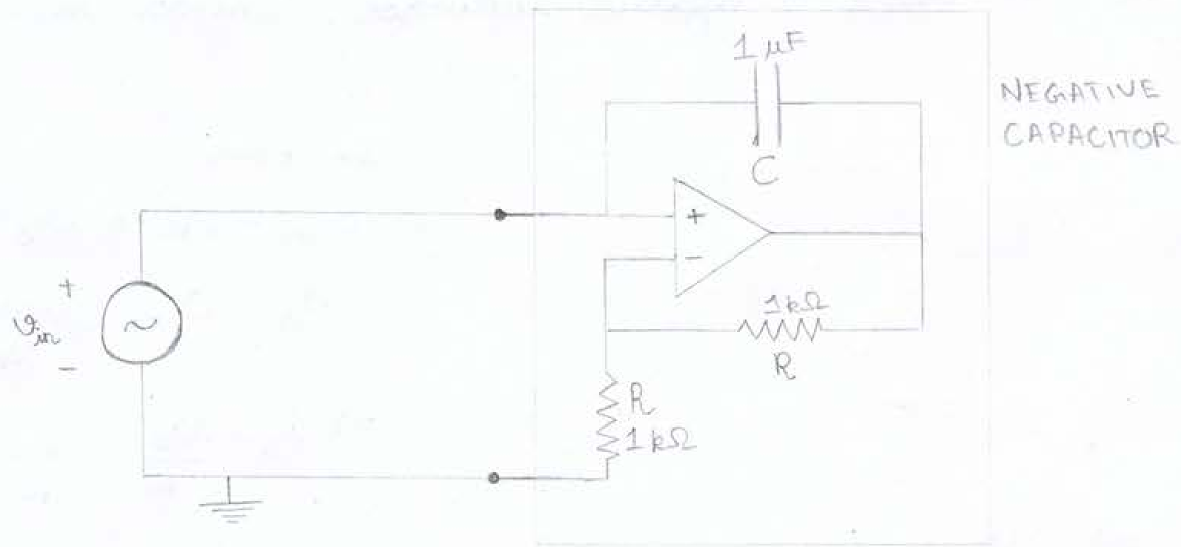
NISARG UPADHYAYA 19C930031

EXPERIMENT 5

(1) NEGATIVE IMPEDANCE CONVERTOR



OBSERVATION TABLE (C = 1 μF)

Frequency (Hz)	Applied voltage magnitude (V)	Current magnitude (A)	Phase of current w.r.t the voltage (degrees)	Calculated complex impedance (Ω)
100	5	3.14×10^{-3}	−90	1592.36j
200	5	6.28×10^{-3}	−90	796.18j
300	5	9.42×10^{-3}	−90	530.79j
400	5	1.26×10^{-2}	−90	396.83j
500	5	1.57×10^{-2}	−90	318.47j
1000	5	3.14×10^{-2}	−90	159.24j
2000	5	6.28×10^{-2}	−90	79.62j
3500	5	1.10×10^{-1}	−90	45.45j
5000	5	1.57×10^{-1}	−90	31.85j
6500	5	2.04×10^{-1}	−90	24.51j
8000	5	2.51×10^{-1}	−90	19.92j
10000	5	3.14×10^{-1}	−90	15.92j

