Experiment No.: 7

Applications of OP-AMP

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Aim: To study various applications of operational amplifiers.

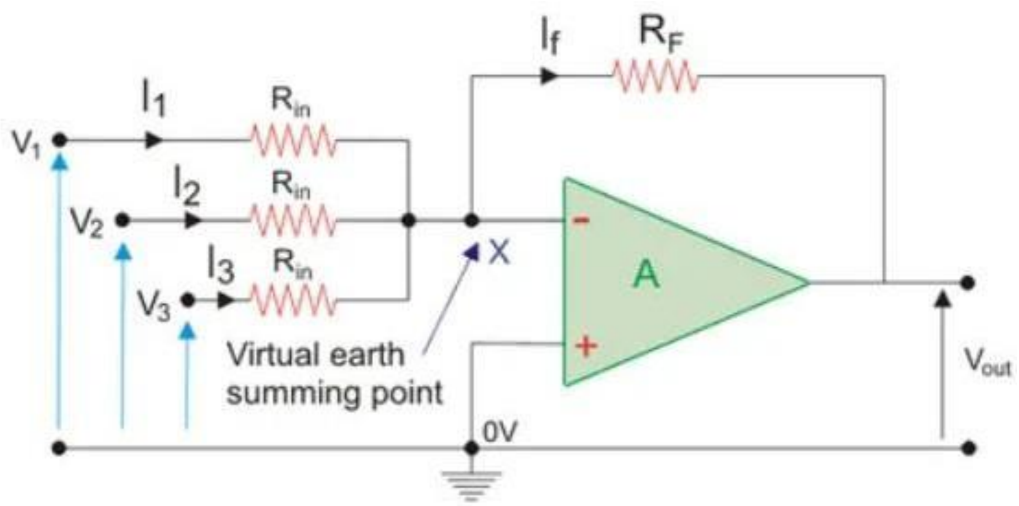
SOFTWARE TOOLS / OTHER REQUIREMENTS:

Multisim Simulator/Circuit Simulator

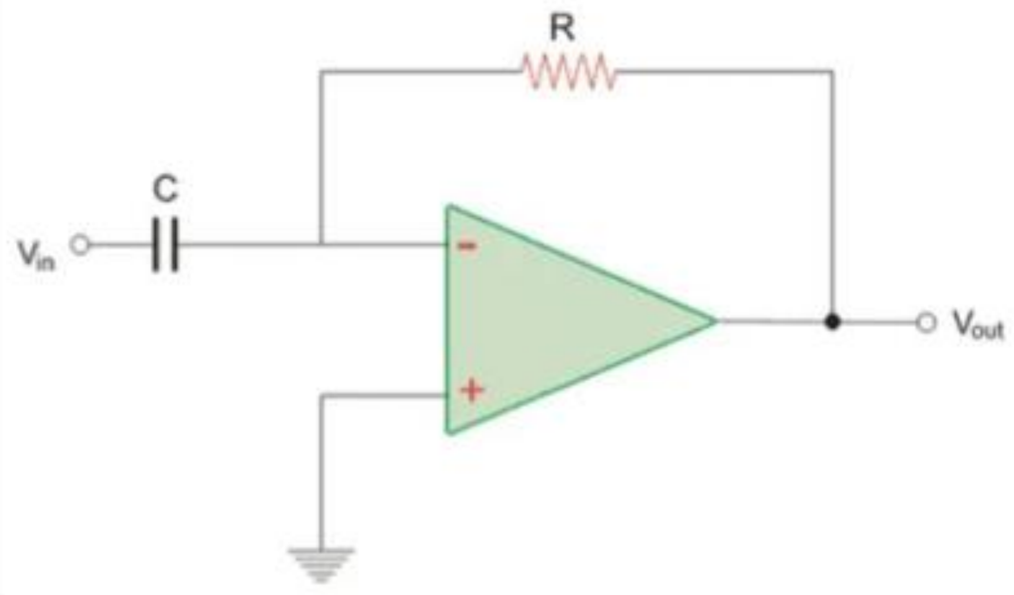
Theory:

OP-AMP Applications as Adder or Summing Amplifier:

Op-amp can be used to sum the input voltage of two or more sources into a single output voltage. Below is a circuit diagram depicting the application of an op-amp as an adder or summing amplifier. The input voltages are applied to the inverting terminal of the op-amp. The inverting terminal is grounded. The output voltage is proportional to the sum of the input voltages.



