EE230: Experiment 3
Instrumentation amplifier and load cell sensor

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1 Overview of the experiment

1.1 Aim of the experiment

Aim of this experiment is to construct a instrumental amplifier with the help of three oamp
Use of instrumentation amplifier INA128. And to see the difference between the two instrumental amplifier

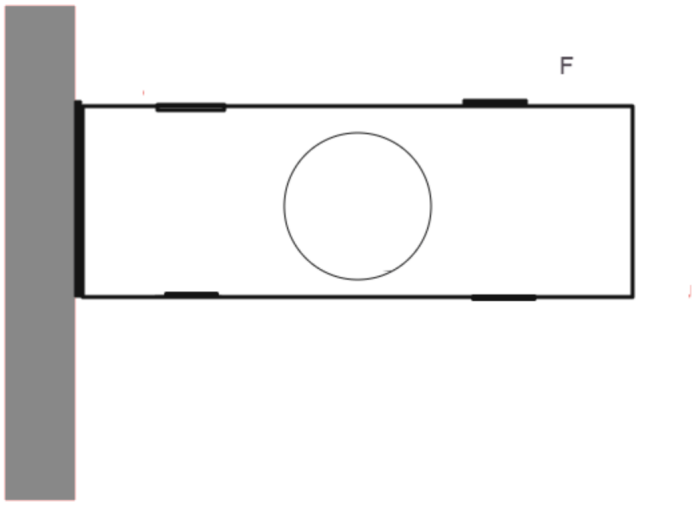
1.2 Methods

In this experiment we will calculate sensitivity of different amplifier.We will calculate the sensitivity by changing the load and comparing the voltage difference it offers.
We will make instrumentation amplifier by three oamps , we will use 2 opamp as buffer and third as amplifying circuit.
We would also find the sensitivity of INA128 by varing loads and measuring voltages.

2 Design of load cell

Based on slide 4 of handout, can you make a rough drawing of how you think the 4 strain gauges must be mounted on the cantilever to realize the load cell that is present in the weighing scale you used in lab? (Scan of a hand-drawn

sketch is also acceptable as a figure, brownie points for making good-looking sketch in inkscape, powerpoint, MS Visio etc.)



cantilever beam

When we push the cantilever down from top the top face undergoes tensile strain as they are stretched apart, whereas bottom face undergoes compressive strain as they are pushed inwards as a result resistances change .

For the wheatstone bridge, derive the relation between bridge voltage and change in resistance (handout, slide 8, bullet point 4)

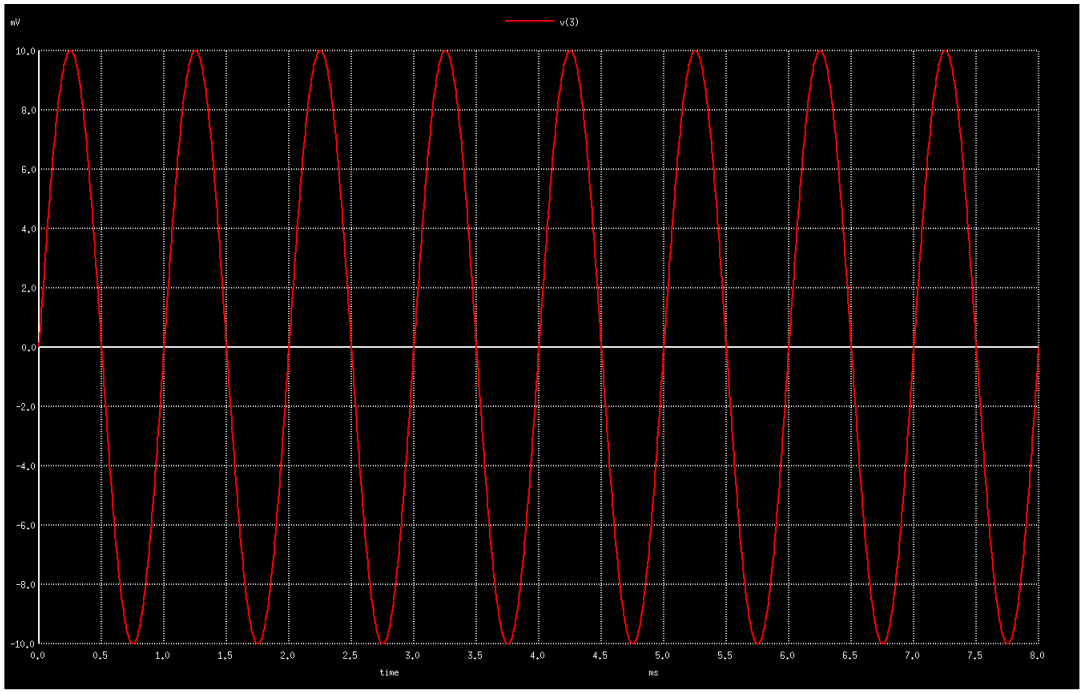
$V_{in+} - V_{in-} = \delta V_{in}$
$V_{in+} - V_{o1} = \frac{\delta V_{in} * R_3}{R_3 + R_4}$
$V_{in+} - V_{o2} = \frac{\delta V_{in} * R_1}{R_1 + R_2}$
$V_{o1} - V_{o2} = \frac{\delta V_{in} * (R_1 - R_3)}{2 * R_g}$
$R_1 - R_3 = 2\Delta R$
$V_{o1} - V_{o2} = \frac{\delta V_{in} * \Delta R}{R_g}$