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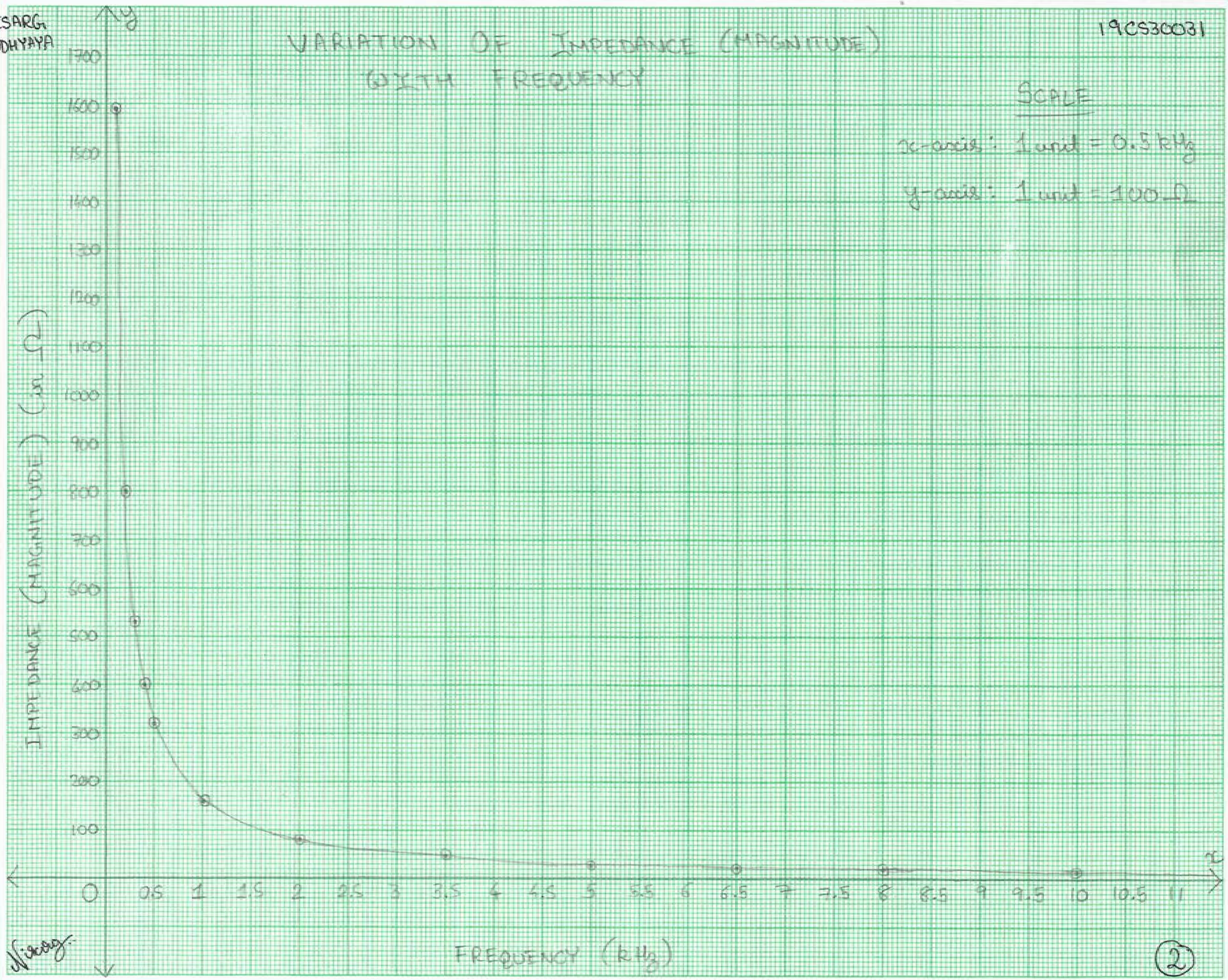

