Department

Of electrical and computer

Engineering

ENEE2103

CIRCUITS AND ELECTRONICS LABORATORY

Experiment No.10 Report

Report#2

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Abstract

The aim of the experiment is to show how some of the Operational Amplifier Applications works and how to implement the circuits to use them, it shows the adding, voltage follower, comparator, integrator, differentiator, the effect of adding hysteresis and active clipping.

Components used for the experiment:

- DC and AC Voltage sources
- Circuit board
- Op Amp
- Resistors: 100k,10k, 220, 220k, 50k, 500k.
- Potentiometer 10k
- Capacitors 1uF
- Diode and zener diode

Contents

List of figures and tables

Figures:

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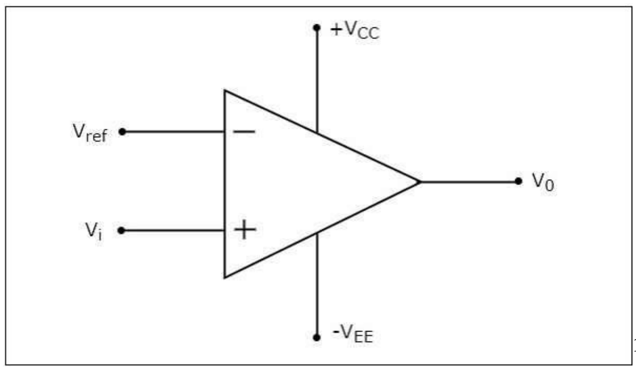
Theory

The theoretical part of the circuits built in this experiment in going to be explained in this part of the report.

There are three main configurations of the op amp connections depending on the feedback on the op amp, the main configurations are:

Without feedback

The only circuit in the experiment connected without feedback is the **comparator Application** circuit.



[1]

Figure 1. 1 Comparator Circuit

In the circuits shown above, the Vo could be one of three values:

- Vo=+Vsat; Vi < Vref
- Vo=0; Vi = Vref
- V=-Vsat; Vi > Vref

In the experiment an AC voltage is applied on the positive input of the op amp, in that case Vo is a signal.

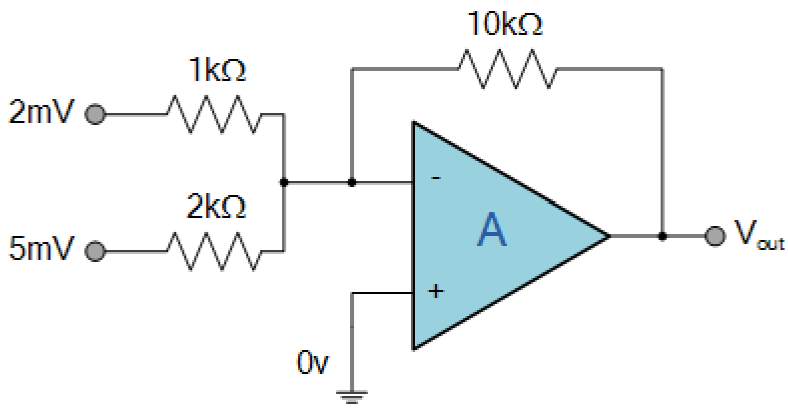
Negative feedback

In this configuration, five applications are shown in the experiment.

The five applications are:

[1] https://www.tutorialspoint.com/linear_integrated_circuits_applications/linear_integrated_circuits_applications_comparators.htm

1. Adding Application
   In this application, two voltages are applied to the negative input of the op amp, each connected with a resistor that controls the weight of the voltage and a resistor called Rref is connected between the output and the negative input of the op amp.



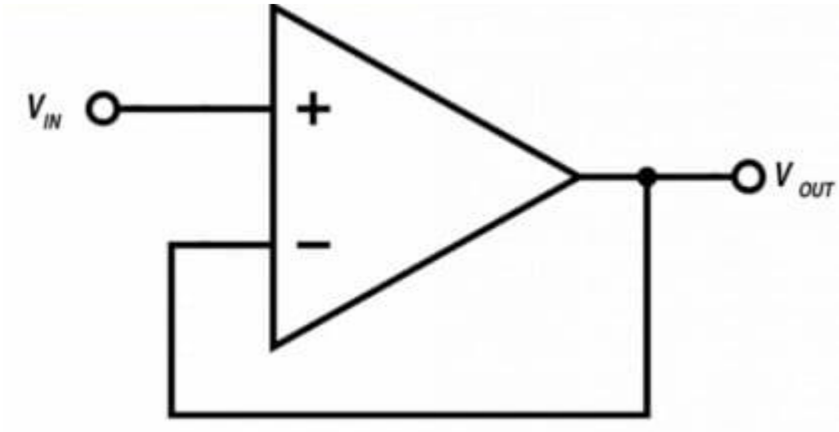
[2]

Figure 1. 2 Adding circuit

In this circuit:

Vout= -Rref*((V1/R1) + (V2/R2))

2. Voltage follower
   In this application, a voltage is applied to the positive terminal of the op amp and the output is connected to the negative input of the op amp.



