D.Lalitha Prasanna
23MTS0013

SIGNAL CONDITIONING EXPERIMENTS

EXPERIMENT 1

WHEAT STONE BRIDGE

AIM:

To understand the Wheatstone bridge sensor working by single element varying, two elements varying and All elements varying.

APPARATUS:

1) AC Voltage supply
2) Resistors
3) Voltage analysis
4) Grounding
5) Multisim software

THEOREY:

Single element varying:

In a Wheatstone bridge with a single varying resistor, the basic bridge equation is:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

To handle a varying resistor without opamps, you might use a potentiometer for $R1$ (the varying resistor). A potentiometer is a three terminal resistor with an adjustable wiper. By adjusting the wiper position, you can vary the resistance of $R1$ until the bridge is balanced. When the bridge is balanced, the ratio of $R1$ to $R2$ is equal to the ratio of $R3$ to $R4$.

Two elements Varying:

If $R1$ and $R2$ are both varying, you could use two potentiometers, one for each resistor. Adjust the positions of the wipers on the potentiometers until the bridge is balanced. This requires careful adjustment to find the right combination that satisfies the bridge equation.

All elements varying:

When all four elements are varying, achieving balance becomes more challenging. One practical approach is to use precision variable resistors or potentiometers for each resistor in the bridge. Again, the challenge lies in adjusting these variable resistors to find a combination that satisfies the Wheatstone bridge equation.

PROCEDURE:

1. Setup the Wheatstone Bridge:

Take a four Resistor arrange them in a diamond shape or connected two resistors in series and another two resistors in parallel. Connect to an AC voltage supply top terminals of the bridge.

2. Replace a resistor to a potentiometer:

For the single element varying replace any one resistor to a potentiometer, For Two elements varying replace two diagonal resistors with a potentiometer and For All elements varying replace all four resistors with a potentiometer.

3. Initial Adjustment:

Set the potentiometer to an arbitrary resistance value. Then, Turn on the voltage supply and allow the circuit to stabilize.

4. Balance the Bridge:

Adjust the potentiometer until the galvanometer shows zero deflection (null point). This indicates that the bridge is in balance.

5. Measurements:

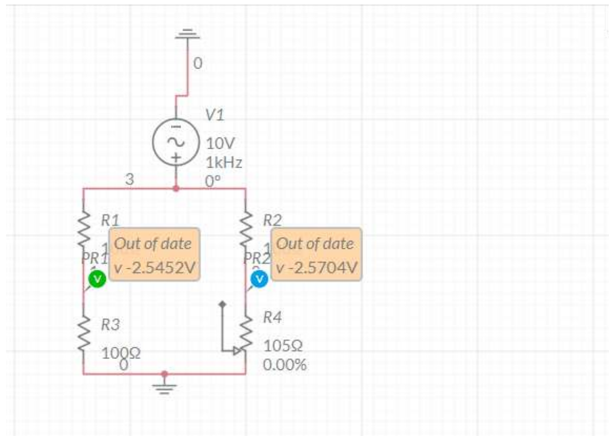
Once the bridge is balanced, measure the resistance value on the potentiometer. Record the resistance values of the fixed resistors in the Wheatstone bridge.

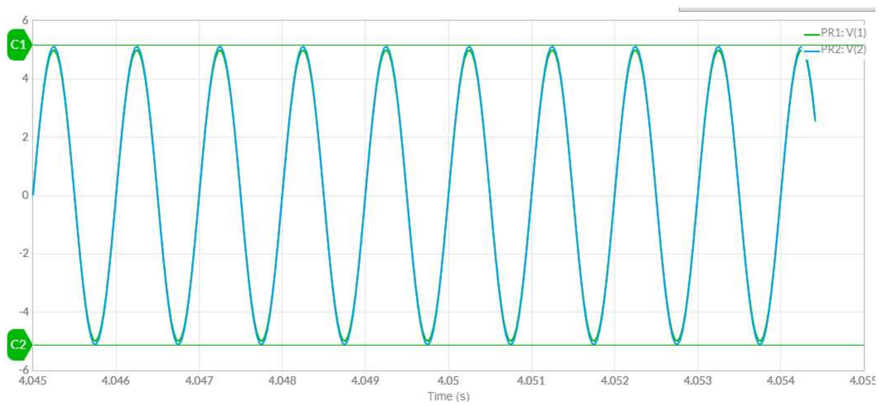
TABULAR COLUMN:

s. no	ΔR (Ohms)	Single element (v)		Two elements – 1 (v)		Two element 2 (v)		All element (v)	
		Simulation	calculations	simulation	calculation	simulation	calculation	simulation	calculation
1.	2	10.095	4.9 m	9.857	4.9 m	10.095	5 m	9.7251	2m
2.	5	10.294	0.124	9.763	0.124	10.569	0.0125	9.539	5m
3.	8	10.408	0.019	9.6209	0.019	10.806	0.020	9.213	8m
4.	10	10.550	0.024	9.6209	0.024	11.043	0.025	9.012	0.01
5.	12	10.605	0.029	9.3839	0.029	11.232	0.03	8.7866	0.012
6.	15	10.777	0.037	9.3365	0.037	11.564	0.0375	8.5355	0.015
7.	20	10.948	0.0475	9.0995	0.0475	11.943	0.05	8.0081	0.02
8.	25	11.175	0.0625	8.8626	0.0625	12.512	0.0625	7.531	0.025
9.	30	11.289	0.075	8.7678	0.075	13.128	0.075	7.07	0.03
10	40	11.716	0.0975	8.2464	0.0975	14.028	0.1	5.983	0.04
11.	50	12.038	0.1225	8.0095	0.1225	15.07	0.125	5.043	0.05
12.	70	12.654	0.1725	7.4408	0.1725	17.014	0.175	3.012	0.07
13.	100	13.318	0.2475	6.7299	0.2475	20.076	0.25	3.009	0.1

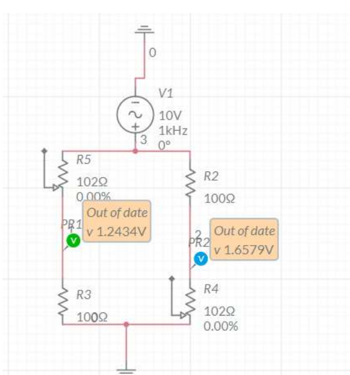
FIGURES:

Single element varying:

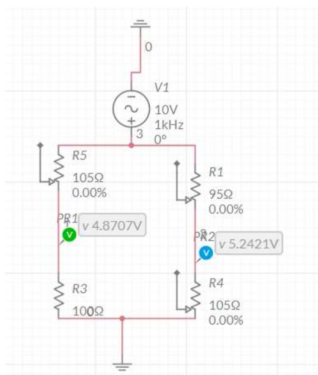


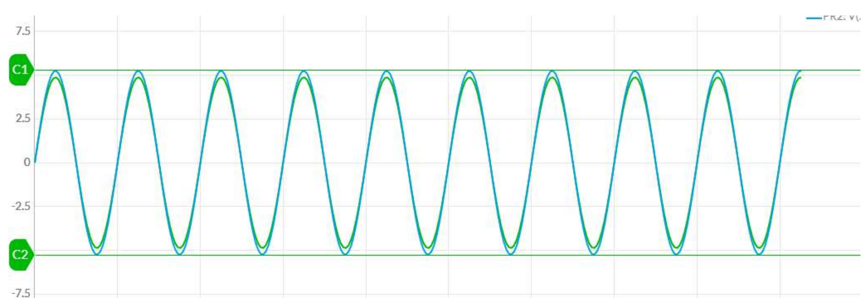


Two element Varying 1:

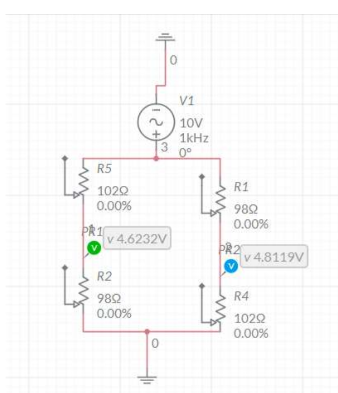


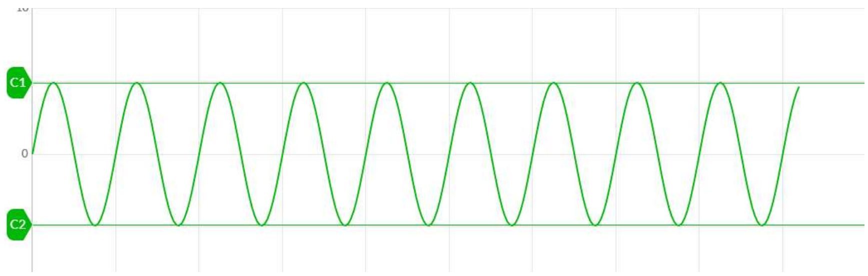
Two element Varying – 2:





All elements varying:





RESULT:

The Result in the Wheatstone bridge experiment determines the balances in the output voltage (V_{out}) for the single elements, Two elements and all elements varying scenario.

D.Lalitha Prasanna
23MTS0013

EXPERIMENT-2

SENSITIVITY AND LINEARITY OF WSB

AIM:

To determine the sensitivity and linearity of a Wheatstone Stone Bridge (WSB) using Multisim.

APPARATUS:

1. Multisim software
2. Resistors
3. AC voltage supply
4. Operational amplifier
5. Grounding
6. Voltage analysis

FORMULA:

Sensitivity:

Single element varying bridge

$S=dV_{out}/d(\Delta R)=V_B/4R=0.023V/ohm$

Two element varying bridge

$S= V_B/2R=0.5v/ohm$

THEORY:

The Wheatstone Stone Bridge is a circuit used to measure an unknown resistance by comparing it to three known resistances. The bridge is balanced when the voltage difference between two of the points is zero. The sensitivity of the bridge is a measure of how small a change in the unknown resistance will produce a detectable change in the voltage difference. The linearity of the bridge is a measure of how accurately the voltage difference changes with the change in the unknown resistance.

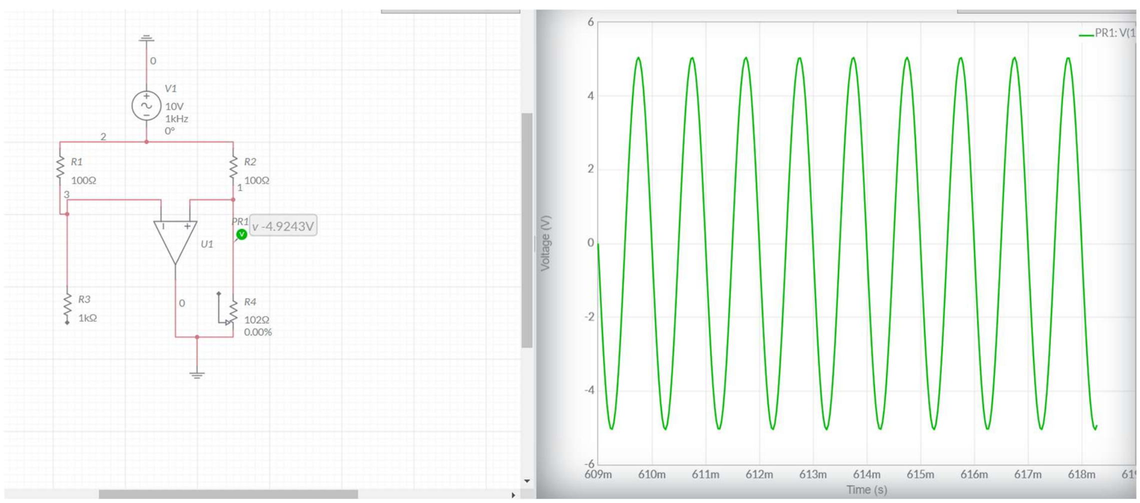
PROCEDURE:

1. Connect the Wheatstone Stone Bridge circuit to the breadboard according to the schematic diagram.
2. Connect the multimeter in voltmeter mode to the two points on the bridge where the voltage difference is measured.
3. Adjust the three known resistances until the voltage difference is zero. Record the values of the three known resistances.
4. Change the value of the unknown resistance andmeasure the voltage difference.
5. Repeat steps 4 and 5 for several different values of the unknown resistance.