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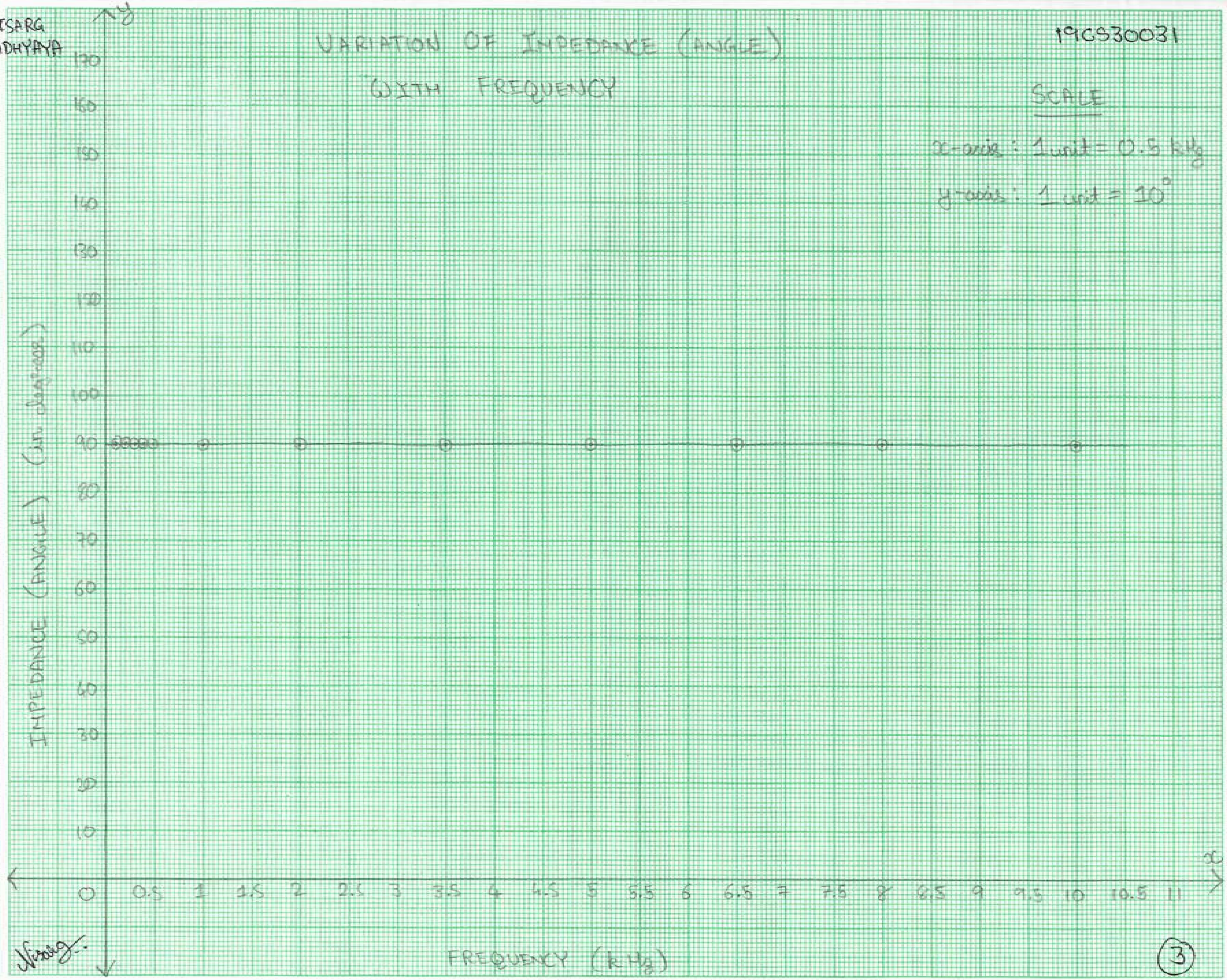
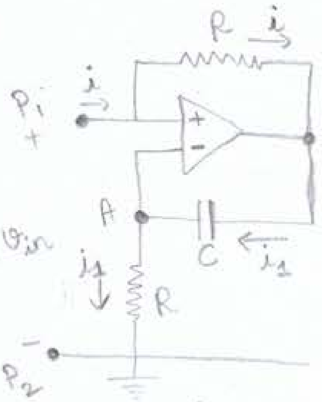


It is indeed possible to create an inductor using a capacitor using this negative impedance convertor with some slight modifications.

First, we will create a negative inductor. Consider the following circuit:



We have

$\Rightarrow v_{in} - iR = v_B$

$\Rightarrow v_A = v_{in}$ (virtual short)

$\Rightarrow i_1 = \dfrac{v_A}{R} = \dfrac{v_{in}}{R}$

$$\Rightarrow v_A + \frac{i_1}{Cs} = v_B$$

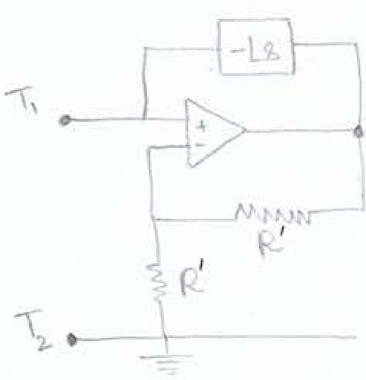
$$\Rightarrow v_{in} + \frac{v_{in}}{RCs} = v_{in} - iR$$

$$\Rightarrow \frac{v_{in}}{i} = Z_{in} = \underline{\underline{-R^2Cs}}$$

If we take $R^2C = L$ then $Z_{in} = -Ls$ which is nothing but a negative inductor.

