩ

The main signal has an amplitude of 10 to 100 microvolts and a frequency of 1 to 100 Hz. The designed amplifier must be able to provide suitable performance within this range. In this section, the only interfering factor is high-frequency noise, similar to the previous section. Eliminating power line noise from the EEG signal is more challenging, and many commercial amplifiers today use batteries to prevent noise from affecting the amplifier circuit through the power supply. Of course, adding 50 Hz noise and using a notch filter to eliminate it will receive a score.


**Grading and Submission:**

- The work report for each section accounts for half of the total grade. An inadequate report undervalues the work done. Please be diligent in completing it.
- Please upload your simulation files along with the work report.
- For circuit testing, please take screenshots of the waveforms at each stage (the main signal, the signal with interfering factors, the signal after filtering, the signal at each amplifier stage, and the output signal).
- For each variable parameter, such as amplitude or frequency of the input signal, test your circuit at least at two points, maximum and minimum, and include the results in your work report.
- The score for each section constitutes half of the project's total score. The grading weight for the ECG section is 10%, and for the EEG section, it is 20%.
- If the results in the work report do not match the simulation files, an in-person submission will be required.