[3]

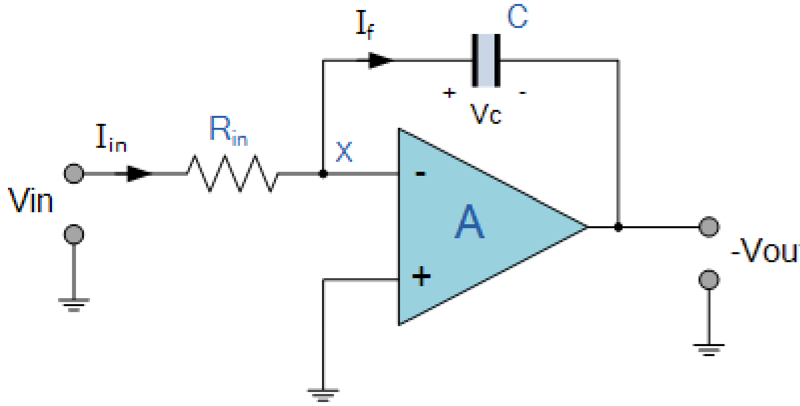
Figure 1. 3 Voltage follower Circuit

[2] https://www.electronics-tutorials.ws/opamp/opamp_4.html

[3] https://www.allaboutcircuits.com/video-tutorials/op-amp-applications-voltage-follower/

This circuit is essentialy a buffer so Vo=Vin but it isolates the input from the output

3. Integrator
   In this application, a voltage source is applied to the negative input of the op amp and the output is connected to the negative input via a capacitor.

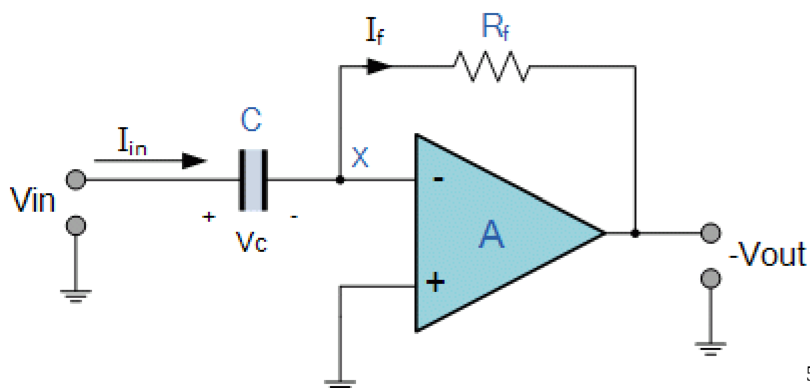


[4]

Figure 1. 4 Integrator circuit

Vo= (1/RC)*(Vin dt)

4. Differentiator
   In this application, a voltage source is connected to the negative input of the op amp via a capacitor and the output is connected to the negative input via a resistor called Rref



[5]

Figure 1. 5 Differentiator circuit

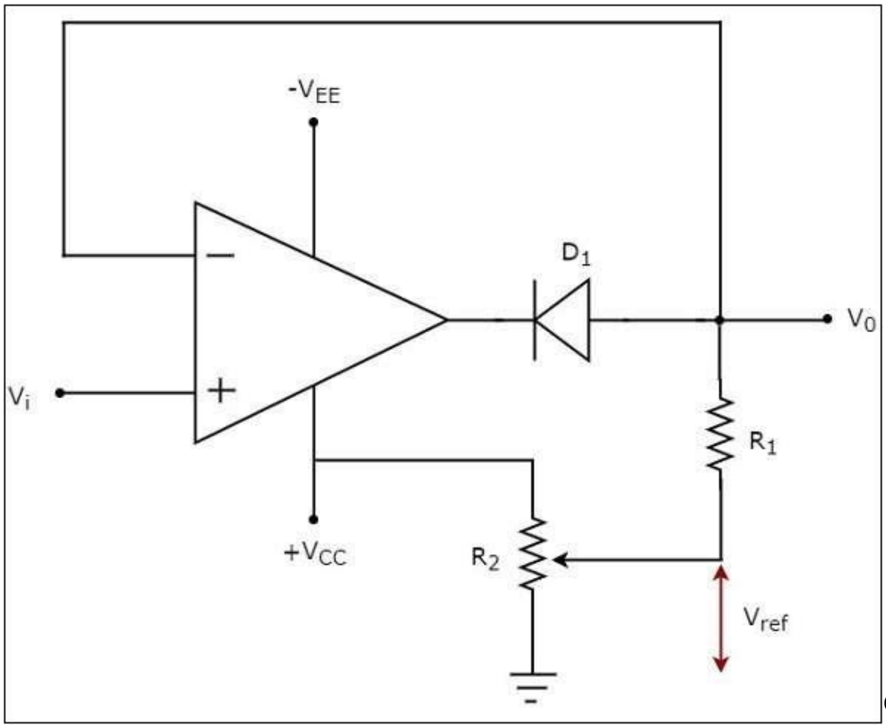
Vout= -Rref*C*(dVin/dt)