We can assume the above to be a two terminal network

Now using our initial negative impedance convertor we can change this to a positive inductor.



Now, the following network between T_1 & T_2 behaves as a positive inductor with inductance

$$\underline{L = R^2C}$$

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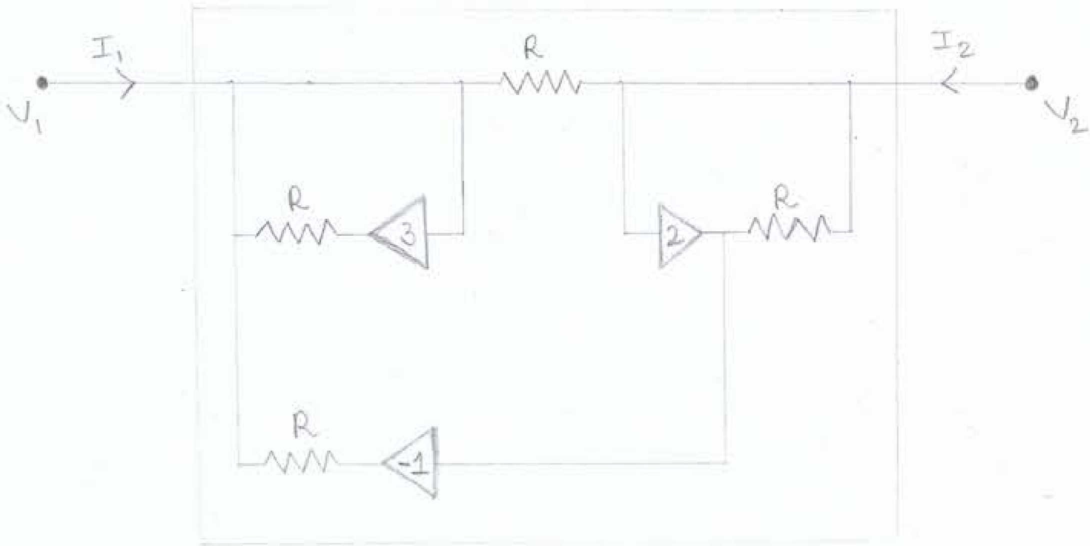
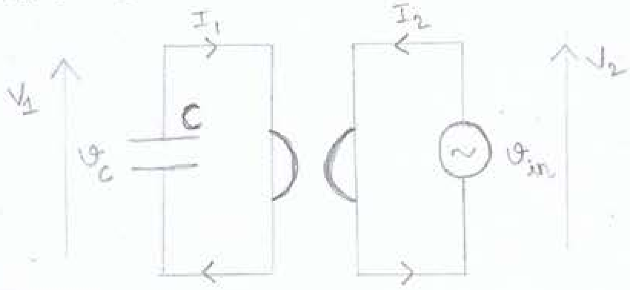
② GYRATOR



GYRATOR

SIMULATING INDUCTOR USING A CAPACITOR

GYRATION RESISTANCE = R



For a gyrator we can write $v_2 = RI_1$ and $v_1 = -RI_2$

Now $v_2 = v_{in}$ and $v_1 = v_c = \frac{-I_1}{Cs}$

Hence $v_1 = -RI_2 = \frac{-I_1}{Cs} \Rightarrow I_1 = RCs\,I_2$

$\Rightarrow \quad v_2 = v_{in} = RI_1 = R^2Cs\,I_2$

$\Rightarrow \quad Z_{in} = \frac{v_{in}}{I_2} = R^2Cs$

If we take $R^2C = L$ then Z_{in} can be treated as an inductor, whose inductance $L = R^2C$.

