Design and Simulation of a Complete ECG Analog Front-End with Wilson Central Terminal and Multi-Stage Filtering for Reliable Cardiac Monitoring

STUDENT NAME: ROOBAK. S

COLLEGE NAME: SRI ESHWAR COLLEGE OF ENGINEERING.

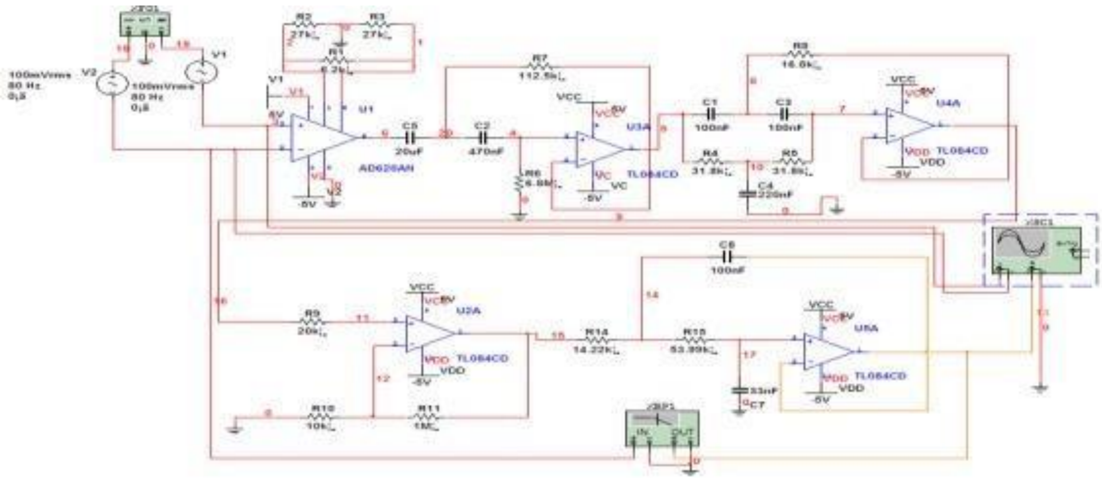
Problem Statement:

Electrocardiogram (ECG) signals are very low amplitude and susceptible to noise such as power-line interference and baseline drift. Designing a robust analog front-end capable of amplifying the ECG signal while effectively filtering out noise and interference is critical for accurate cardiac monitoring. The challenge lies in implementing this multi-stage conditioning circuit within the open-source eSim 2.3 platform using discrete components and standard op-amp subcircuits.

Abstract:

This project presents the design and simulation of a comprehensive ECG analog front-end system within the eSim 2.3 environment. The system consists of a precision instrumentation amplifier stage, a twin-T notch filter to remove 50/60 Hz power-line interference, followed by low-pass and high-pass filters for wideband noise attenuation and baseline correction. The instrumentation amplifier is constructed using three avsd_opamp subcircuits with gain tuning via discrete resistors and potentiometers. Simulation results verify high gain amplification, effective notch filtering, and stable output within the clinically relevant ECG frequency spectrum. This work demonstrates the efficacy of eSim for biomedical analog front-end design, promoting open-source tools in electronic health monitoring development.

Proposed Circuit:



Conclusion:

The ECG analog front-end designed and simulated in eSim 2.3 demonstrates effective signal conditioning suitable for accurate ECG acquisition. The multi-stage design achieves significant amplification and filtering, removing power-line interference and noise while preserving key cardiac signal features. eSim proves to be an effective open-source simulation environment for complex medical electronics projects, enabling detailed circuit analysis and validation. This work lays a foundation for further enhancements and real-world ECG front-end implementations using readily available components and free simulation tools.

References:

- Lv Jinhua and Xu Yanyi, “Circuit Design for Front-End Electrocardiograph,” International Journal of Multimedia and Ubiquitous Engineering (IJMUE), vol. 11, no. 5, pp. 345–354, 2016.
- M. Kumar, "Voltage Mode Notch Filter Using Differential Difference Current Conveyor," IEEE Conference, 2012
- R. Hasnul Azha, S. Ramli, "Design of Analog Front-End Circuit for ECG Signal Acquisition," Int. Journal of Electronics and Communications, 2016.
- Sergio Franco, Design with Operational Amplifiers and Analog Integrated Circuits, 4th Ed., McGraw-Hill, 2014.
- Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 7th Ed., Oxford University Press, 2015.
- FOSSEE eSim Documentation and Component Library, 2025 Edition.