5. Active Clipping

[4] https://www.electronics-tutorials.ws/opamp/opamp_6.html

[5] https://www.electronics-tutorials.ws/opamp/opamp_7.html

In this application, a voltage source is applied to the positive input of the op amp and the output is connected to the negative input of the op amp via a diode.



[6]

Figure 1. 6 Active Clipping cercuit

Vout is clipped at certain outputs.

Positive feedback

In this configuration, only one application is shown in the experiment and it's the effect of adding hysteresis.

In this application, a voltage source is applied to the negative input of the op amp and a voltage source is applied to the positive one with a feedback to the positive input.

Vo= Vsat in a certain range of Vin

Vo= -Vsat in the remaining range of Vin

6 https://www.tutorialspoint.com/linear_integrated_circuits_applications/linear_integrated_circuits_applications_clippers.htm

Procedure and data analysis

In the following experiment, seven circuits are going to be connected each shows how the op amp works.

I. Adding Application

1. The circuit in figure 2.1 should be connected. The potentiometer will control V1 and V2 will be controlled by the variable DC power supply.

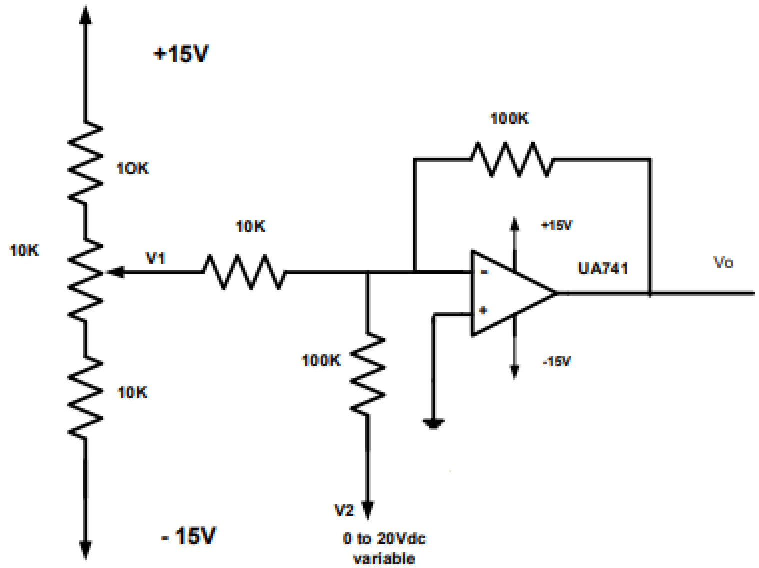


Figure 2. 1 Adding application Circuit

2. The output voltage Vo will be measured by the DC voltmeter for V1 and V2 shown in the table 1.1

Input voltage		Output voltage	
V1	**V2**	**V0**	**Calculated voltage**
0.5	**2**	-7.1	-7
0.1	**6**	-7.25	-7
0.3	**4**	-6.95	-7
-0.9	**2**	6.8	7
-1.1	**4**	7.03	7
-1.5	**6**	8.88	9

Table 1. 1 Adding Application Vo VS V1,V2

3. The output voltage should be calculated for each entry of the table using the formula: Vout= -Rref*((V1/R1) + (V2/R2))

