Discipline of Electrical and Electronic Engineering
EE5105 Laboratory Design Project 2025-26

Introduction: The EE5105 laboratory project will undertake the design of an instrumentation amplifier which will serve in the measurement of the human electrocardiogram, generally known as the ECG signal. The amplifier is intended to provide a reasonable quality of output signal that could be used for clinical diagnostic purposes as shown in Fig.1. It will be ac-coupled to eliminate dc polarisation voltages present in the electrodes, and must have adequate bandwidth to ensure that distortion of the wanted ECG signal is minimised. A suitable amplifier will be designed and constructed on breadboard and then its performance tested and verified using standard laboratory test equipment. A simulated/synthesized ECG signal will be also be available from a signal generator. The facilities to superimpose noise and mains interference onto this signal will also be available. This will allow the amplifier's ability to remove these unwanted components to be assessed. The amplifier's overall compliance with the performance specification given will be tested and verified as part of the project.

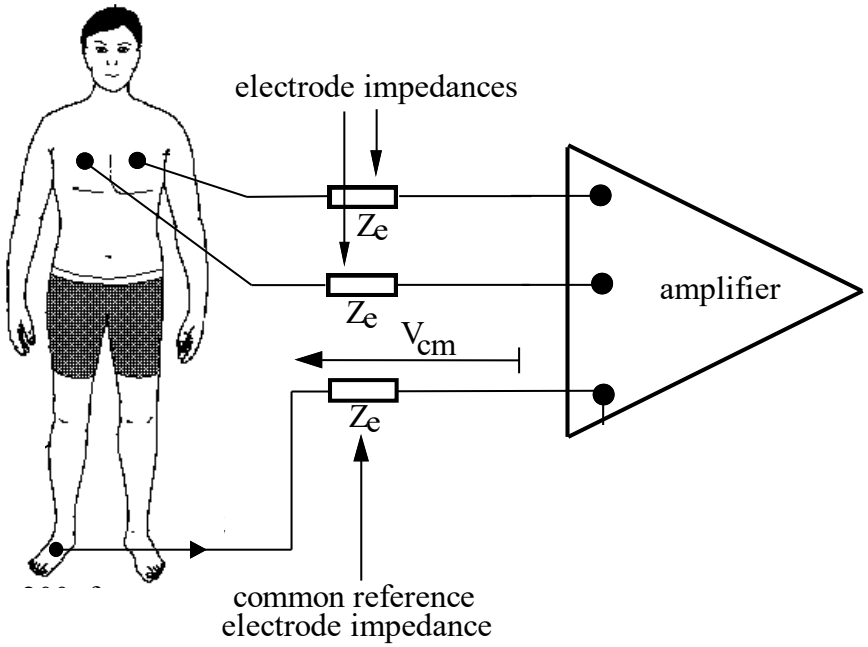

Fig. 1 Measurement of the Electrocardiogram

Performance Specification:
Input Signal Level: 10 – 20mVpk (QRS)
Source Impedance: 10kΩ ± 10%
Target Output Signal Level: 2Vpk approx. (QRS)
Gain Range: 40 - 54 dB.
Minimum 3dB Bandwidth: 0.5Hz – 150Hz
Maximum Phase Shift: $<\pm 20^{O}$ at 0.5Hz and 150Hz (relative to 0^{O} mid-band).
Minimum CMRR: 60dB (within 3dB bandwidth)
Maximum Output Noise Level: 30mVptp (inputs grounded through 10kΩ).

Schedule: The laboratories will run on selected Monday mornings (Week 6-Week 10) in Semester 1 from 09:00am – 11:00am as indicated in the EEE timetable given on the university website. They will take place in ENG3001, located on the third floor of Alice Perry Engineering Building. Students will work in groups for their project. Attendance at and performance during scheduled laboratory sessions will be monitored and marked. Students may attend at other times during the week to avail of extra time on the project, provided that the laboratory is not in use. However, there is no guarantee of technical assistance or demonstrator support outside of the scheduled attendance times.

Procedure: Each student group is expected to come up with its own proposal for circuit design and to determine the component values required. Breadboards, components and test equipment will be provided in the laboratory. An op-amp based instrumentation amplifier, such as that shown in Fig.2, can be used as a starting point for the design. This circuit may then be adapted, modified, extended and refined as required to meet the performance specifications as given. Ideas for improvement of the basic circuit are welcome and encouraged (e.g. single supply operations of the amplifier). These may be obtained from the Internet and incorporated into your own design, provided that circuit structures and operation are shown to be fully understood and are explained in the technical report. Component values should also be systematically calculated with this goal in mind. The OP27 op-amp will be used for the project which is a relatively cost-effective, mid-range performance, op-amp with properties adequately suited to the requirements of the ECG amplifier. The manufacturer's data sheet for this op-amp is available on the EE5105 CANVAS website.

Each student group is then expected to construct their circuit on the breadboard provided and to get it operational. They should carry out bench testing using standard electronic test equipment in order to verify that their circuit meets the design specification given. Unfortunately, it will not be possible to use a right-leg-drive mechanism with the patient simulator due to the nature of its internal circuitry. The ECG amplifier designed by each group will be

expected to reproduce an undistorted ECG signal with a reasonable signal-to-noise ratio.

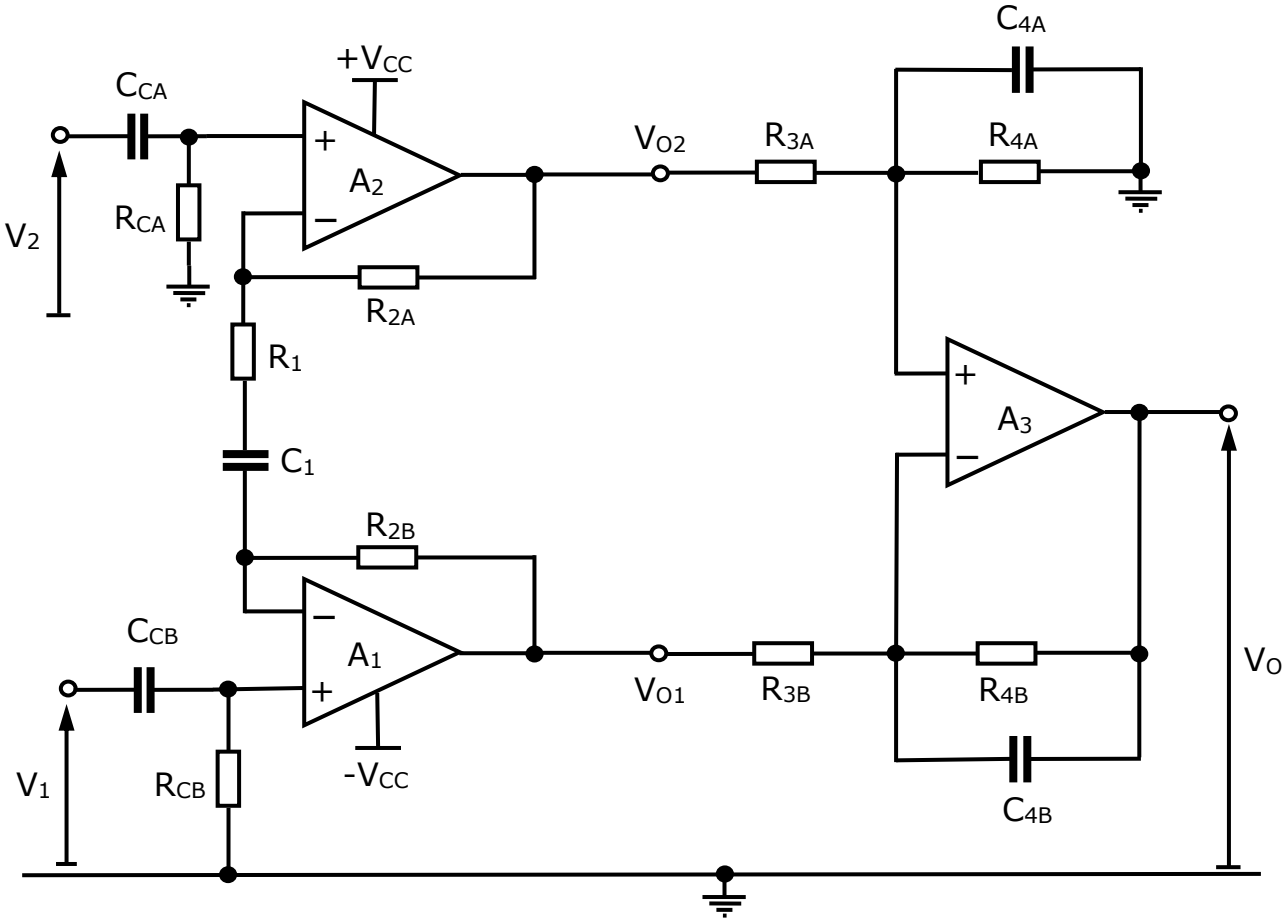

Fig. 2 Schematic Diagram of Initial ECG Amplifier

Materials Available: Breadboard, op-amps OP27, resistors (max 10MΩ), capacitors (max 10μF) , tools, test equipment etc.

Report: An individual typed report must be completed and submitted by each student. The report should be each student's own work individually written in style and content and plagiarism will be penalised. In addition, they should also outline their contributions within the group. The report should fully explain the concepts and the philosophy of decisions made during the design phase of the project. It should include schematic diagrams of complete circuits with all components suitably labelled. Please note that handwritten circuit diagrams will note be accepted. Comprehensive details of the reasons for the choice and the calculation of component values should be given. Explanation of test procedures should be included along with proper tables and graphs showing the results obtained, as well as printouts of recordings of synthesised ECG and/or other signals. A photo of the constructed breadboard should also be included. Moreover, every student needs to upload all the raw files (filenames need to be

relevant) from the oscilloscope, along with the relevant code used to plot the results. The report should be a maximum of 20 pages long and is due for submission on or before Friday 28th November 2025 (the end of the last week of teaching term in Semester 1). A portal will be available within the EE5105 module on CANVAS to upload your report. The uploaded file should be in PDF format. All equations must be fully typed; handwritten submissions will not be accepted.

This design project will account for 40% of the EE5105 module mark at the annual examinations, while the remaining 60% of the module mark will be awarded based on the written examination. Marks for the laboratory design project will be awarded only to students who attend the laboratory and also submit a report. Reports will not be accepted from students who do not attend and participate in the laboratory. Students who attend the laboratory but do not submit a report will obtain a zero mark. Reports submitted up to one week late will have a penalty of 25% of the awarded mark deducted. Reports submitted later than one week and up to two weeks after the submission deadline will have a penalty of 50% of the awarded mark deducted. Reports will not be accepted later than two weeks after the deadline for submission has expired.