TABULAR COLUMN:

s. no	ΔR	Single element (v)		Two elements – 1 (v)		Two element -2 (v)		All element (v)	
		Simulation	calculations	simulation	calculation	Simulation	calculation	simulation	calculation
1.	2	10.095	4.9 m	9.857	4.9 m	10.095	5 m	9.7251	2
2.	5	10.294	0.124	9.763	0.124	10.569	0.0125	9.539	5
3.	8	10.408	0.019	9.6209	0.019	10.806	0.020	9.213	9
4.	10	10.550	0.024	9.6209	0.024	11.043	0.025	9.012	0.01
5.	12	10.605	0.029	9.3839	0.029	11.232	0.03	8.7866	0.012
6.	15	10.777	0.037	9.3365	0.037	11.564	0.0375	8.5355	0.015
7.	20	10.948	0.0475	9.0995	0.0475	11.943	0.05	8.0081	0.02
8.	25	11.175	0.0625	8.8626	0.0625	12.512	0.0625	7.531	0.025

FIGURES:



RESULT:

The sensitivity of the WSB is 0.5 V/Ω. The linearity of the WSB is good.

D.Lalitha Prasanna
23MTS0013

EXPERIMENT-3

SIGNAL CONDITIONING OF WHEAT STONE BRIDGE AND OP-AMP

AIM:

To design a signal conditioning circuit for Wheatstone bridge using Multisim.

APPARATUS REQUIRED:

1. DC Voltage Source
2. Resistors - 1010Ω, 990 Ω, 1k Ω, 200k Ω
3. Ground
4. Two terminal Op amp
5. Multisim Software

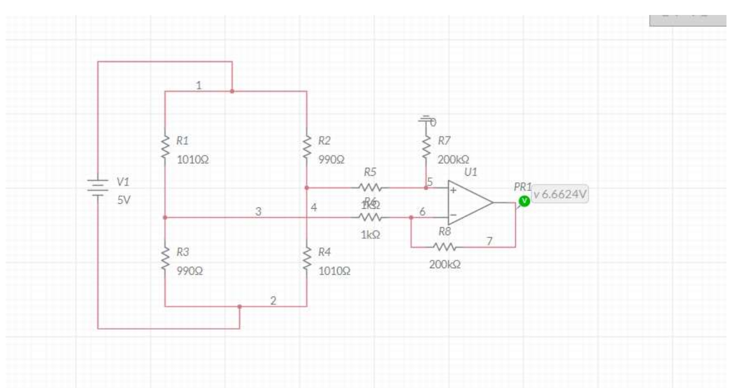
THEORY:

The instrumentation amplifier is a three-op-amp configuration that provides high input impedance, high common-mode rejection, and differential input capabilities. It's well-suited for amplifying the small differential voltage produced by a Wheatstone bridge. Signal conditioning of the Op-amp is the process of modifying the input signal to meet the specific requirements. The primary role of an op-amp in the Wheatstone bridge is to amplify the small differential voltage that is produced across the bridge which is smaller in amplitude, the output voltage is amplified to a more usable level.

PROCEDURE

1. Open the Multisim software with a new file.
2. Connect the circuit of Wheatstone bridge with an op-amp.
3. Then connect a probe at op-amp output.
4. After running the program we will get the output voltage of the circuit

FIGURES:



RESULT :

The input voltage of the bridge is 5V and the output voltage measured at the output terminal of the op amp is amplified value of 6.642V.

