Experiment No. 5 Date:

Aim: Temperature to voltage converter using Instrumentation Amplifier.

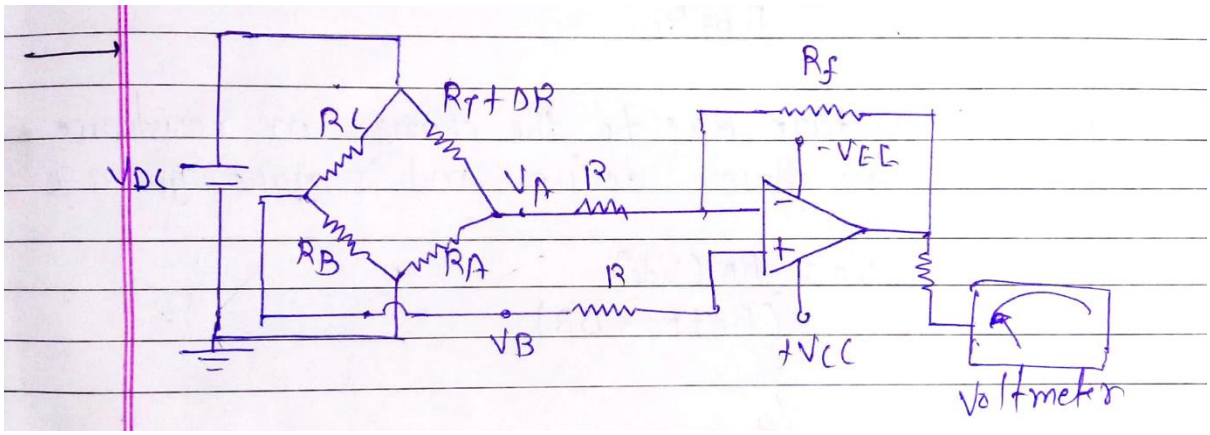
Objectives:

1. To measure the effect of change in resistance for bridge balance and unbalanced conditions.
2. To convert temperature into electrical voltage and calculate the percentage of errors.

Pre-Lab Quiz:

1. Derive the relation between change in temperature and output voltage.

Ans:



When bridge is balanced, we get,

$$V_A = V_B$$

Therefore,

$$\frac{\Delta R(V_{DC})}{R_A + R_T} = \frac{R_\Delta(V_{DC})}{R_B + R_C}$$

When there is change in the physical quantity being measured the voltage V_A will no longer be equal to V_B.

Now,

$$V_B = \frac{R_B(V_{DC})}{R_B + R_C}$$

But due to the change in resistance of the transducer device and is now given as

$$V_A = \frac{R_A(V_{DC})}{R_A + R_T + \Delta R}$$

$$V_{Diff} = V_B - V_A$$

$$V_{Diff} = \frac{R_B(V_{DC})}{R_B + R_C} - \frac{R_A(V_{DC})}{R_A + R_T + \Delta R}$$

If $R_A = R_B = R_C = R_T = R$

$$V_{Diff} = \frac{R(V_{DC})}{2R} - \frac{R(V_{DC})}{2R + \Delta R}$$

$$V_{Diff} = \frac{\Delta R(V_{DC})}{2(2R + \Delta R)}$$

If $V_{Diff} > 0$,
$V_A < V_B$

$$V_O = \frac{R_3}{R_2} V_{Diff}$$

$$V_O = \left(\frac{R_3}{R_2}\right)\left(\frac{\Delta R(V_{DC})}{2(2R + \Delta R)}\right)$$

