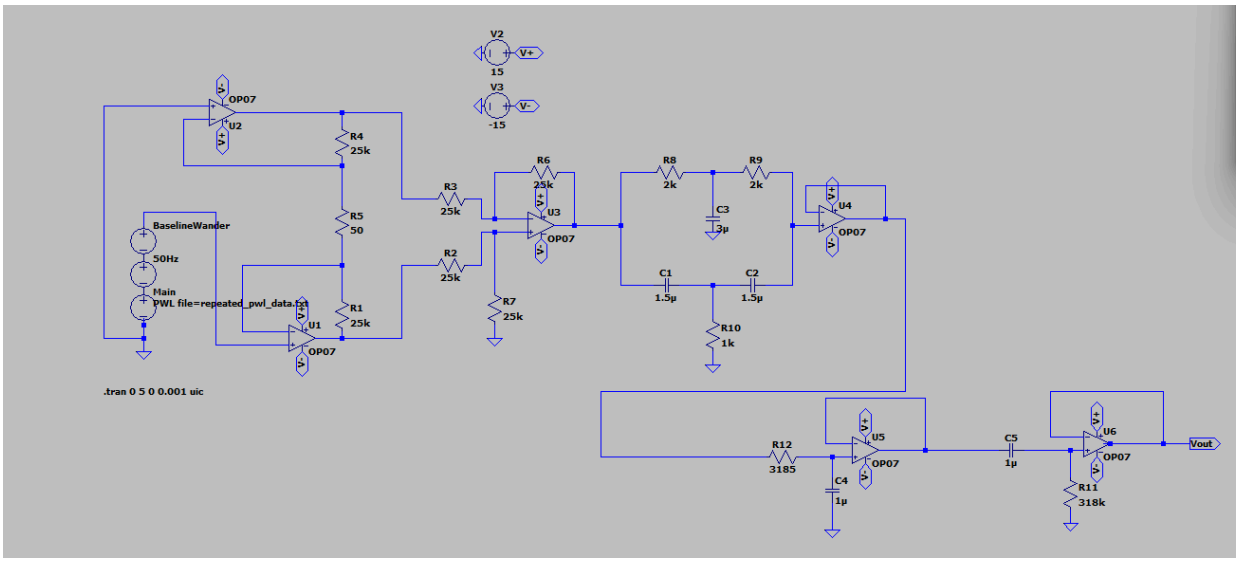
ECG SIMULATION

The project we worked on deals with enhancement and simulation of a signal, in particular an ECG signal. The signal was obtained using a PWL file that we obtained on the internet, and many others are available. The maximum amplitude of the signal was around 2.3 mV, which is typical for an ECG signal measured by Hospital instruments. All simulations were done on LTspice software.

CIRCUIT



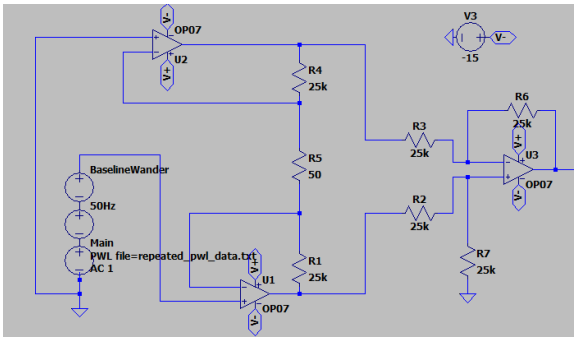
In addition to the signal produced by the heart, which is represented by the voltage source named ‘Main’, we also introduced low frequency disturbances and Power Line interference, which are denoted by ‘BaselineWander’ and ‘50 Hz’ respectively. OP07 op-amp only was used.

- 50Hz interference is noise produced in power lines, which operate at 50 Hertz in India.
- Baseline Wander is the collective term for disturbances in voltage signals caused due to respiratory and muscle movements.

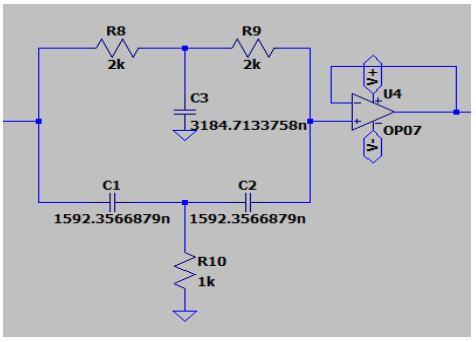
The Circuit consists of three parts (Left to Right in circuit):

- **Instrumentation Amplifier:** This part is a single stage amplifier consisting of a buffer section and amplifier section. The low amplitude signal is amplified by around a 1000 times, making it noticeable.
- **Notch Filter:** This is a bandstop filter which is used to remove signals of certain frequencies. In our case, it is used to remove the 50Hz interference specifically. Therefore, it is also designed to have a very low bandwidth. The frequency of the notch filter is given as 1/4πRC. It is set to 50Hz.
- **Active Bandpass Filter:** This consists of a low-pass and high-pass filter. The frequency of a typical ecg waveform is 0.5-250 Hz. Therefore,it is also what we're going to use. The frequencies are given by 1/2πRC, where R and C are the resistance and capacitance of the high pass and low pass filters.