3 Simulation results

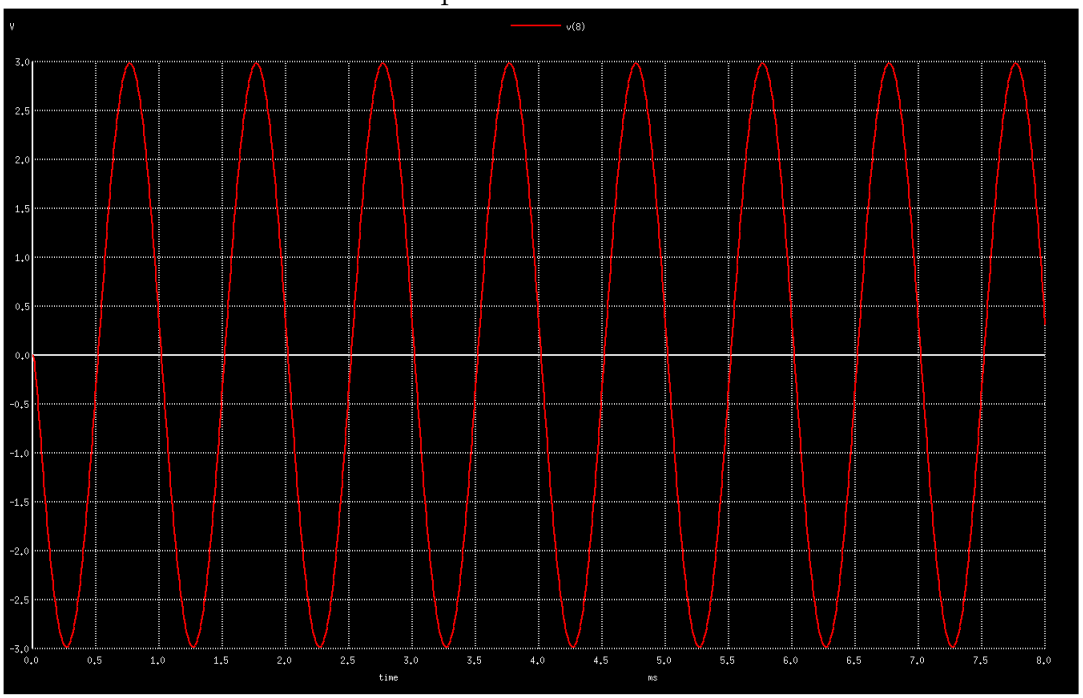
```
    *--------------------------------------------------------------------------
*
* To use a subcircuit, the name must begin with 'X'.  For example:
```

```
* X1 1 2 3 4 5 ua741
*
* connections:   non-inverting input
*                |  inverting input
*                |  |  positive power supply
*                |  |  |  negative power supply
*                |  |  |  |  output
*                |  |  |  |  |
.subckt ua741    1  2  3  4  5
*
  c1   11 12 8.661E-12
  c2    6  7 30.00E-12
  dc    5 53 dx
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
  ga    6  0 11 12 188.5E-6
  gcm   0  6 10 99 5.961E-9
  iee  10  4 dc 15.16E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 5.305E3
  rc2   3 12 5.305E3
  re1  13 10 1.836E3
  re2  14 10 1.836E3
  ree  10 99 13.19E6
  ro1   8  5 50
  ro2   7 99 100
  rp    3  4 18.16E3
  vb    9  0 dc 0
  vc    3 53 dc 1
  ve   54  4 dc 1
  vlim  7  8 dc 0
```

```
  vlp  91  0 dc 40
  vln   0 92 dc 40
.model dx D(Is=800.0E-18 Rs=1)
.model qx NPN(Is=800.0E-18 Bf=93.75)
.ends

X1 3 2 11 12 1 ua741
X2 5 6 11 12 7 ua741
X3 10 9 11 12 8 ua741
r1 9 8 100k
r2 9 1 1k
r3 1 2 1k
r4 2 6 1k
r5 6 7 1k
r6 7 10 1k
r7 10 0 100k
vcc 11 0 12v
vss 12 0 -12v
r8 5 0 0

Vin 3 0 SIN(0 10m 1k)

.TRAN 0.005m 8m
.control
run
plot v(8)
plot v(3)
.endc
.end
```