II. Voltage Follower Application

1. The circuit should be connected as shown in figure 2.2

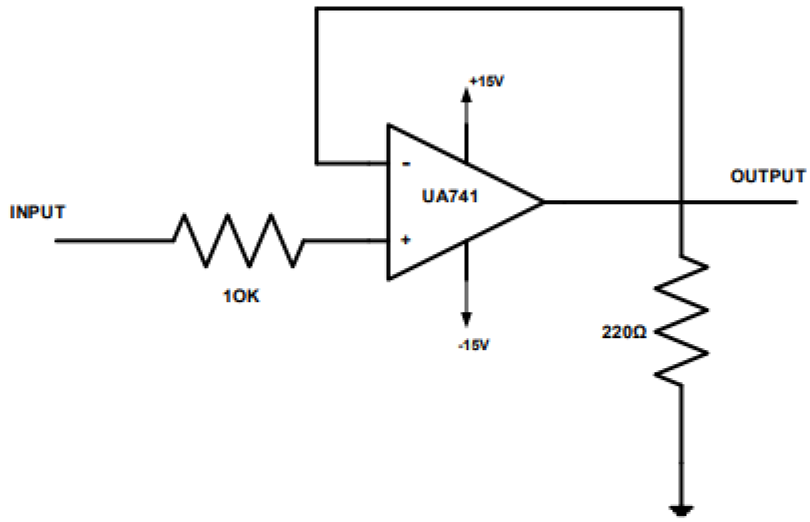


Figure 2. 2 Voltage Follower Application Circuit

2. Vo(t) should be measured on the oscilloscope for Vi(t) = 2V p-p sinusoidal with 100Hz which can be obtained from the AC Voltage supply

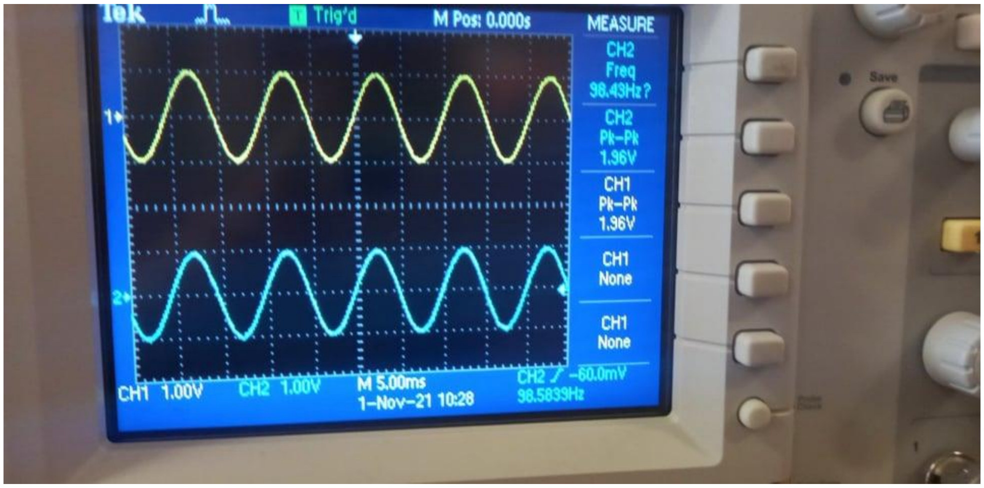


Figure 2. 3 Voltage Follower Vo(t)

3. Vo should be measured and recorded for DC Vi in table 1.2

Vi	**Vo**
2	2
4	4.05
6	6.01
7	6.27

Table 1. 2 Voltage follower Vi vs Vo for 220Ω

4. Vo should be measured and recorded for DC Vi in table 1.3 after RL is changed from 220Ω to 1kΩ

Vi	**Vo**
6	6.08
8	7.9
10	10.04
12	12.01
15	12.96

Table 1. 3 Voltage follower Vi vs Vo for 220Ω

Question:

- Is this circuit has similar properties as the emitter follower. Explain ?
  No its not, the Voltage follower doesn't provide any amplification to the voltage while the emitter follower does

- For what applications is this circuit used?
  As a buffer to isolate circuit A from circuit B
- What is the relation between your Vi, Vo?
  Vo= Vi; Vi < Vsat
  Vo= Vsat; Vi >= Vsat
- What the approximate value of maximum output current of the op-amp?
  Imax= 6.27/220= 28.5mA

III. Comparator Application

1. The circuit should be connected as shown in figure 2.4

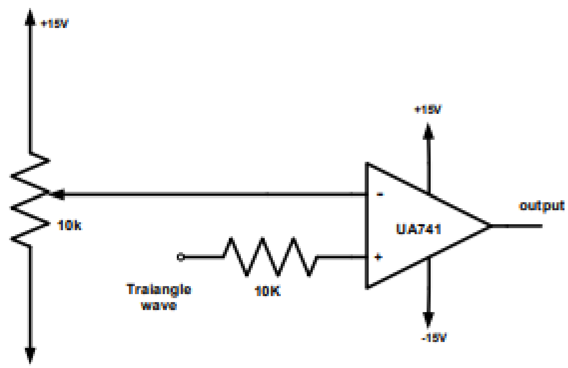


Figure 2. 4 Comparator Application circuit

2. Connect a Vin(t) of 1kHz triangular signal from the function generator
3. The input signal should be set to 2 Vp-p and the DC reference voltage should be changed so that the Vo(t) be positive Vsat then negative Vsat and a square wave
4. the output voltage should be on the oscilloscope