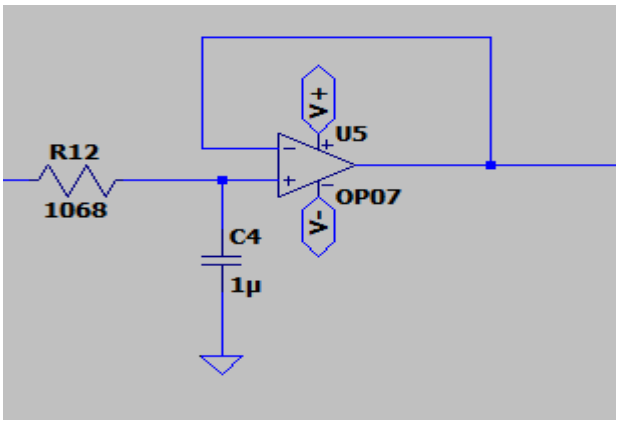
The gain is chosen such that the amplified output of the signal does not exceed the input power voltage of the op-amp, which is 15V in our case.



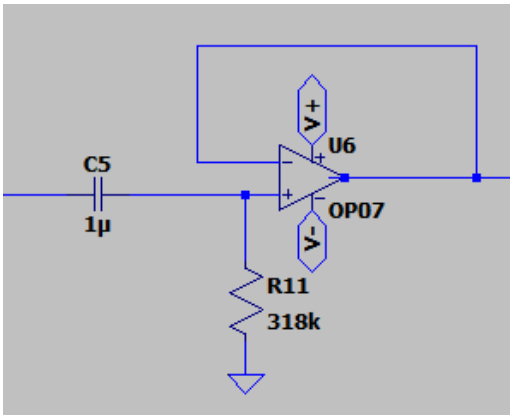
Instrumentation Amplifier



Notch Filter

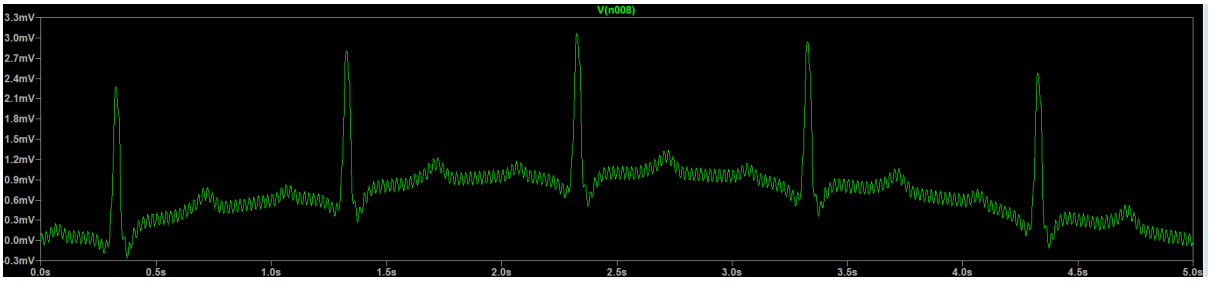


Low-pass filter

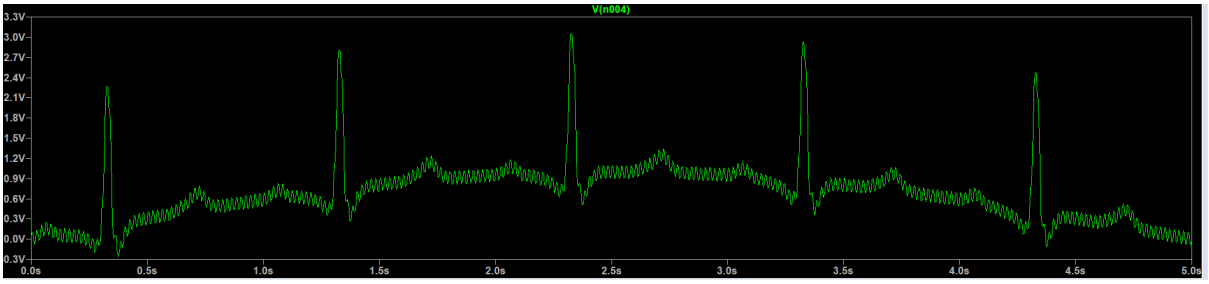


High-pass filter

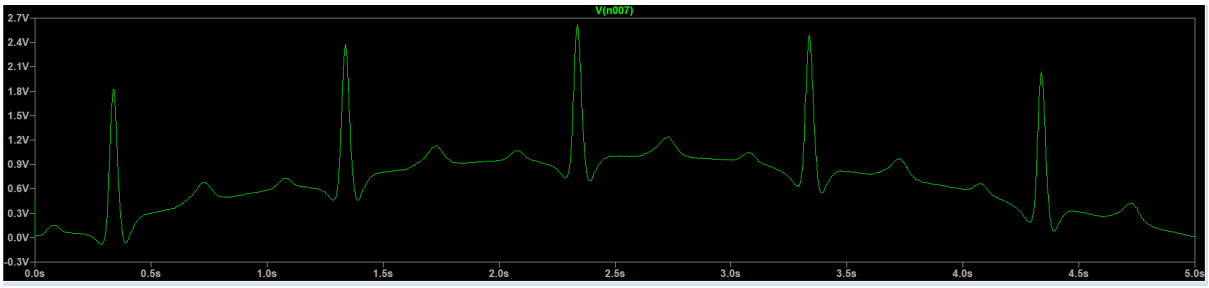
RESULTS



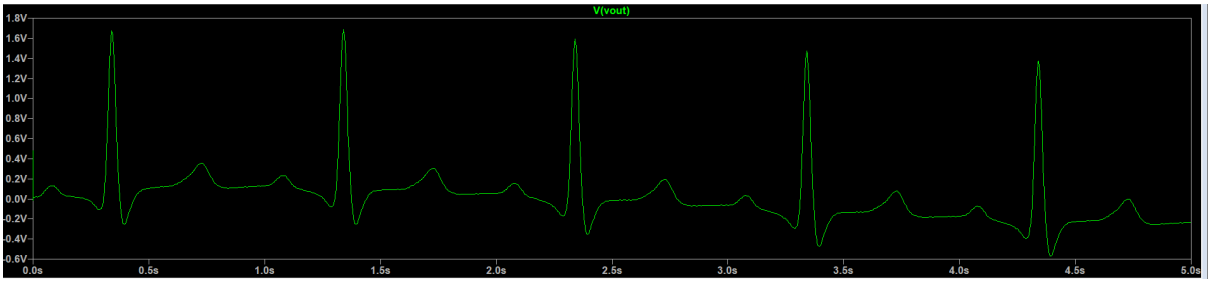
Original signal



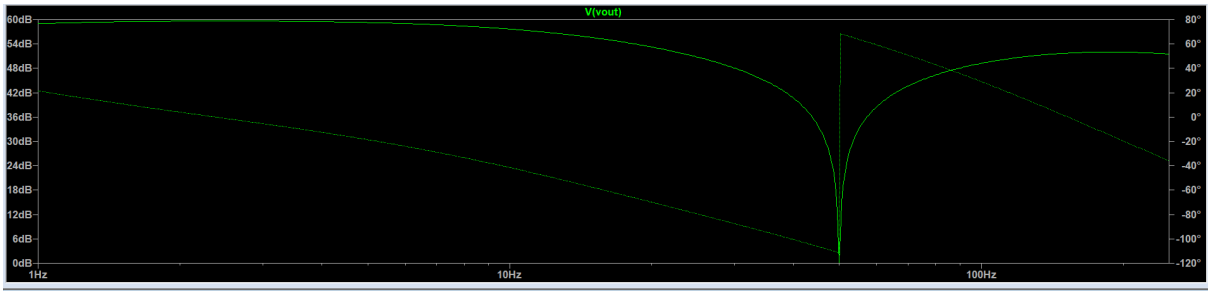
Signal after amplification



Signal after removal of 50Hz interference



Final output after removal of low frequency disturbance



Frequency Distribution curve

CONCLUSION

This project successfully developed a functional ECG (Electrocardiogram) circuit capable of capturing and processing electrical signals from the heart. The circuit design incorporated key elements such as signal amplification, noise filtering, and analog-to-digital conversion to ensure accurate and reliable signal acquisition. By optimizing component selection and layout, the circuit demonstrated its ability to detect and display heart activity with minimal interference. The implementation validated the circuit's ability to handle real-world challenges such as signal noise and baseline drift, making it suitable for use in basic diagnostic and monitoring applications. The results underline the potential for this circuit to serve as a foundation for further enhancements, such as integration with wireless communication modules or advanced signal processing algorithms for real-time analysis.