D.Lalitha Prasanna
23MTS0013

EXPERIMENT - 4

SIGNAL CONDITIONING CIRCUIT FOR RTD

AIM:

To designing and simulating circuits that can accurately measure and condition the resistance variations in an RTD to obtain a usable voltage signal.

APPARATUS:

1. DC Voltage Source
2. Resistors - 1010Ω, 990 Ω, 1k Ω, 200k Ω
3. Ground
4. Two terminal Op amp
5. Multisim Software

THEORY:

Understanding the theory behind RTDs, temperature-resistance relationships, and signal conditioning techniques is crucial. This might include topics such as Wheatstone bridge configurations, amplification, filtering, and other relevant concepts.

FORMULAS:

$R_T=R_0(1+\alpha T)$

Bridge Output: $\Delta V=\left(\frac{R_T}{R_T+R_0}-\frac{1}{2}\right)E$

$V_{out}=\Delta V_A$

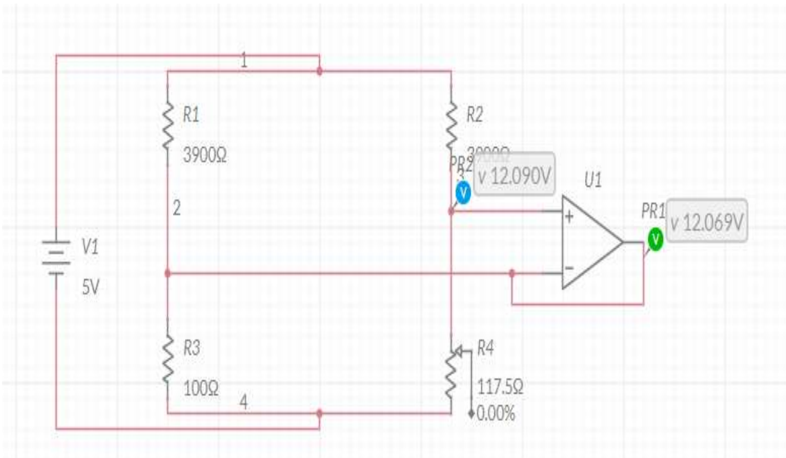
α is the resistance change/°C

PROCEDURE:

1. Use Multisim to design a circuit that includes an RTD and the necessary components for signal conditioning. This could involve creating a Wheatstone bridge, amplifiers, and filters.
2. Configure the properties of the RTD and other components in the circuit based on the experiment requirements. Adjust resistance values, amplifier gains, filter parameters, etc.
3. Run the simulation in Multisim to observe the behavior of the circuit. Measure and analyse the output voltage under different temperature conditions or other specified variations.
4. Record and analyse the simulation results. Evaluate the effectiveness of the signal conditioning circuit in accurately capturing and conditioning the RTD signal.

D.Lalitha Prasanna
23MTS0013

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S.no	Temperature	RTD	Bridge output		Amplifier output	
	°C	Resistance	Theory	Measured	Theory	Measured
1.	-10	96.5	-0.044	-12.069	-0.0445	-12.069
2.	-5	98.25	-0.022	-12.065	-0.022	-12.063
3.	0	100	-2.610	-92.564	0	-92.564μ
4.	5	101.75	2.521	12.065	0.0215	12.063
5.	10	103.5	0.042	12.069	0.0425	12.065
6.	15	105.25	0.063	12.073	0.064	12.066
7.	20	107	0.084	12.078	0.0845	12.067
8.	25	108.75	0.104	12.078	0.105	12.067
9.	30	110.5	0.124	12.081	0.1247	12.068
10.	35	112.25	0.144	12.083	0.1442	12.068
11.	40	114	0.163	12.086	0.1635	12.069
12.	45	115.25	0.182	12.088	0.1825	12.069
13.	50	117.5	0.201	12.090	0.2011	12.069

RESULT:

We designed circuit in Wheatstone bridge for RTD signal conditioning, you would observe the output voltage of the bridge. The goal may be to balance the bridge for maximum sensitivity to changes in the RTD resistance.