input waveform



output waveform

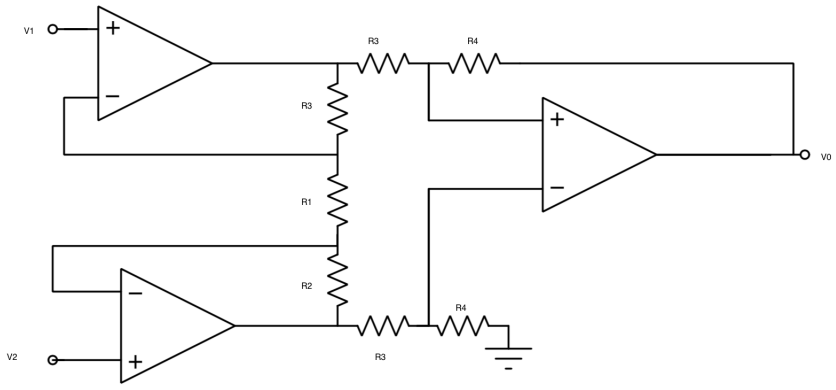
In your own words, describe how you set up the simulation, and document your observations. Also copy-paste your own simulation code (netlist) here.

What challenges did you face in simulation? Were there any discrepancies compared to what you expect from KCL-KVL based analysis?

Vin should be of low amplitude otherwise the oamp will drive into saturation as the gain is 300. No there were no discrepancies to what I was expecting from KCL and KVL based analysis.

