Experiment No. 03

3.1 Experiment Name

Measurement and analysis of the gain in an instrumentation amplifier circuit

3.2 Objectives

- To observe the amplification of differential input and rejection of common-mode input
- To understand the basic principles and operation of an instrumentation amplifier
- To measure the differential gain in instrumentation amplifier

3.3 Theory

Instrumentation amplifiers are a specialized type of differential amplifier boasting exceptional common-mode rejection and high differential gain. Essentially, they amplify the difference between two input signals while simultaneously rejecting any common noise present in both.

This remarkable ability is achieved through a specific internal circuit configuration where a current, I3, flows through resistors R1, R2, and R3 based solely on the difference in voltage between the two inputs, Vi1 and Vi2. As a result, the output voltage differential, Vo1-Vo2, becomes directly proportional to this voltage difference, further amplified by a factor of (1+2(R1/R3)) and multiplied by the gain of the output stage (R6/R4).

This clever design allows the instrumentation amplifier to effectively extract the desired signal while ignoring any unwanted common-mode noise, making it a valuable tool in various applications requiring precise and accurate measurements.

3.4 Apparatus

- Multimeter
- Oscilloscope
- Resistor
- Potentiometer
- Op-amp
- Project Board
- Wires
- Signal generator

3.5 Data Table (Measured value)

V_{i1}(volt) (p-p)	V_{i2}(volt) (p-p)	R_3 (Ω)	V_o (volt)	Differential gain, $A_d = V_o/(V_{i1}-V_{i2})$
4	4.5	10k	3	6
4	4.5	20k	2.8	5.6
4	4.5	40k	2.72	5.44
4	4.5	infinity	0.5	1

3.6 Calculated value

For R_3 = 10kΩ; V_{i1} = 4 V; V_{i2} = 4.5 V

$V_o = (1+2(10/10))(10/10)(4-4.5) = 1.5$ V

$A_d = V_o / V_{i1}-V_{i2} = 1.5/0.5 = 3$

For R_3 = 20kΩ; V_{i1} = 4 V; V_{i2} = 4.5 V

$V_o = (1+2(10/10))(10/10)(4-4.5) = 1$ V

$A_d = V_o / V_{i1}-V_{i2} = 1/ 0.5 = 2$

For $R_3 = 40k\Omega$; $V_{i1} = 4$ V; $V_{i2} = 4.5$ V

$V_o = (1+2(10 /40)) (10/10) (4-4.5) = 0.75$ V

$A_d = V_o / V_{i1}-V_{i2} = 0.75/ 0.5 = 1.5$

For $R_3 = \infty$; $V_{i1} = 4$ V; $V_{i2} = 4.5$ V

$V_o = (1+2(10 / \infty)) (10/10) (4-4.5) = 0.5$ V

$A_d = V_o / V_{i1}-V_{i2} = 0.5/ 0.5 = 1$

3.7 Discussion & Conclusion

The experiment successfully constructed the instrumentation circuit and accurately utilized a potentiometer as the gain resistor (R3). By varying the value of R3, different differential gains (Ad) were achieved, demonstrating its role in amplifying the differential input. While some discrepancies existed between the estimated and measured output, the observed decrease in Ad with increasing R3 aligned perfectly with theoretical predictions, validating the experiment's successful execution.