D.Lalitha Prasanna
23MTS0013

EXPERIMENT –5
TWO OP-AMP INSTRUMENTATIONAL AMPLIFIER

AIM:

To design two op-amp instrumentational amplifier

APPARATUS:

1. Multisim Software
2. Resistors
3. DC voltage
4. Ground
5. Operational amplifier

THEORY:

An instrumentation amplifier (in-amp) is a type of differential amplifier that is designed for amplifying a signal while rejecting common-mode noise. It typically consists of three operational amplifiers (op-amps) and precision resistors. The two op-amp configuration mentioned might be a simplified representation, as a typical instrumentation amplifier uses three op-amps.The Two-Op-Amp Instrumentation Amplifier is a variation of the classical three-op-amp instrumentation amplifier circuit. It simplifies the design by using only two operational amplifiers.

In this two-op-amp instrumentation amplifier, the non-inverting input of the first op-amp (with resistors R1 and R2) is connected to the input signal Vin+, and the non-inverting input of the second op-amp (with resistors R3 and R4) is connected to the input signal Vin-. The outputs of the two op-amps are then connected to produce the final output Vout. This configuration provides a differential gain determined by the ratio of R3 to R1.

The Two-Op-Amp Instrumentation Amplifier is often used in applications where a balance between simplicity and performance is required. It finds use in instrumentation and measurement systems where differential signal amplification and common-mode noise rejection are essential. Understanding the trade-offs and limitations is crucial when selecting this configuration for a specific application.

FORMULAS:

$V = (V_2 – V_1)\ [1 + K +\frac{R2+R4}{R5}] + V_{ref}$

Where $R = \frac{R4}{R3} = \frac{R2}{R1}$

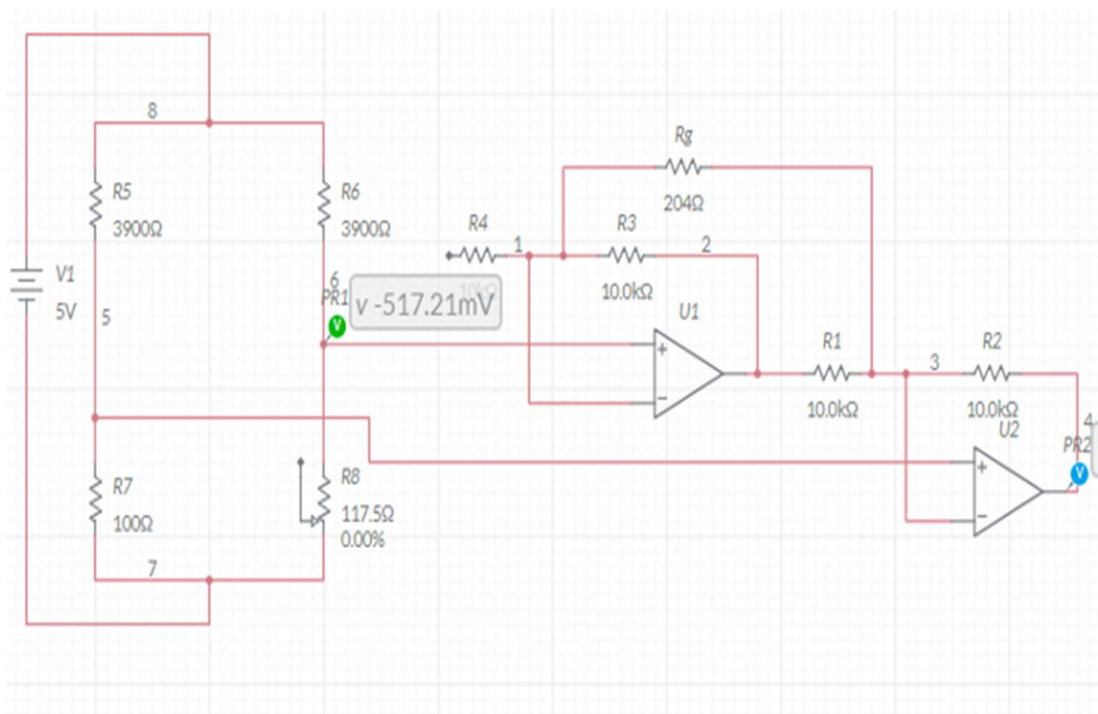
Assume $R_1 = R_2 = R_3 = R_4 = 10K\Omega$ And$V_{ref} = 0$ V