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OBSERVATION TABLE $(C = 1\mu F, R = 1k\Omega)$

Frequency (Hz)	Applied voltage magnitude (V)	Current magnitude (A)	Phase of current w.r.t the voltage (degrees)	Calculated complex impedance (Ω)
100	5	7.96×10^{-3}	−90	628.14j
500	5	1.59×10^{-3}	−90	3144.65j
1000	5	7.96×10^{-4}	−90	6281.41j
2000	5	3.98×10^{-4}	−90	12562.81j
3000	5	2.65×10^{-4}	−90	18867.92j
4000	5	1.99×10^{-4}	−90	25125.63j
5000	5	1.59×10^{-4}	−90	31446.54j
6000	5	1.33×10^{-4}	−90	37593.98j
7000	5	1.14×10^{-4}	−90	43859.65j
8000	5	9.95×10^{-5}	−90	50251.26j
9000	5	8.84×10^{-5}	−90	56561.09j
10000	5	7.96×10^{-5}	−90	62814.07j

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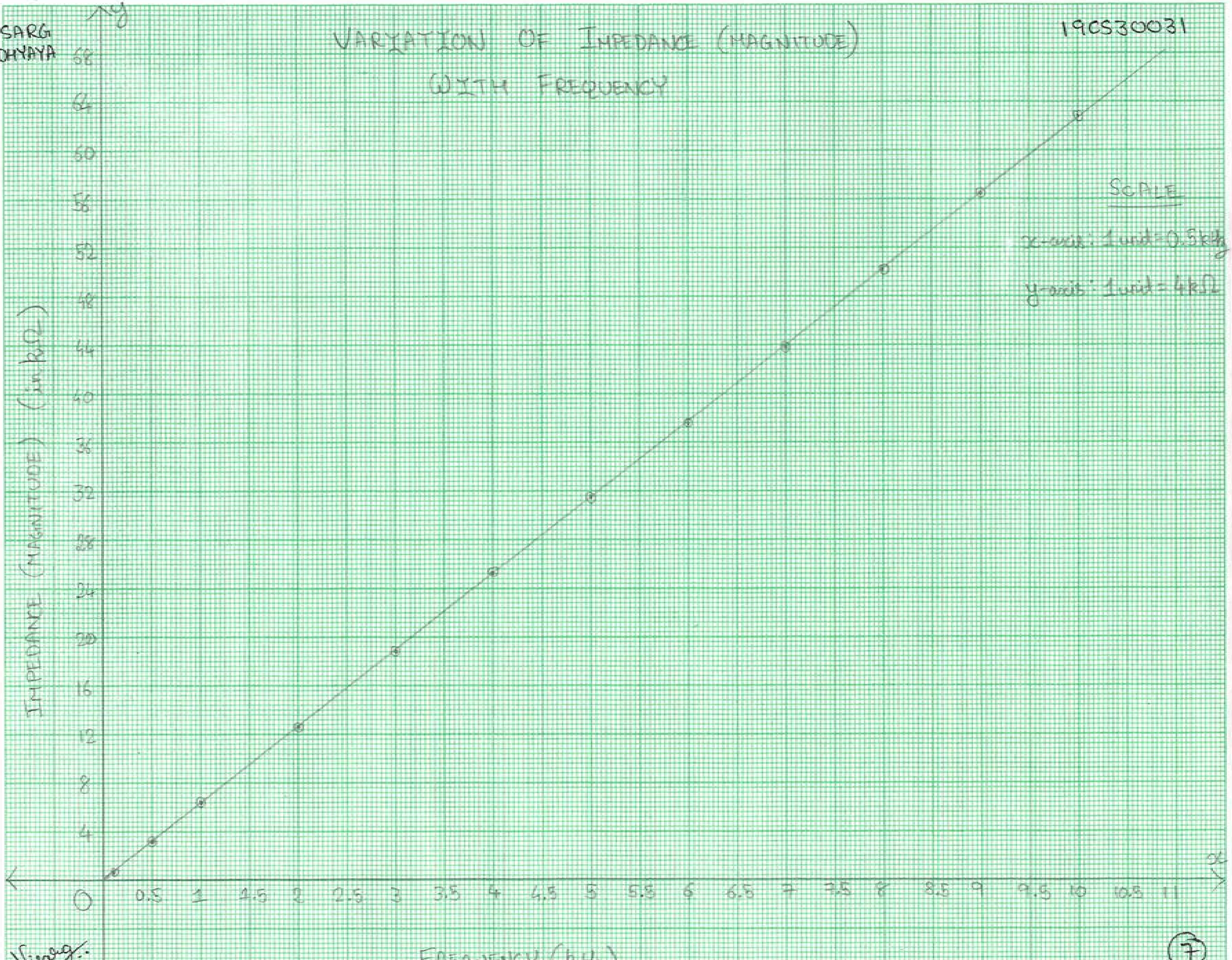