OP-AMP Application as a Differentiator:

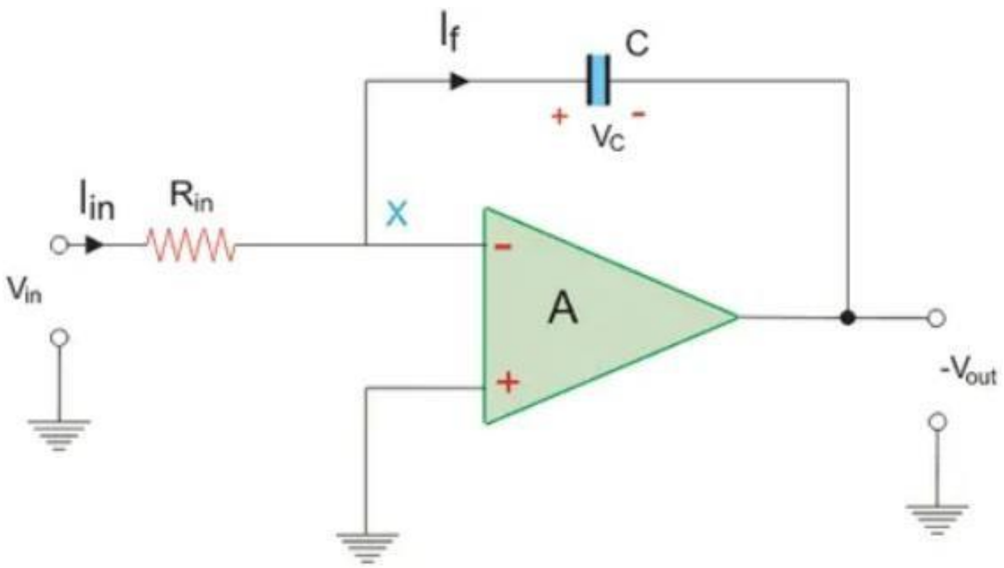


Op-amp can be used as a differentiator where the output is the first derivative of the input signal. The following equation gives the relation between the input signal and the output signal.

$$V_{OUT} = -R_F C \frac{dV_{IN}}{dt}$$

OP-AMP Application as an Integrator:

Op-amp is used as an integrator also. The integrator op-amp produces an output that is proportional to the amplitude of the input signal as well as the duration of the input signal. Instead of a resistor in the feedback loop, we have a capacitor. It is able to perform the mathematical operation of integration as the output varies with the input and duration of the signal.



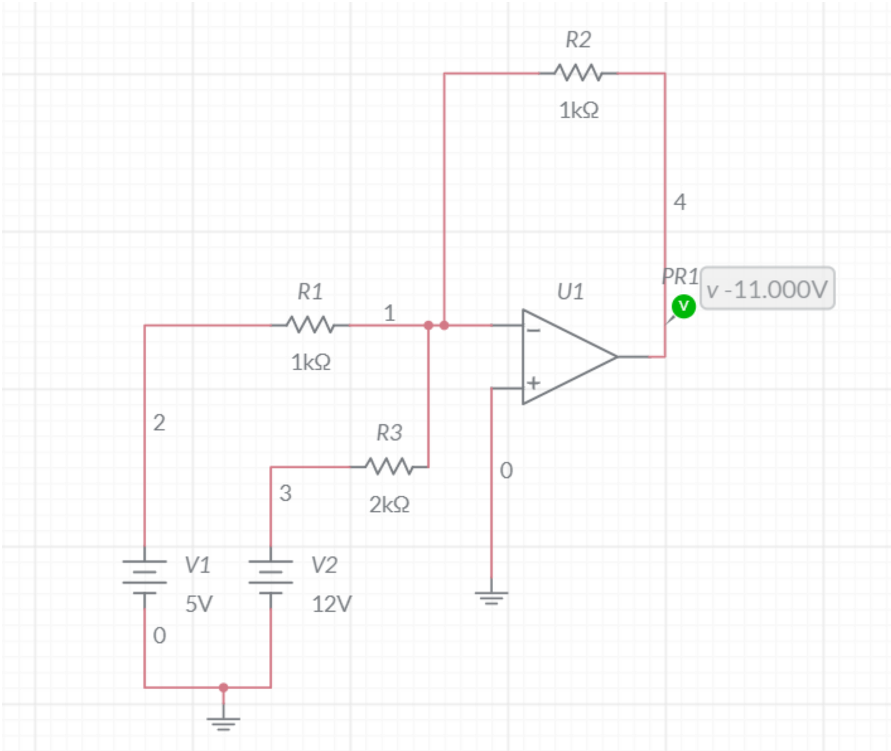
<u>OP-AMP Application as a Comparator:</u>