$Rg = 204\Omega$

PROCEDURE:

1. Set up the Two-Op-Amp Instrumentation Amplifier circuit according to the provided schematic.
2. Apply a known differential input signal and measure the output at Vout.
3. Introduce common-mode signals and observe the rejection capabilities of the amplifier.
4. Adjust resistor values (R1, R2, Rgain) and observe the impact on gain.
5. Record data, including resistor values, input signals, and corresponding output signals.
6. Analyse the data and compare the experimental results with theoretical expectations.
7. Document any challenges or unexpected observations.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

Vout = 500.15

S.No	Temperature	RTD Resistance	Bridge Output		Amplifier Output	
			Theory	Measured (mV)	Theory	Measured (mV)
1	-10	96.5	-0.0445	120.73	-0.0445	547.52
2	-5	98.5	-0.022	123.17	-0.022	305.99
3	0	100	0	125	0	125
4	5	101.75	0.0215	127.13	0.0215	-85.982
5	10	103.5	0.0425	129.26	0.0425	-296.78
6	15	105.25	0.064	131.39	0.064	-507.39
7	20	107	0.0845	133.52	0.0845	-717.82
8	25	108.75	0.105	135.64	0.105	-928.06
9	30	110.5	0.1247	137.76	0.1247	-0.0011381
10	35	112.25	0.1442	139.88	0.1442	-0.001348
11	40	114	0.1635	142	0.1635	-0.0015577
12	45	115.75	0.1825	144.12	0.1825	-0.0017672
13	50	117.5	0.2011	146.24	0.2011	-0.0019765

RESULT:

Conclude the experiment by summarizing the observed behavior of the Two-Op-Amp Instrumentation Amplifier. Discuss the effectiveness of common-mode rejection, the impact of resistor variations on gain, and any limitations encountered.

D.Lalitha Prasanna
23MTS0013

EXPERIMENT - 6
SIGNAL CONDITIONING CIRCUIT FOR STRAIN SENSOR

AIM:

To design a signal conditioning circuit in Multisim for a strain sensor

APPARATUS:

1. Multisim Software
2. Resistors
3. DC voltage
4. Ground
5. Operational amplifier

THEORY:

A strain sensor's signal conditioning circuit strengthens the weak electrical signal produced by mechanical deformation, increasing the output accuracy and dependability of the sensor. To maximize sensitivity and guarantee precise measurement, it has a Wheatstone bridge arrangement, a filter circuit, and an instrumentation amplifier. In order to maintain steady performance, the circuit also incorporates a voltage regulator to stabilize the power supply. In order to convert mechanical strain into differential voltage and maximize sensor sensitivity, the Wheatstone bridge configuration is used.

Amplification, noise filtering, and voltage regulation are used to optimize the strain sensor's output, producing a conditioned signal that can be precisely measured and used in a variety of applications that call for precise mechanical strain monitoring.