4 Experimental results

4.1 Part 1: Three op-amp implementation

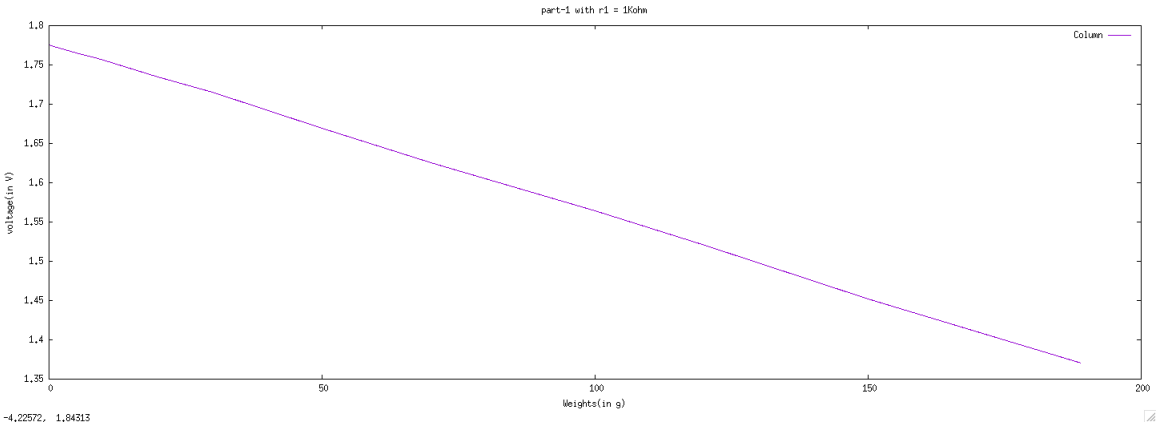


R1 = 1 kohm ; R3 =1 kohm ;R4 = 100kohm;R2 = 1kohm

Weights(in gm)	Vo(in V)
0	1.776
1	1.774
6	1.764
8	1.761
10	1.757
20	1.735
30	1.715
50	1.67
70	1.626
100	1.564
120	1.52
150	1.452
188	1.37

$senstivity = 0.002156643737$

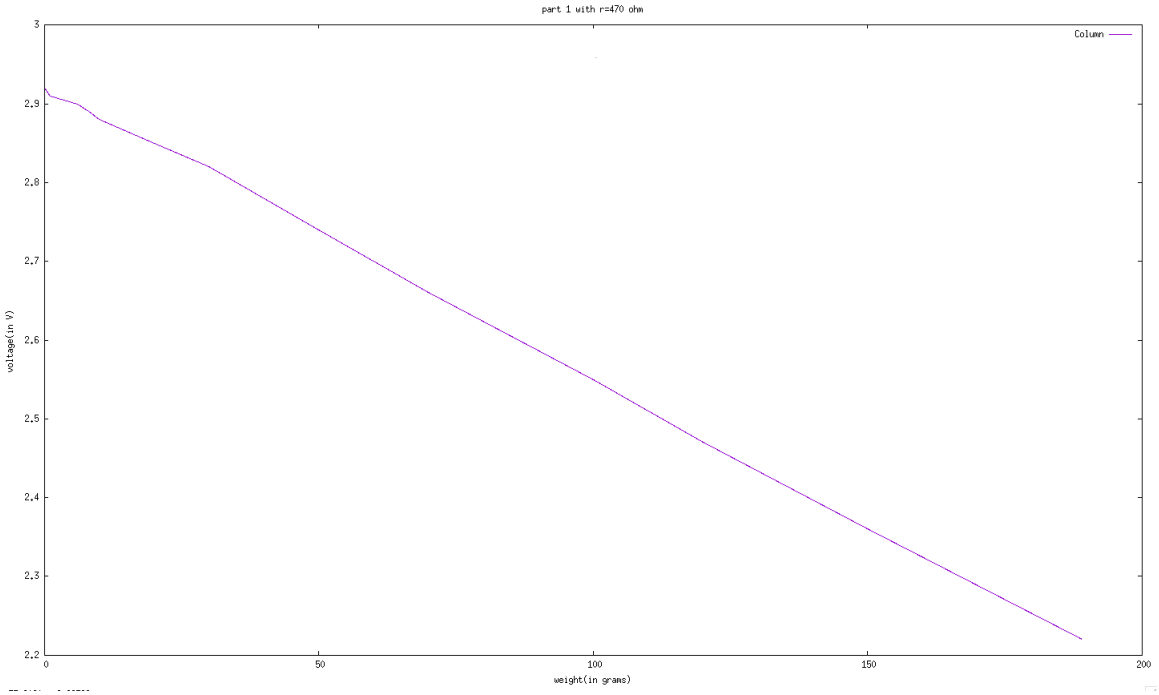
$R1 = 1kohm$



Weights(in gm)	Vo(in V)
0	2.92
1	2.91
6	2.9
8	2.89
10	2.88
20	2.85
30	2.82
50	2.74
70	2.66
100	2.55
120	2.47
150	2.36
188	2.22