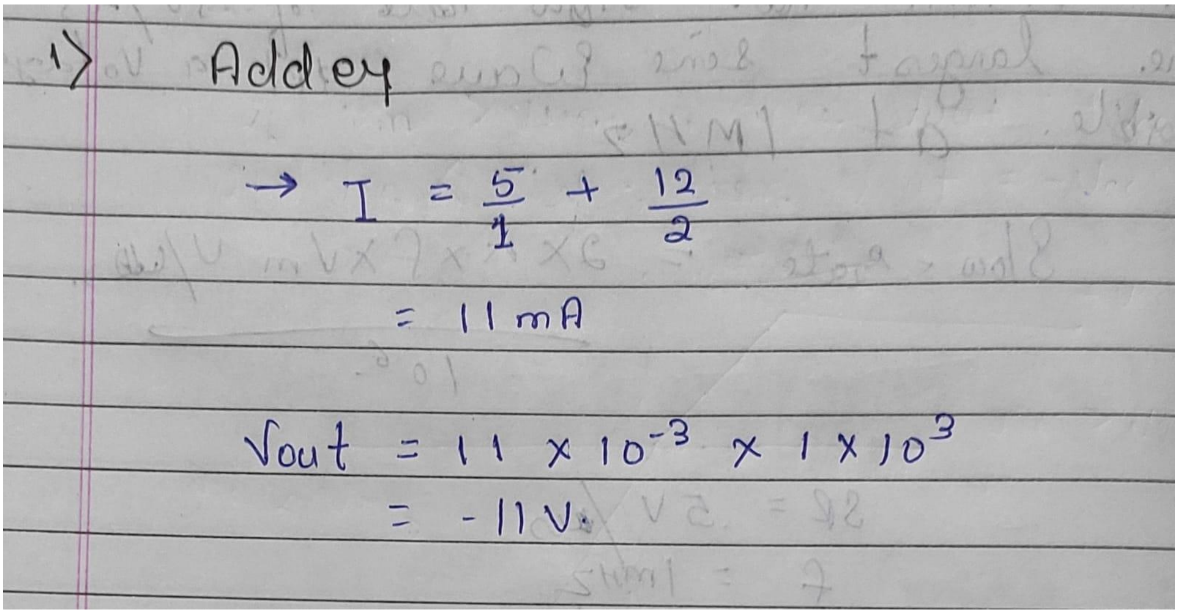
Operational amplifier compares the voltage applied at one input to the voltage applied at the other input. Any difference between the voltages ever if it is small drives the op-amp into saturation. When the voltages supplied to both the inputs are of the same magnitude and the same polarity, then the op-amp output is 0Volts.

A comparator produces limited output voltages which can easily interface with digital logic, even though compatibility needs to be verified.

CIRCUIT DIAGRAM (FROM MULTISIM)

<u>ADDER</u>





1) Adder

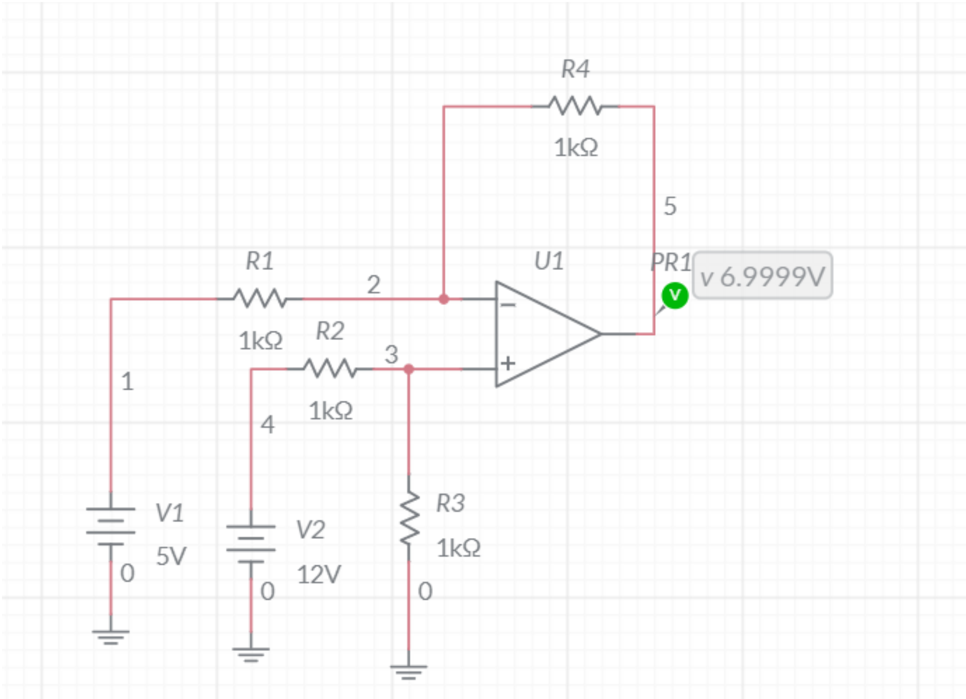
$$\rightarrow I = \frac{5}{1} + \frac{12}{2}$$