If $\Delta R << 2R$

$$V_O = \left(\frac{R_3}{R_2}\right)\left(\frac{\Delta R}{4R}\right)(V_{DC})$$

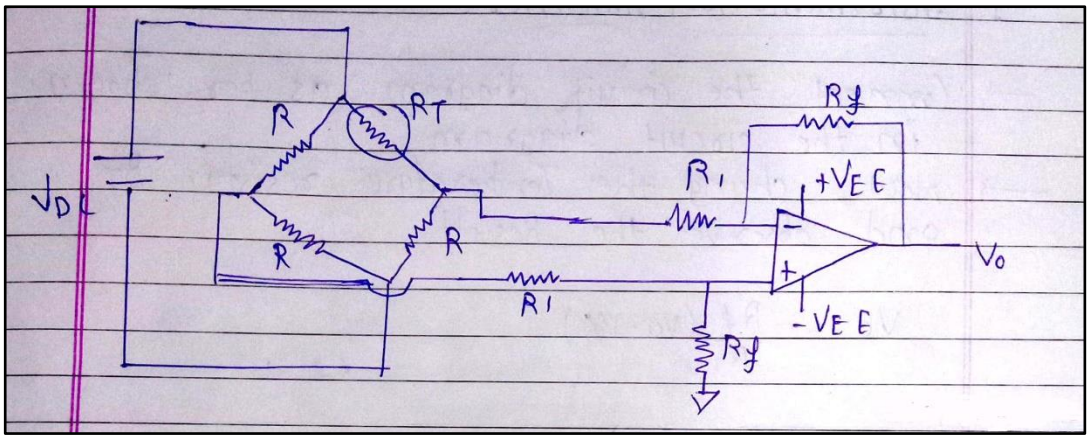
Reference Book:

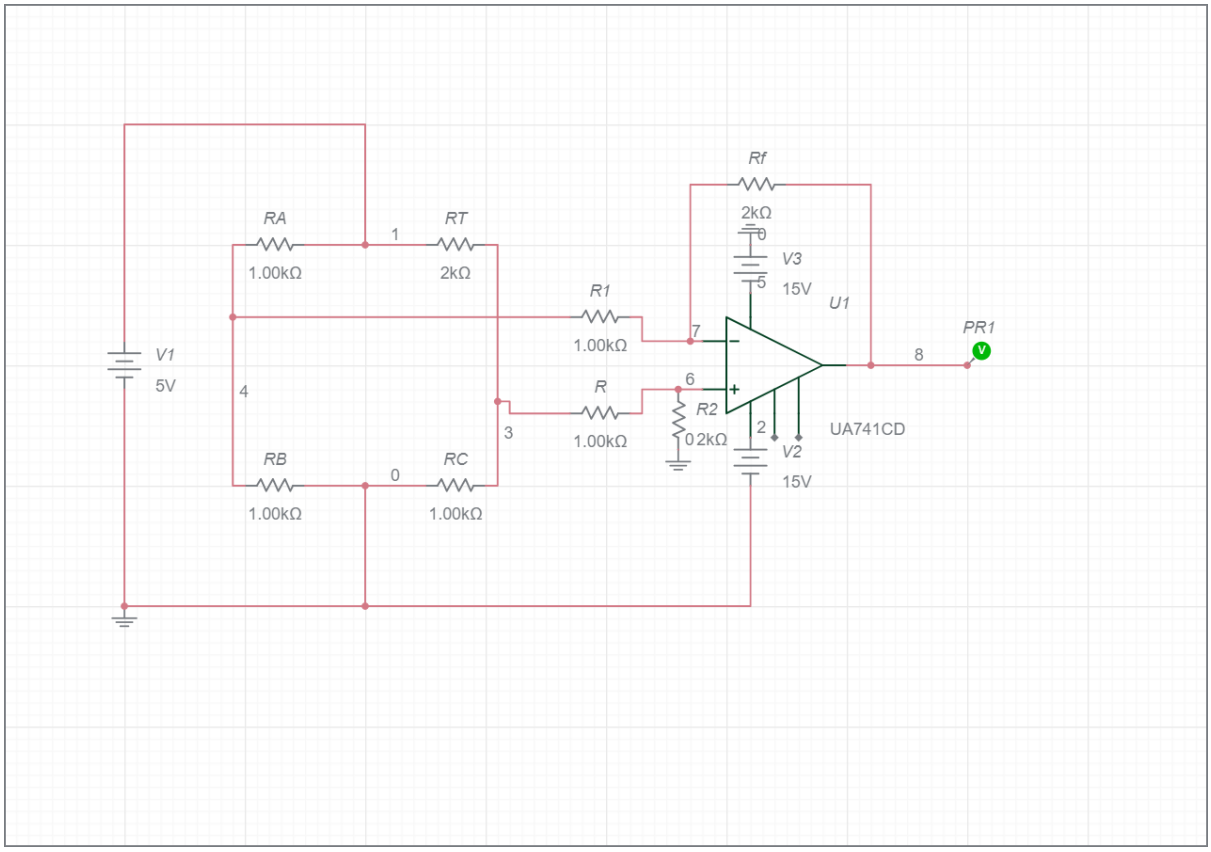
1. Ramakant A. Gayakwad- op-amp and Linear Integrated Circuits, Pearson Education; Fourth edition.