$$senstivity = -0.003721489851$$

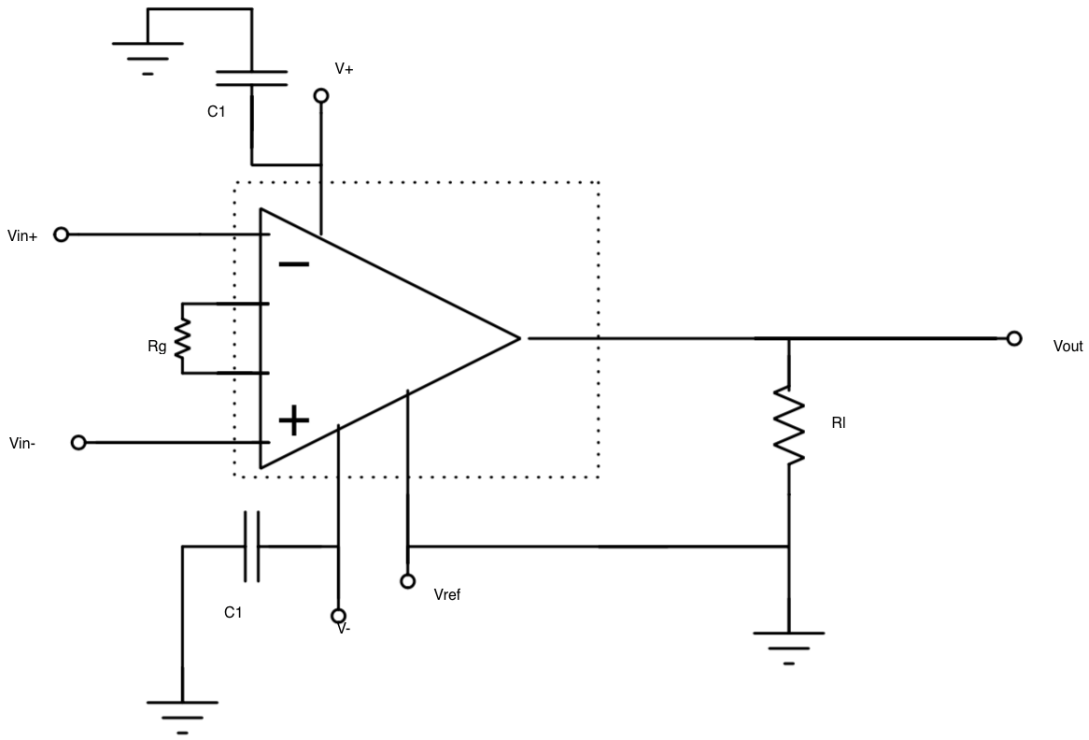
$$R1 = 470ohm$$



We can increase sensitivity by simply increasing gain.to increase gain we can decrease R1. We increased gain by half to increase sensitivity by half. The excact value of the resistance that we calculated were not available in

the lab.