$$= 11\,mA$$

$$V_{out} = 11 \times 10^{-3} \times 1 \times 10^{3}$$

$$= -11\,V$$

SUBTRACTOR

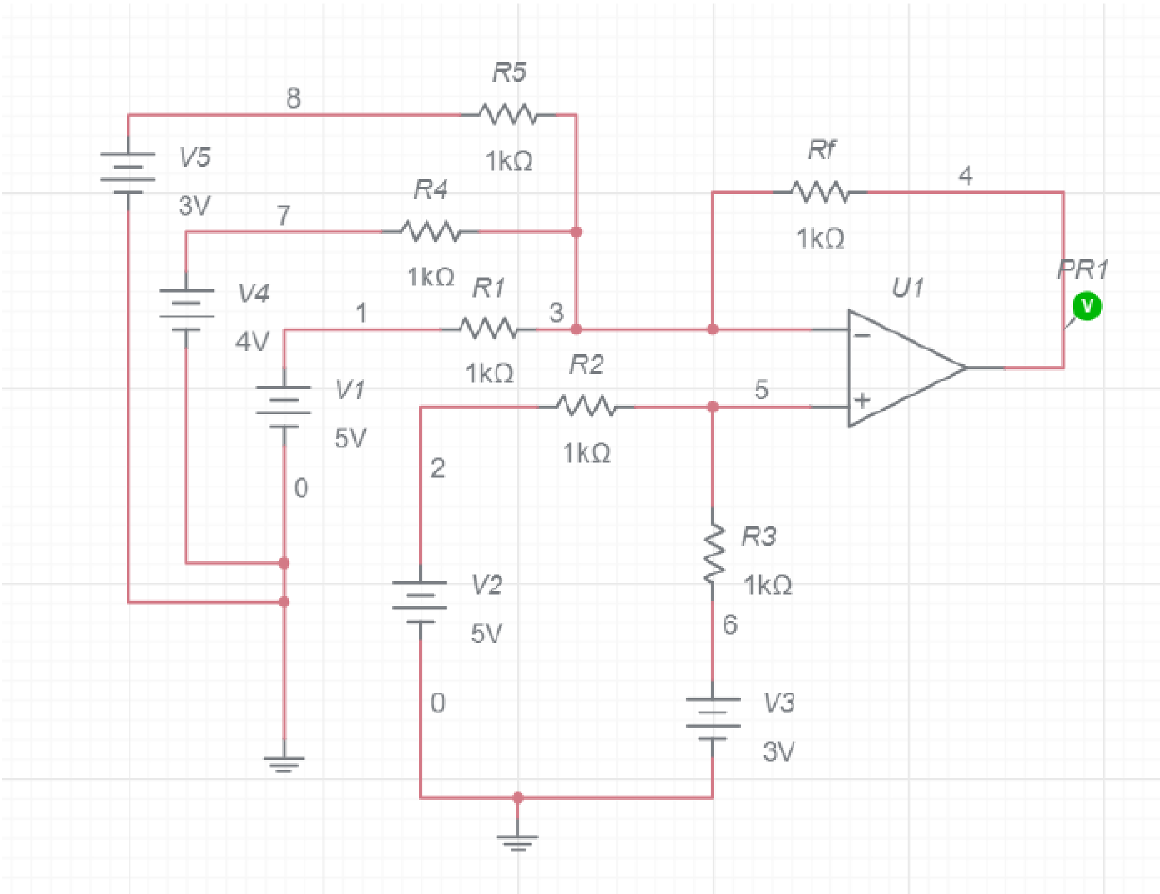


2) Subtractor

$$\frac{5-6}{1k\Omega} = \frac{6-V_{out}}{1k\Omega}$$

$V_{out} = 7V$

SUMMING AMPLIFIER



R5
8
1kΩ
V5
3V
Rf
4
1kΩ
R4
7
1kΩ
V4
4V
R1
1
3
1kΩ
U1
PR1
V
V1
5V
R2
5
1kΩ
2
0
R3
1kΩ
V2
5V
6
V3
3V
0

3) Summing Amplifier.

→ Take inverting terminal & non inverting ground. Vout 1, $= -R_f \left(\frac{V_1}{R_3} + \frac{V_1}{R_4} + \frac{V_3}{R_5} \right)$

$= -1 \left(5/1 + 4/1 + 3/1 \right)$

$= -12V$

Take non-inverting terminal & inverting ground

$V_{out\,2} = 12 + 4$

$= 16\,V$

Current through R, R_4 & R_5 = 4mA.