Theoretical Calculations:

Design Specifications	Calculation
V_{CC} = +15 V V_{EE} = −15 V V_{DC} = 5 V R_1 = 10 kΩ R_f = 100 kΩ $R_A = R_B = R_C$ = 10 kΩ	When, $\frac{R_C}{R_B} = \frac{R_T}{R_A}$, V_O = 0 V, as ΔR = 0 When, $\frac{R_C}{R_B} = \frac{R_T + \Delta R}{R_A}$, $V_O = \frac{R_f}{R_1}(V_A - V_B)$

Practical Circuit Diagram:





Requirements:
Select the necessary equipment/apparatus/components required for this experiment and list all of them in below-given space:

Name of Equipment/Components	Range/Value/Specification	Justification of the selection of each component/equipment
Op-Amp IC	µA741	Voltage Amplifier
Resistors	10 kΩ, 100 kΩ	To limit current
Supply Voltage	$V_{EE} = V_{CC} = 15$ V	To power all the components
R_T → Thermistor	103 (10 kΩ at 25°C)	Temp. dependent resistor
Voltmeter	0 – 20 V	To measure Voltage

Procedure:

1. **Instrumentation Amplifier:**

- Connect the circuit as per the circuit diagram.
- Now, change the Temperature Resistor (Thermistor) R_T and observe the results.