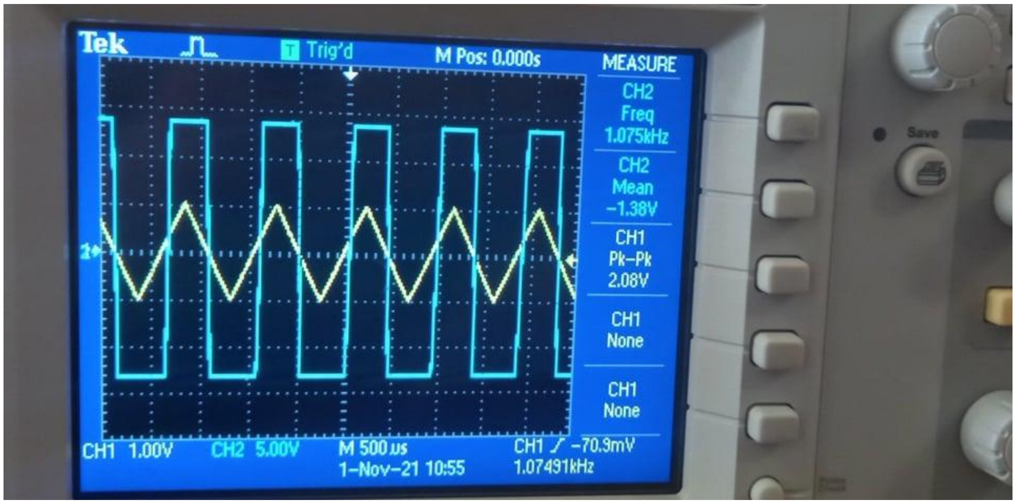


Figure 2. 5 Comparator Application square wave output

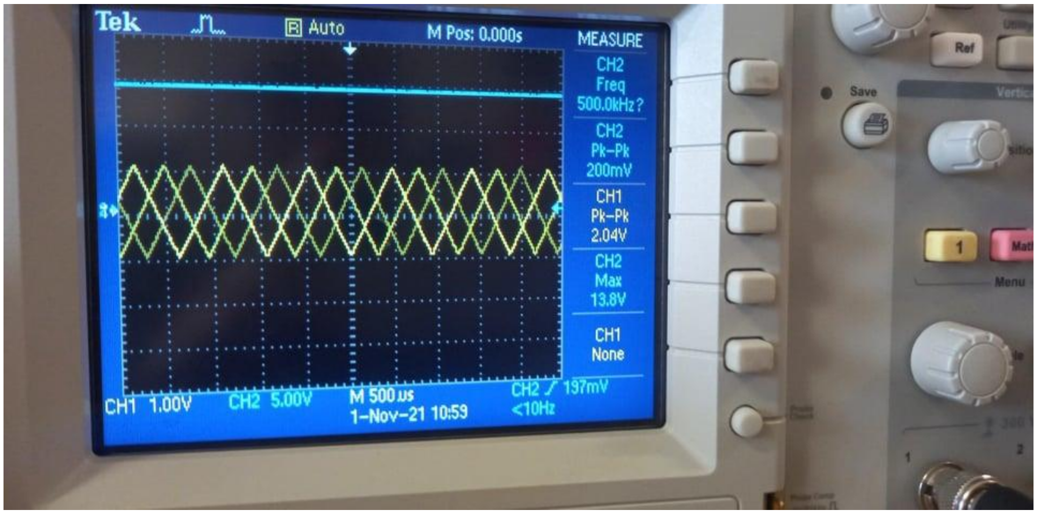


Figure 2. 6 Comparator Application square wave output

Question:

5. What happens to the amplifier output?. For what application is this circuit used?
   The ouput of the amplifier is:
   Vo= V+sat; if Vi1>Vi2
   Vo= 0; if Vi1=Vi2
   Vo= V-sat; if Vi1<Vi2
   This Application can be used for 1-bit digital comparator and in analog to digital converters

6. Is there any similarity between this circuit and the diff amplifier, what is the shape of the output?

The diff amplifier can give the diffirence of two voltages but the comparator can only give +Vsat or -Vsat

IV. Integrator and Differentiator

A. Integrator

1. the circuit should be connected as shown in figure 2.7

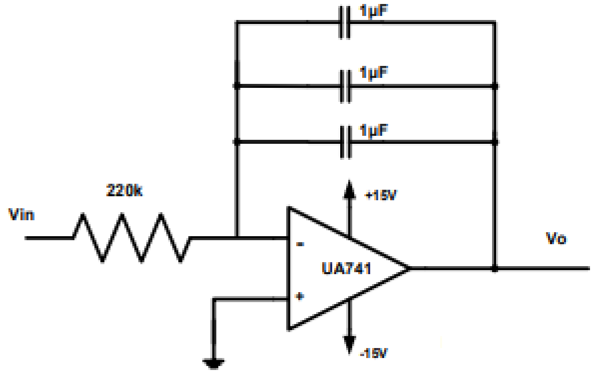


Figure 2. 7 Integrator Application Circuit

2. an input signal with 2p-p and frequency of 30Hz from the function generator and dawn from the oscilloscope
3. the output should be drawn for input of:
   - sin wave