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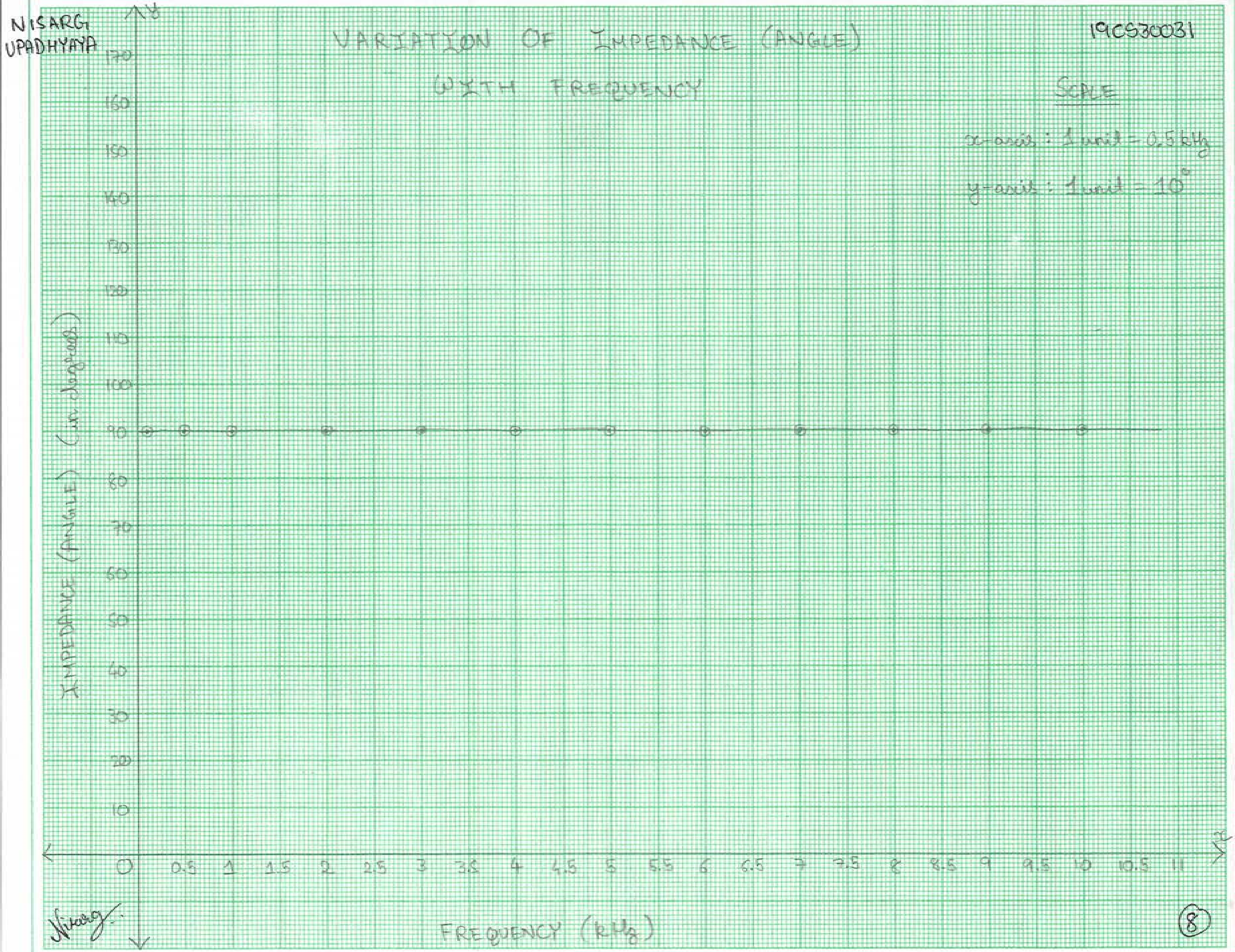
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VARIATION OF IMPEDANCE (ANGLE) WITH FREQUENCY
SCALE
x-axis : 1 unit = 0.5 kHz
y-axis : 1 unit = 10°
IMPEDANCE (ANGLE) (in degrees)
FREQUENCY (kHz)
y
x
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
10.5
11
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8