$I_{total} = 3 \times 4 = 12\,mA$

$12 = \frac{V_{out}\,2 - 4}{1}$

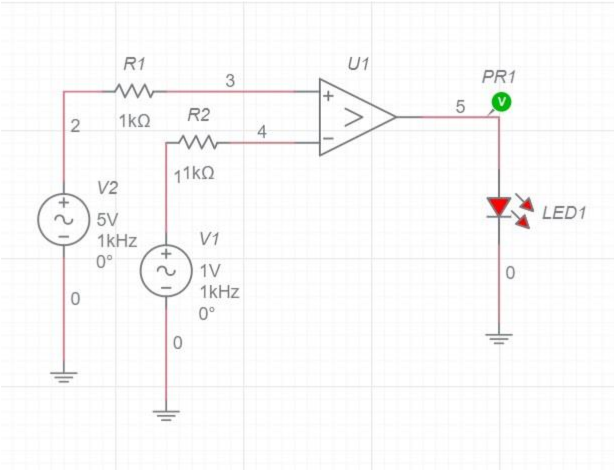
$V_{out}\,2 = 16V$

$V = V_{out}\,1 + V_{out}\,2$

$= (16 - 12)$

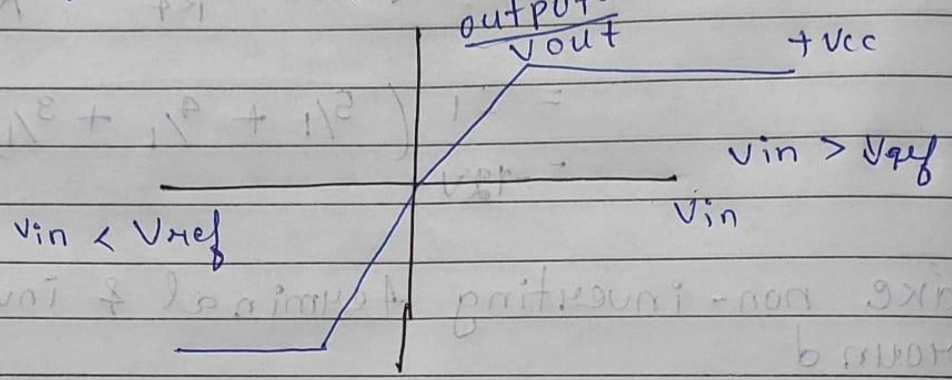
$= 4V$

COMPARATOR


R1
1kΩ
R2
1kΩ
U1
PR1
V2
5V
1kHz
0°
V1
1V
1kHz
0°
LED1
2
3
4
5
1
0
0
0

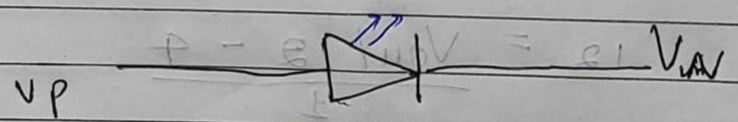
4) Comparator

If $V_{in} > V_{ref}$, then $V_{out} = +V_{cc}$
If $V_{in} < V_{ref}$, then $V_{out} = -V_{cc}$



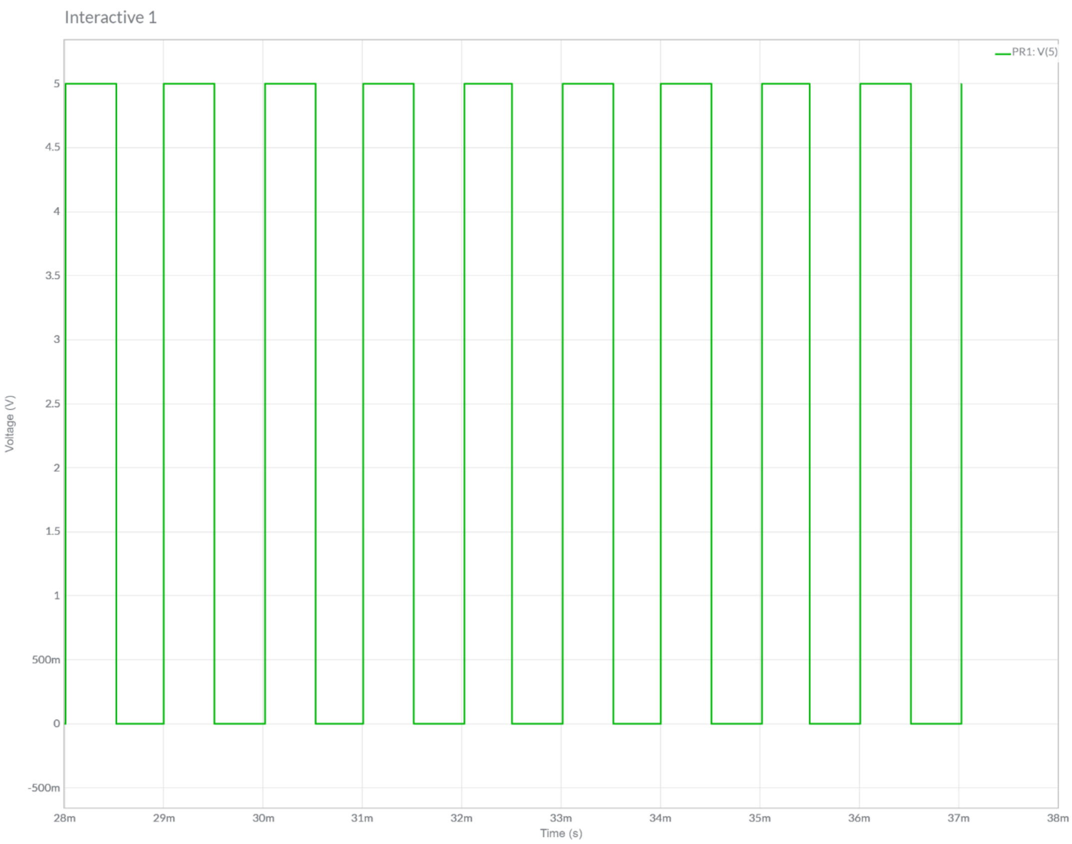
Sudden change from $-V_{cc}$ to $+V_{cc}$ is not allowed, that's why, we get linear region.

LED will glow only when it goes into forward biased region.

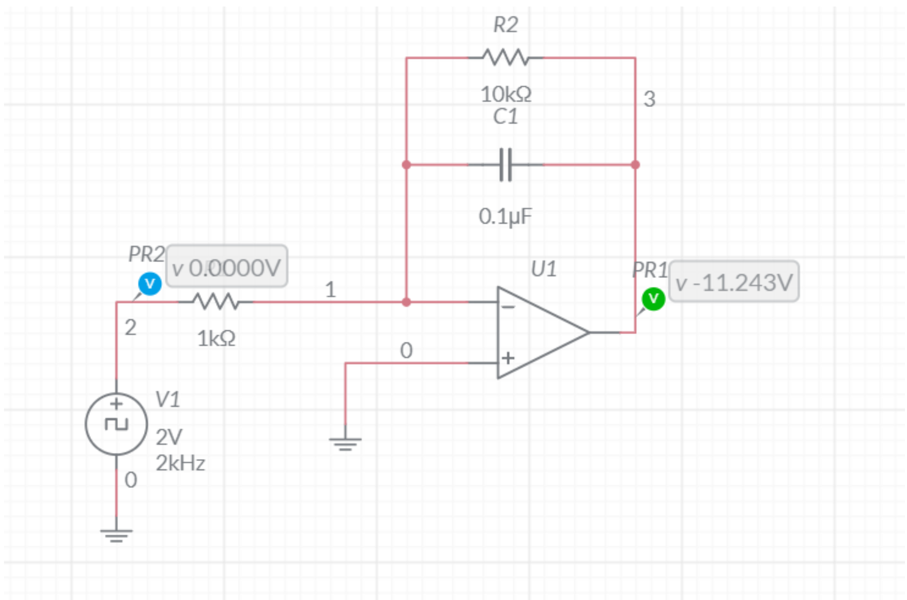


$V_P > V_N$ → LED glows.
(forward bias)

$V_P < V_N$ → LED does not glow
(reverse bias)



OP-AMP INTEGRATOR



5) Integrator.