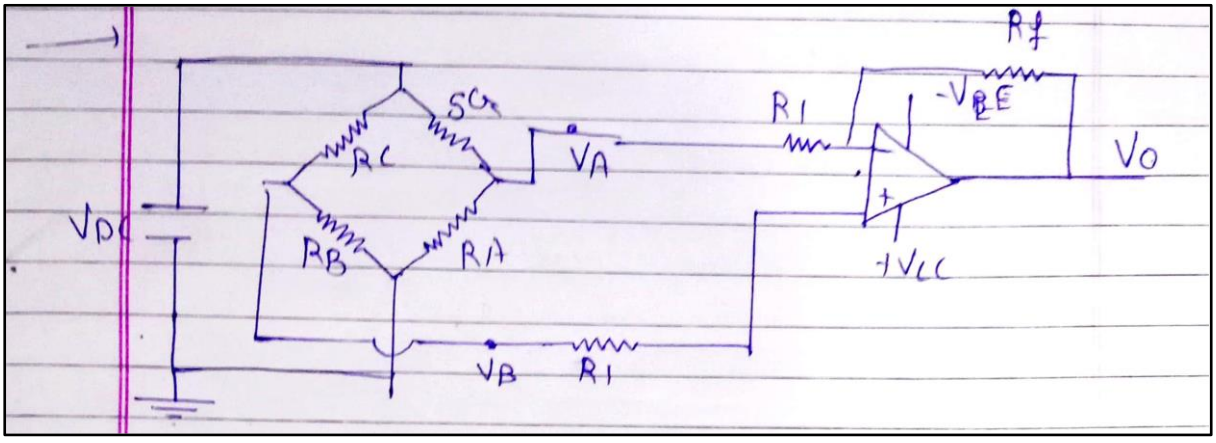
$$V_O = \frac{R_f}{R_1}(V_A - V_B)$$

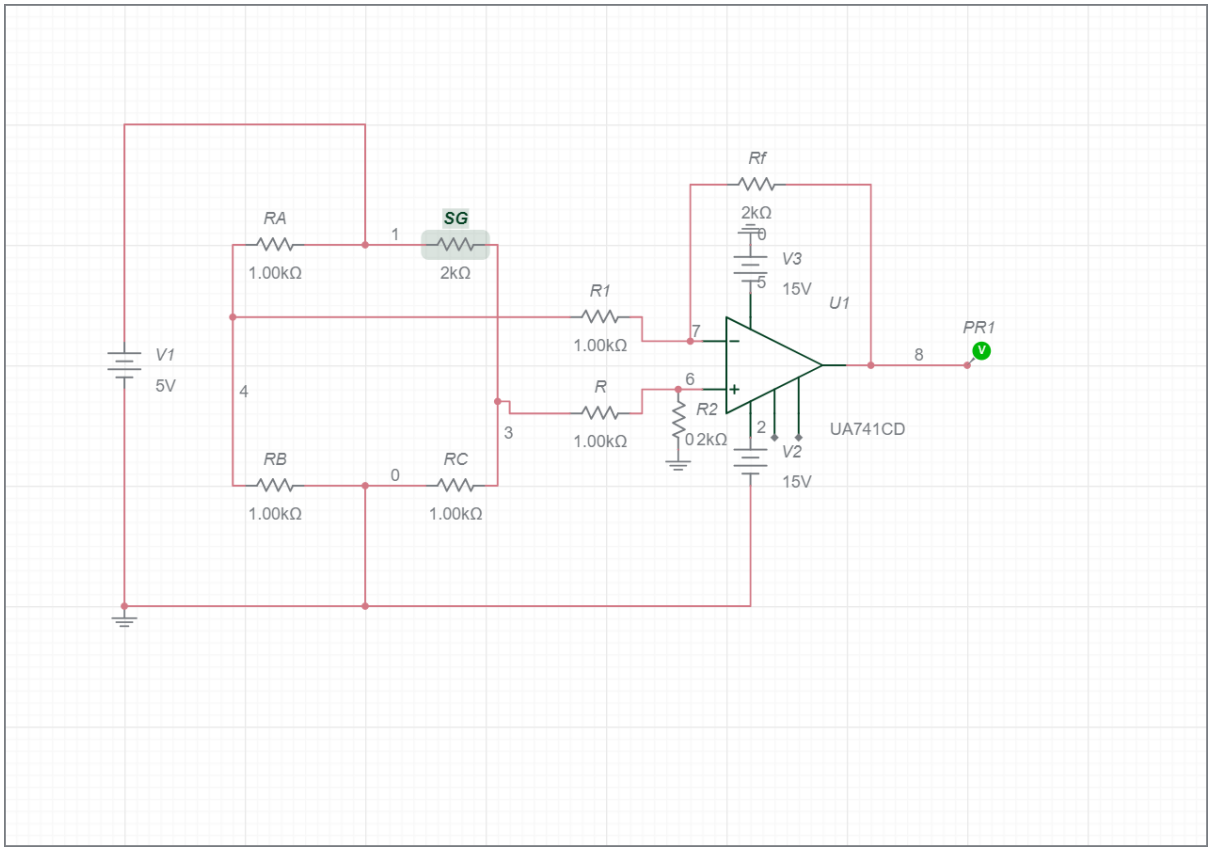
Observation:

Sr No	Resistance R_T (kΩ)	Voltage V_A (V)	Voltage V_B (V)	Output voltage V_O
1.	1	2.15	2.14	-33.9 µV
2.	2	1.58	2.15	1.14 V
3.	3	1.33	2.14	1.70 V
4.	4	1.20	2.14	1.90 V
5.	5	1.103	2.14	2.077 V

Post Lab Quiz:

Design and Simulate Strain gauge bridge interface for pressure measurement using instrumentation amplifier.





Here, instead of thermistor a pressure measuring component Strain Gauge (SG) is used. When pressure change is experienced, SG changes resistance and corresponding voltage output is obtained.

Conclusion:

In this experiment, we see how we can implement operational amplifier as an Instrumentation Amplifier. We specifically saw how to use the op-Amp as an Instrumentation Amplifier which responds to changes in temperature or in pressure.

Assessment:

1.	**Experimental Procedure (3 Marks)**	Develops and implement the most logical experimental procedures. Included prelab and post-lab exercise. (3 Marks)	Experimental Procedure most often followed but occasionally oversight leads to loss of experimental efficiency and /or loss of data. Partially included pre-lab and post-lab exercise. (2 Marks)	It doesn't follow the experimental procedure. Not included pre-lab and post-lab exercise. (1 Marks)
2.	**Result and measurement error**	Tries to achieve the	Achieve the desired results. He is aware of	Unable to achieve the desired results.

	(3 Marks)	results from different viewpoints. He is aware of measurement error and able to account for it statistically. (3 Marks)	measurement error but does not account for it statistically. (2 Marks)	Is unaware of measurement error. (1 Marks)
3.	**Documentation (4 Marks)**	Report writing in the proper format for all experiments (No, Date, Objective, Apparatus with specifications, software used if any (4 Marks)	Most of the lab report is in format but some of the formatting guidelines are missed. (2 Marks)	Experiments not written in a pre-lab proper format. (1 Marks)
Total Marks (10)				

Signature of Faculty Member with date: