Presenter: RAKSHA A DAVE
Course: M.Sc Physics
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Project – Three Op-Amp Instrumentation Amplifier (IA) Design & Simulation

Reference Research Paper:

R. D. White, "Phase Compensation of the Three Op-Amp Instrumentation Amplifier," IEEE Transactions on Instrumentation and Measurement, 1987.

Direct PDF Link (Accessible):

https://www.researchgate.net/profile/David-White-74/publication/258422382_Phase_Compensation_of_the_Three-Op-Amp-Instrumentation-Amplifier/links/5524eecd0cf22e181e73b30c/Phase-Compensation-of-the-Three-Op-Amp-Instrumentation-Amplifier.pdf

[Note: This paper is originally published in IEEE Transactions (IEEE Journal), but the free-access version is available via ResearchGate.]

1. Introduction

An instrumentation amplifier (IA) is a special type of amplifier made using three operational amplifiers (op-amps). It is used when we want to measure very small signals accurately, without noise. It is used to amplify the difference of two input signals.

We mostly use it in physics labs when we measure:

• Temperature using sensors (thermistors/RTDs)
• Small voltages from Wheatstone bridge
• Tiny signals from experiments

2. The three-op-amp IA is popular because:

- If input sources to amplifier have high output impedence or unbalanced output impedence then we should be using instrumentation amplifier which is having high input impedence.
- Very high input resistance.
- Very stable and accurate gain
- Removes common noise (high CMRR)

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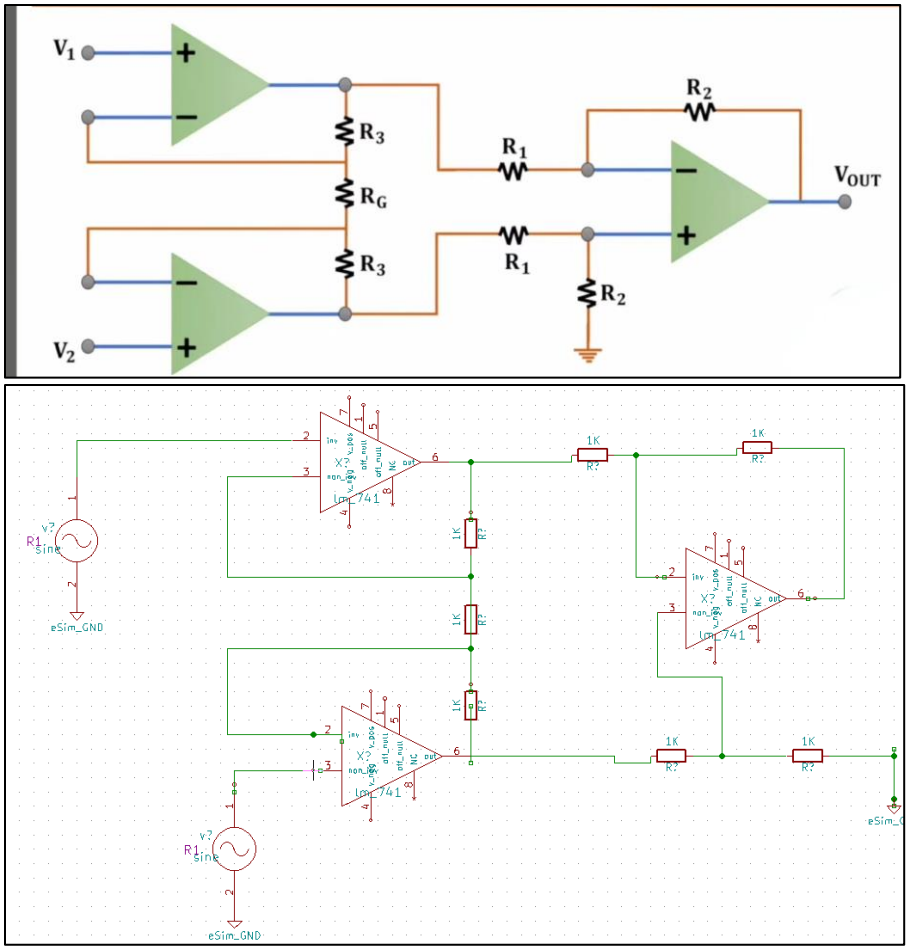
3. Aim of the Project

1. To design a Three Op-Amp Instrumentation Amplifier using eSIM (FOSSEE IIT Bombay).
2. To simulate the gain, input-output relation, and noise behaviour.
3. To validate the performance by comparing with the reference IEEE research paper.
4. To understand phase compensation and stability in op-amp circuits.

4. Basic Concept

The IA has 3 op-amps:
• Op-Amp 1 and Op-Amp 2 → amplify small difference between inputs.
• Op-Amp 3 → removes noise and gives stable output.

5. Circuit Diagram



[Circuit Simulated on Esim]

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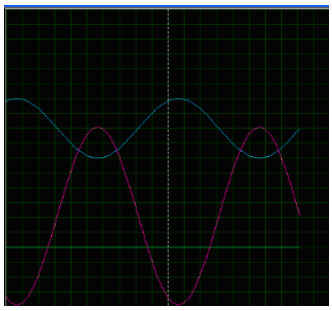
6. Formula of Gain & Output

$$V_{\text{out}} = \left(1 + \frac{2R_1}{R_G}\right)\left(\frac{R_3}{R_2}\right)(V_2 - V_1)$$



7. Conclusion

The three-op-amp instrumentation amplifier successfully amplifies small differential signals while rejecting common-mode noise, making it ideal for precision measurements. Its high input impedance and adjustable gain allow accurate signal conditioning even for low-level sensor outputs. The simulation results confirm stable operation and a clear, noise-free amplified output waveform. Overall, this design proves to be reliable, efficient, and suitable for real-world instrumentation applications.

8. Reference

R. D. White, “Phase Compensation of the Three Op-Amp Instrumentation Amplifier,” IEEE Transactions on Instrumentation and Measurement, 1987.