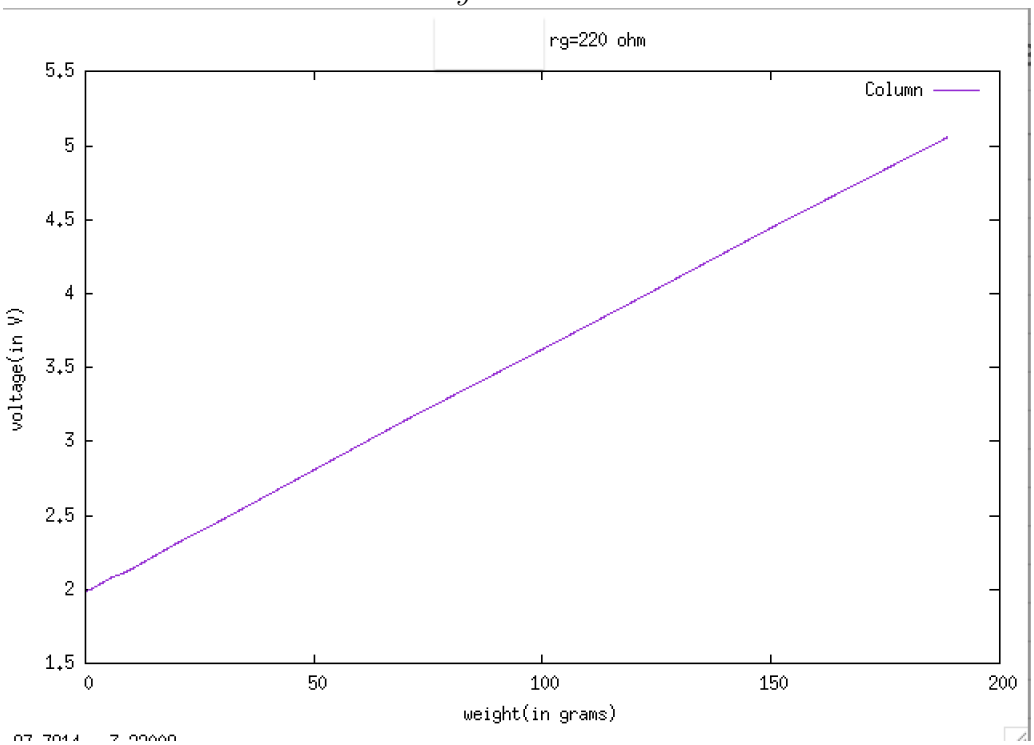
4.2 Part 3: Three op-amp implementation



Weights(in gm)	Vo(in V)
0	1.99
1	2
6	2.08
8	2.11
10	2.14
20	2.31
30	2.47
50	2.81
70	3.14
100	3.62
120	3.95
150	4.44
189	5.06

$Rg = 220ohm$

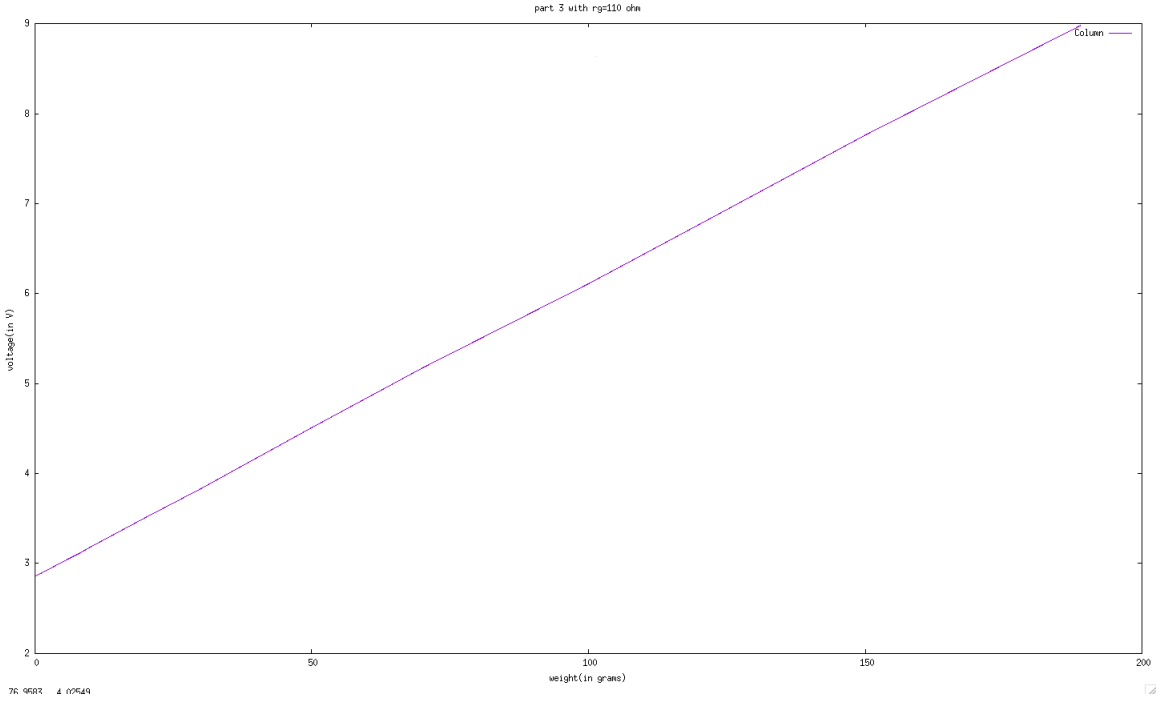
$sensitivity = 0.01633689056$



Weights(in gm)	Vo(in V)
0	2.86
1	2.89
6	3.05
8	3.11
10	3.18
20	3.51
30	3.83
50	4.51
70	5.17
100	6.11
120	6.77
150	7.77
189	8.99