FORMULAS:

Sensitivity = 10.25mV/1000με

Gauge Factor = 1.025

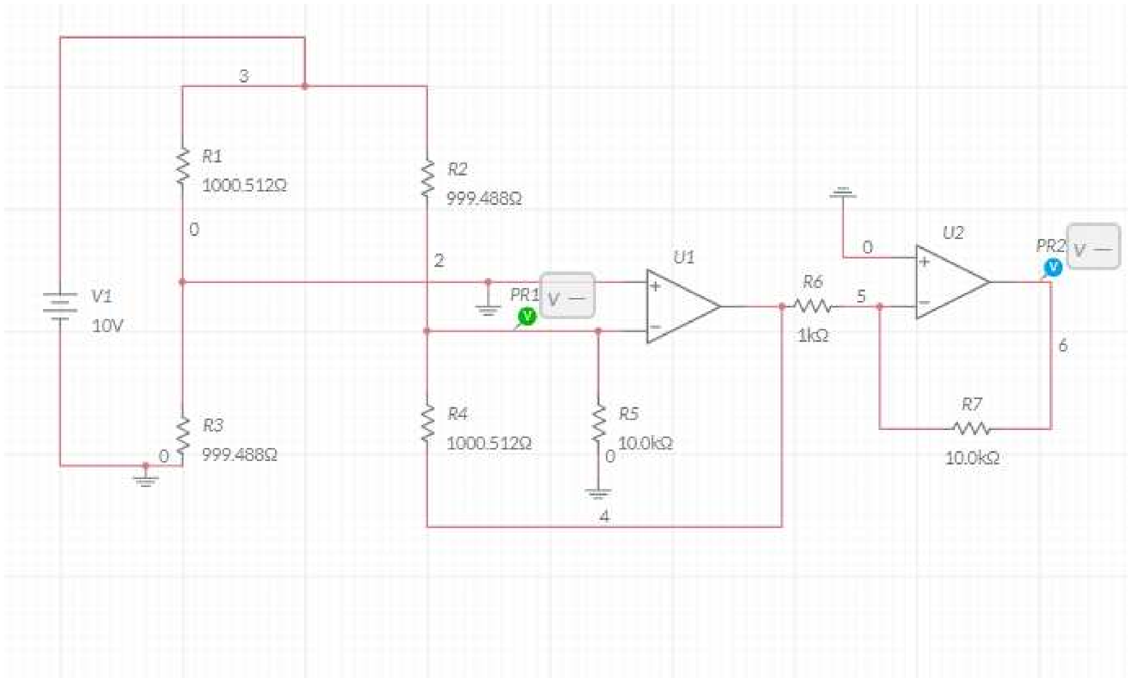
$V_B = V_{in} * (\Delta R/R)$

$K\varepsilon = \Delta R/R$

PROCEDURE:

1. Open Multisim software and create a new file.
2. Take 7 resistors from the passive components box.
3. Take 2 3-Terminal Op-amps from the analog components box.
4. Here we are connecting the DC voltage with 10 volts.
5. By changing the resistors R_1, R2, R3, R4 values we can see the difference in bridge output voltage and a slight change in amplifier output.
6. By using the above formulas we have to calculate theoretical bridge output voltage.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S.No	Srain (με)	ΔR	Bridge Output		Amplifier Output Simulated
			Theory (V)	Measured(μV)	
1	-3500	-3.5875	-0.035875	50.24	12.065
2	-3000	-3.075	-0.03075	50.292	12.065
3	-2500	-2.5625	-0.02565	50.343	12.065
4	-2000	-2.05	-0.0205	50.394	12.065
5	-1500	-1.5375	-0.015375	50.446	12.065
6	-1000	-1.025	-0.01025	50.497	12.065
7	-500	-0.5125	-0.0051	50.548	12.065
8	0	0	0	50.6	12.065
9	500	0.5125	0.0051	50.651	12.065
10	1000	1.025	0.01025	50.703	12.065
11	1500	1.5375	0.015375	50.805	12.065
12	2000	2.05	0.0205	50.807	12.065
13	2500	2.5625	0.02565	50.858	12.065
14	3000	3.075	0.03075	50.91	12.064
15	3500	3.5875	0.035875	50.962	12.064
16	4000	4.1	0.041	51.014	12.064
17	4500	4.6125	0.04612	51.066	12.064
18	5000	5.125	0.05125	51.118	12.064

RESULT:

Here we designed a signal conditioning circuit in Multisim for a strain sensor and observed that by changing the resistor values of the respective strain we can see that there is a very slight change in the amplifier output.