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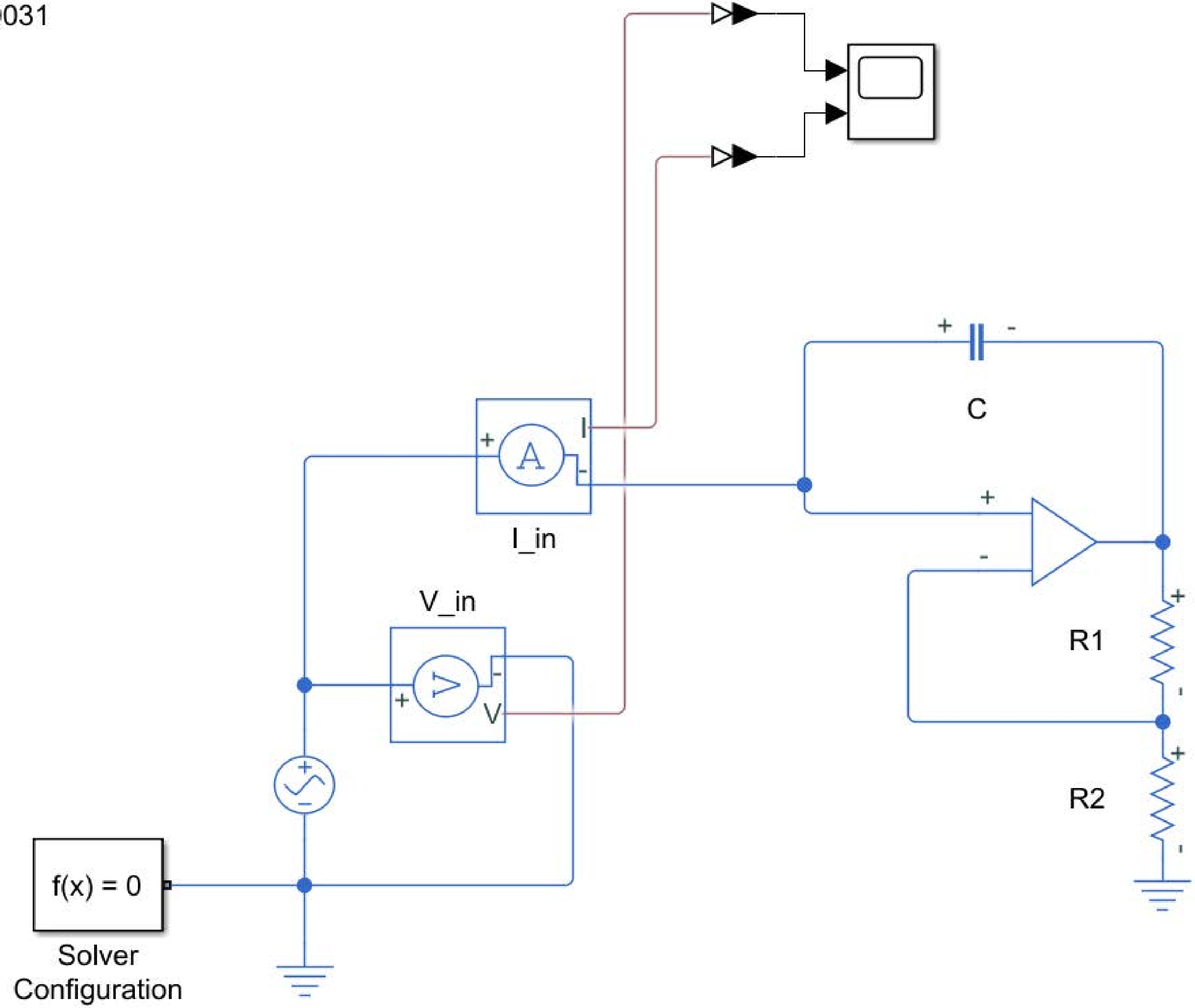

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