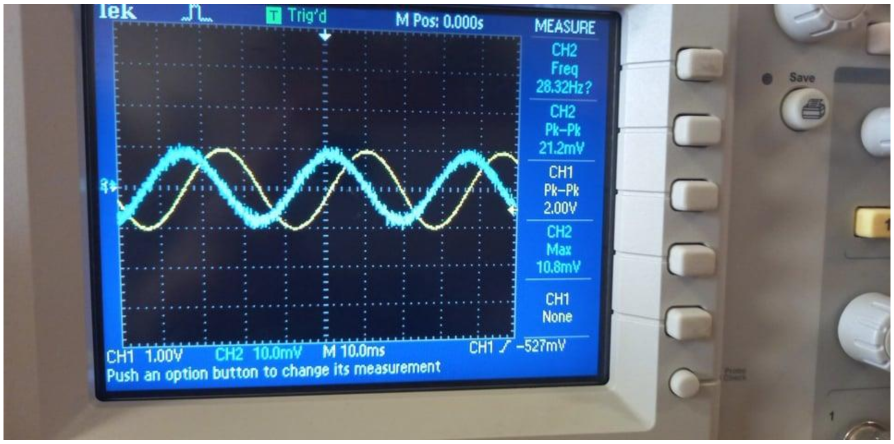


Figure 2. 8 Integrator Application sin wave

   - triangular wave

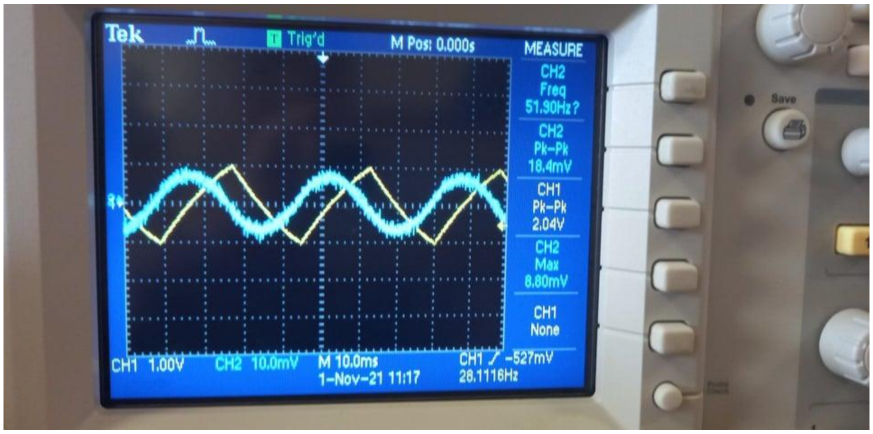


Figure 2. 9 Integrator Application triangular wave

- square wave

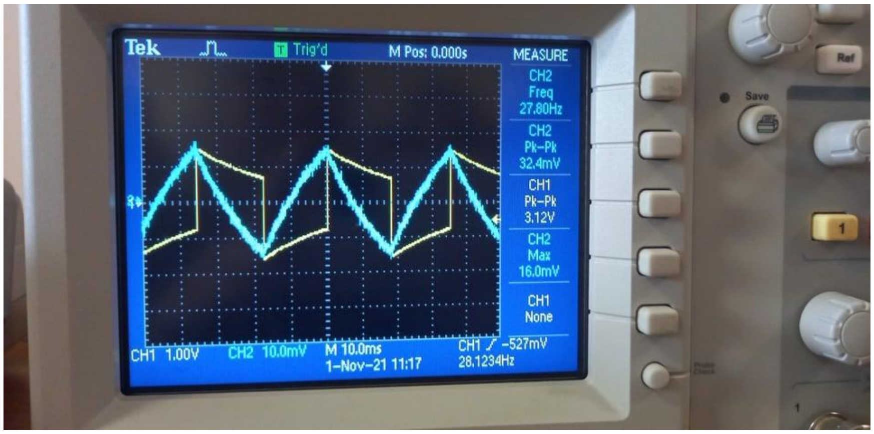


Figure 2. 10 Integrator Application square wave

B. Differentialtor:

1. the circuit should be connected as shown in figure 2.11

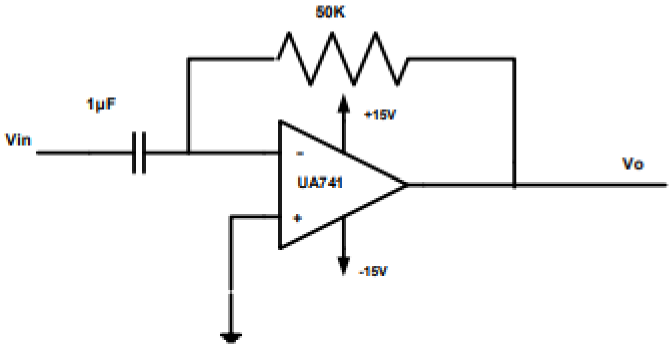


Figure 2. 11 Differentiator Application Circuit

2. an input signal with 2p-p and frequency of 30Hz from the function generator and dawn from the oscilloscope