$RG = 110ohm$

$sensitivity = 0.03257752668$



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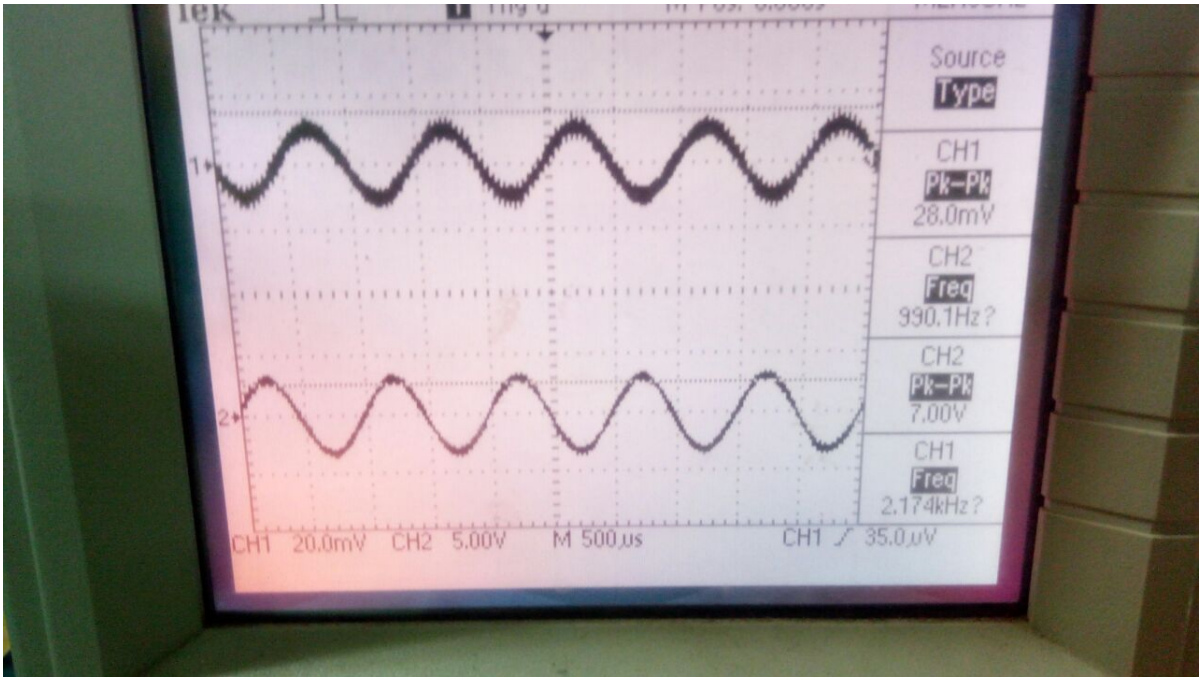
The sensitivity of the circuit was much more than previous instrumentation amplifier, used in part-1.It was about 10 times than previous. The

sensitivity is further inversely proportional to Rg i.e. if we decrease Rg then sensitivity increases.

We initially used Rg=220 ohm, to double the sensitivity we had to Resistance of 110 ohms,which was not available. so connected two resistances in parallel to make an equivalent Resistance of 110ohm



We could see small oscillations in the DSO. This happens due to the fluctuations caused in the input.These fluctuation gets amplified in the output.We were initially expecting a straight line i.e. a constant dc voltage.

5 Questions for reflection

1. Explain the waveform you see on DSO. What could be the reason for this (this is called a hypothesis - where you are making a well educated guess)? How will you verify your hypothesis (suggest experiments that will either prove or disprove your theories)
Ans. We could see small oscillations in the DSO. This happens due to the

fluctuations caused in the input.These fluctuation gets amplified in the output.We were initially expecting a straight line i.e. a constant dc voltage.

2. Can you implement an instrumentation amplifier with 2 op-amps? Read up some reputed references on the internet or some reputed textbook, and explain in your own words. (Turnitin catches verbatim copying cases, from each others' reports as well as from the internet!)
Ans. Yes we can implement instrumentation amplifier with two oamps.

3. What would happen if you did not connect capacitor C1 in the circuit in part 3?
Ans.The capacitor c1 does not allow the slight change of voltage. Due to this capacitor even if the source voltage changes it does not reflect in the oamp.this blocks the variation in the source voltage.
Due to variation in source voltage the opamp might run into osillations.

4. Will you copy or cheat in this lab and other courses, now that you are aware of Turnitin? Explain your answer.
Ans. Enter answer here.