~~Vou~~ $V_{out} = -\frac{1}{RC} \int V_{in}\, dt$

$$= \frac{1}{RC} \left[\int_0^{T/2} 4\, dt + \int_{T/2}^{T} 0\, dt \right]$$

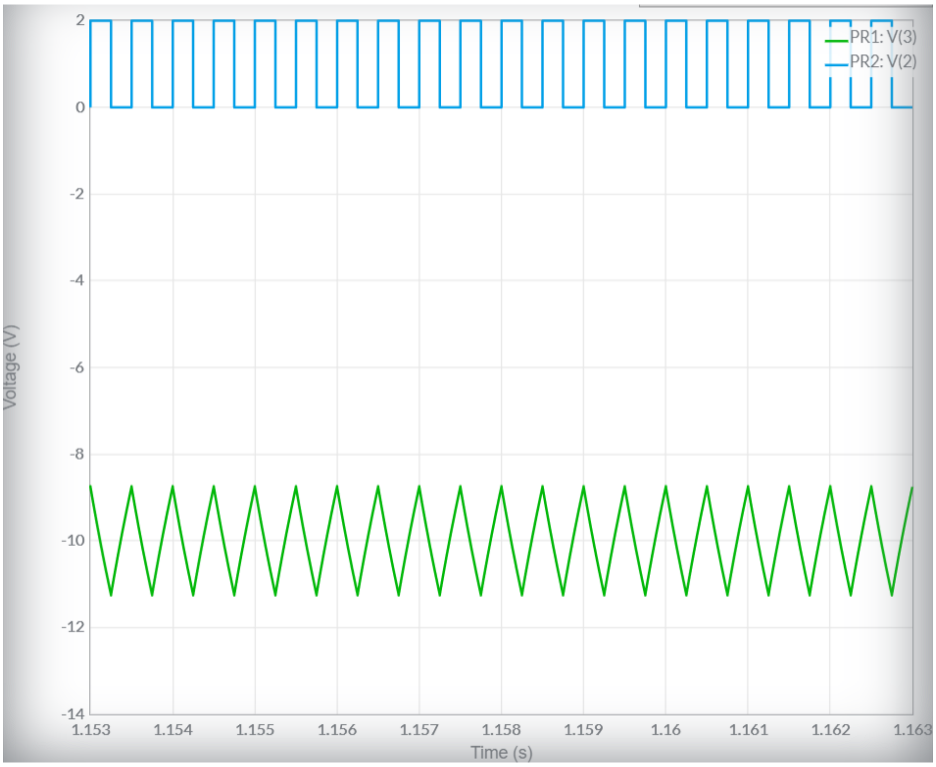
$$= -4/RC \times T/2$$

at ; $T = RC$

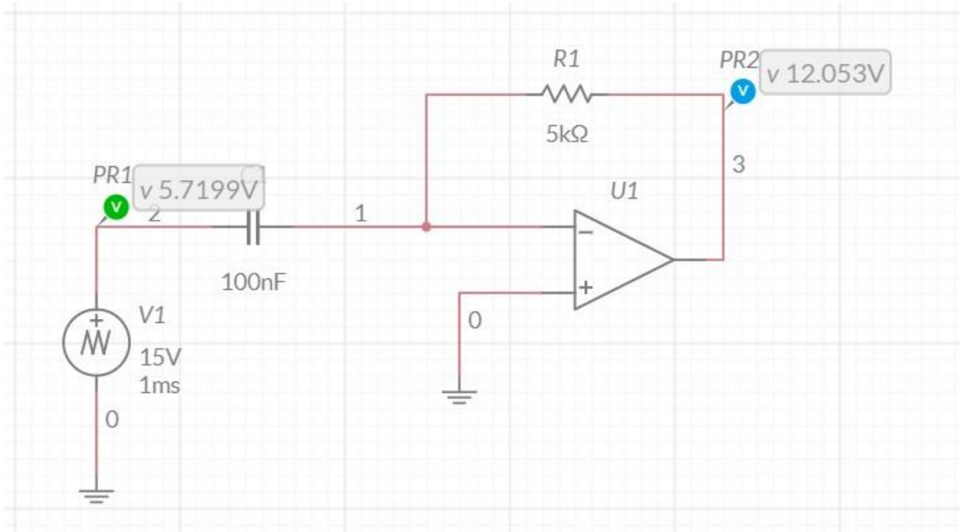
$V_{out} = -2V$

for (+)ve half cycle, slope is (-ve) & vice-versa.

GRAPH



OP-AMP DIFFERENTIATOR



6) Differentiator.

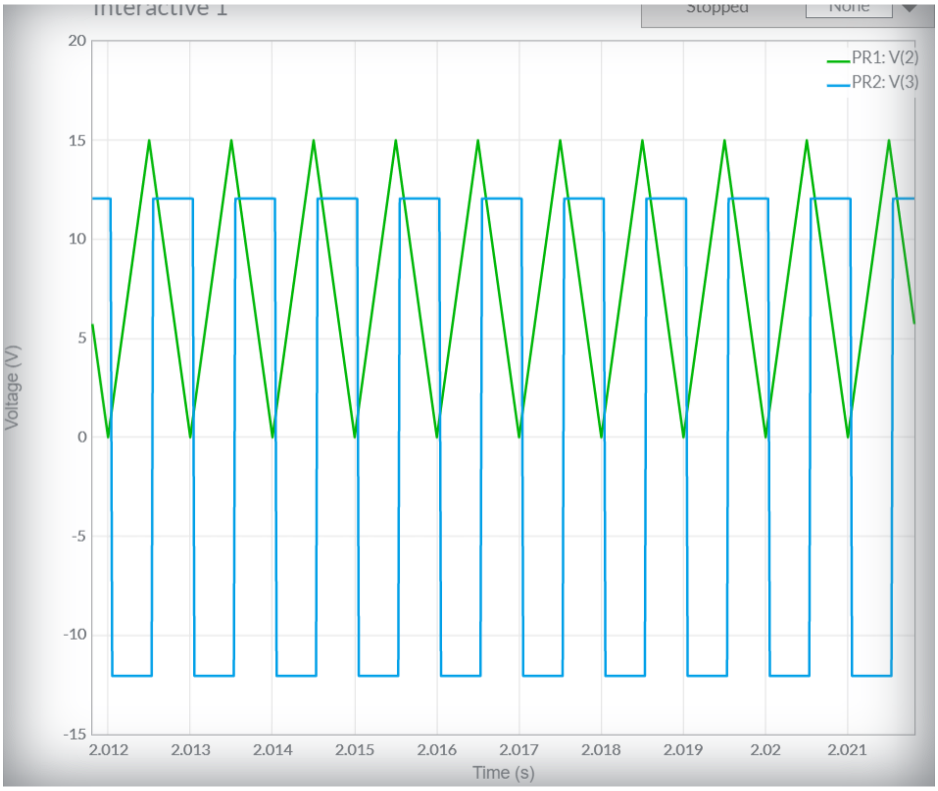
$$I = C \cdot d/dt \, (V_{in})$$

$$I = \frac{0 - V_{out}}{R_f}.$$

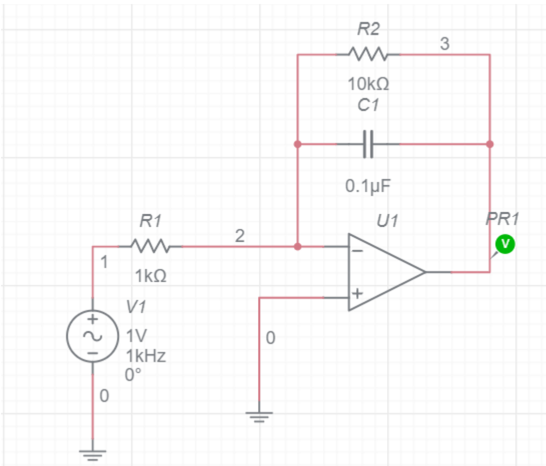
$$\frac{-V_{out}}{R_f} = \frac{C d \, (V_{in})}{dt}$$

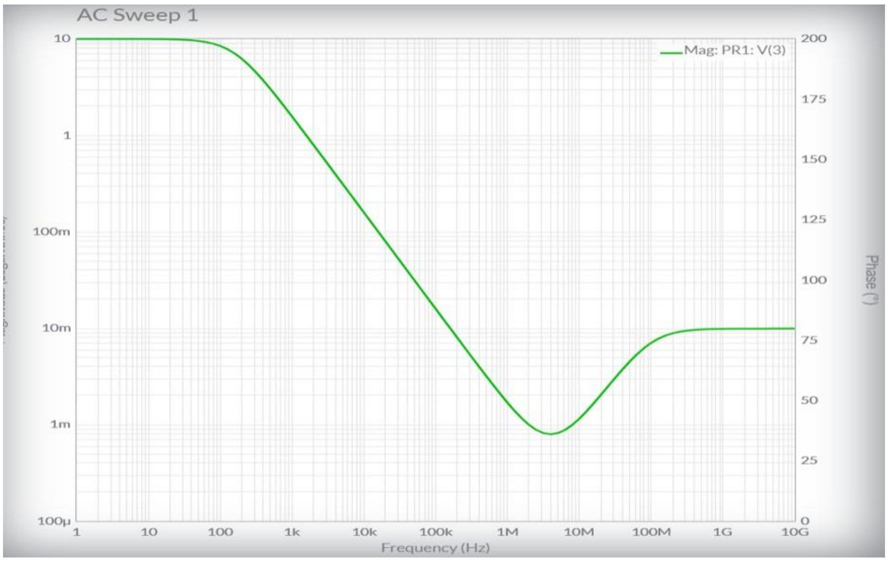
$$\underbrace{V_0 = -R_f \, C \cdot \frac{d (V_{in})}{dt}}_{\text{diff of input voltage}}$$

GRAPH

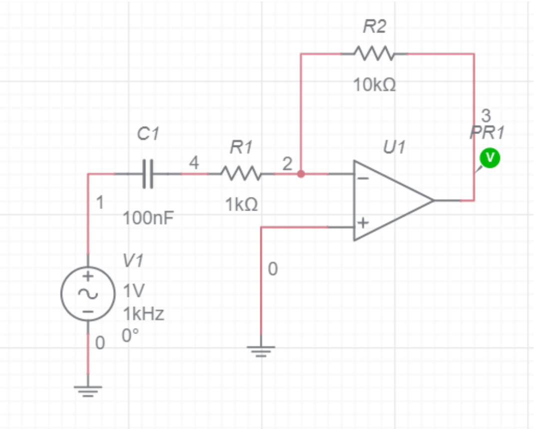


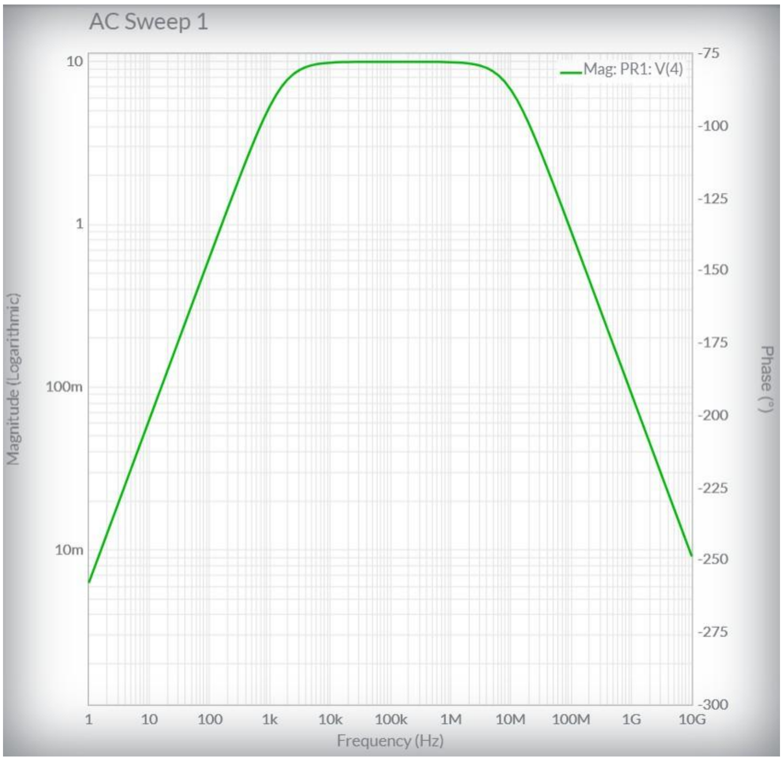
FREQUENCY RESPONSE OF INTEGRATOR





FREQUENCY RESPONSE OF DIFFERENTIATOR





Conclusion

THROUGH THIS EXPERIMENT, WE OBSERVED AND VERIFIED VARIOUS APPLICATIONS OF OPERATIONAL AMPLIFIERS.
IT CAN BE USED AS ADDER, SUBTRACTOR, SUMMING AMPLIFIER, COMPARATOR, INTEGRATOR, DIFFERENTIATOR AND MANY MORE APPLICATIONS.