3. the output should be drawn for input of:

- sin wave

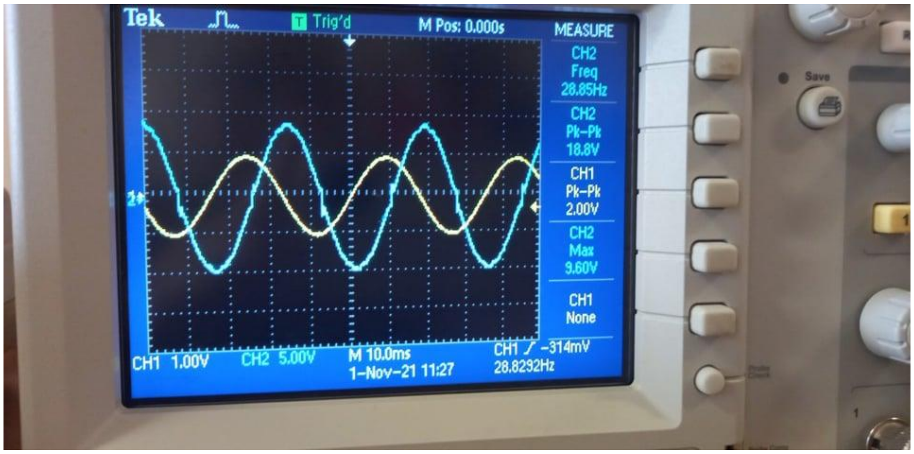


Figure 2. 12 Differentiator Application sin wave

- triangular wave

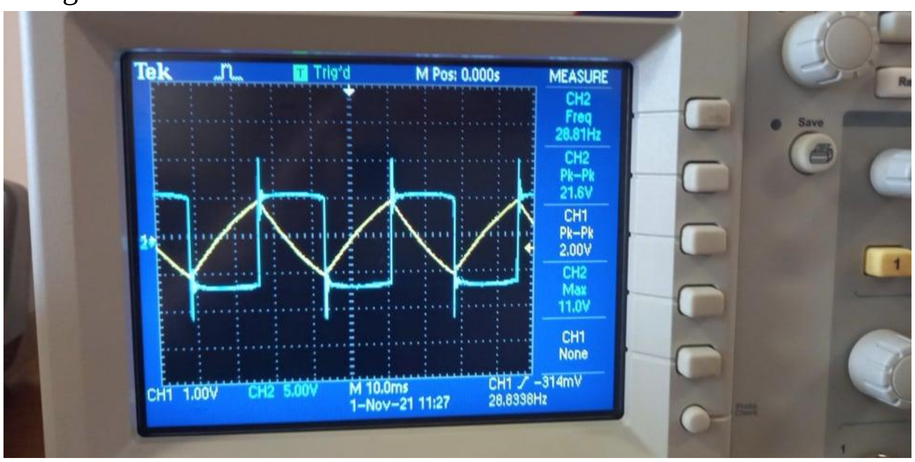


Figure 2. 13 Differentiator Application triangular wave

- square wave

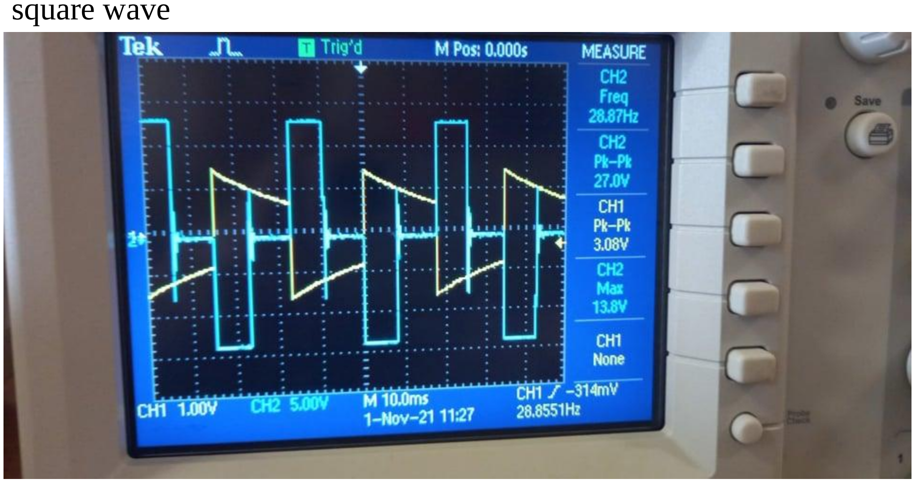


Figure 2. 14 Differentiator Application square wave

Question:

- Is the output realize the differentiation and integration theory?
  Yes it does,

V. To investigate the effect of adding hysteresis

1. The circuit should be connected as shown in figure 2.15

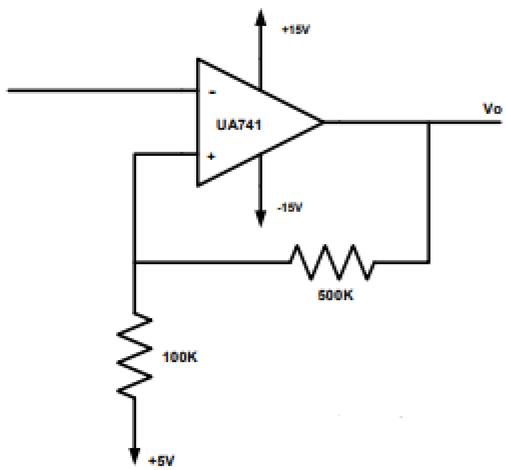


Figure 2. 15 Adding Hysteresis Circuit

2. Vi(t) should be generated from the function generator with a 15Vp-p and frequency of 1kHz
3. Vo(t) should be shown on the oscilloscope
4. The change of Vo(t) level should be indicated on the oscilloscope for Vi(t)

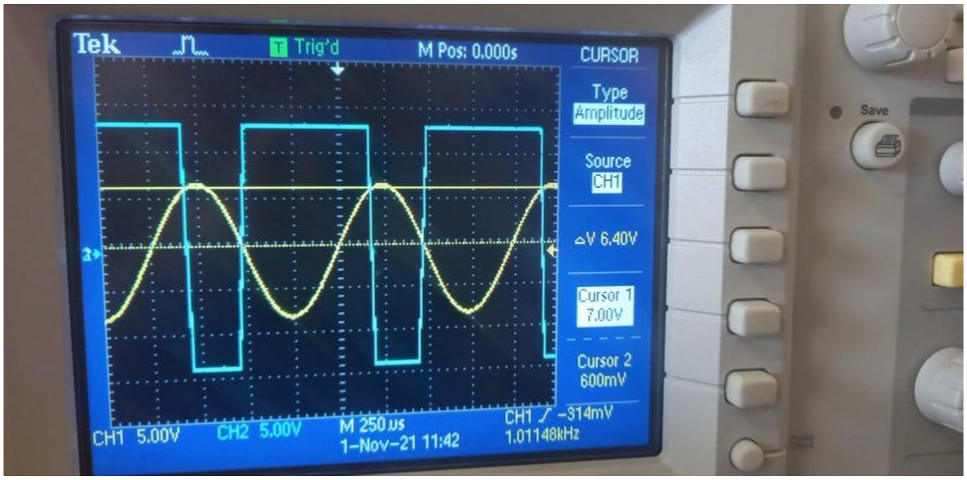


Figure 2. 16 Adding hysteresis Vo

VI. Active Clipping Circuit

1. The circuit should be connected as shown in figure 2.17

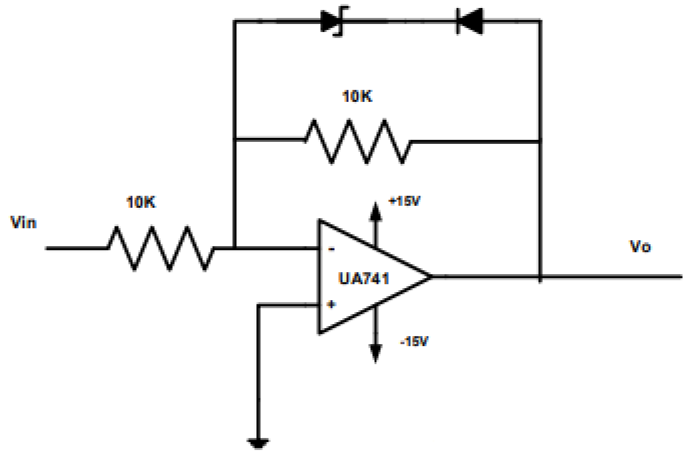


Figure 2. 17 Active Clipping Circuit

2. Vi(t) should be taken from the function generator with frequency of 1kHz
3. The Vi(t) amplitude should be changed until Vo(t) is clipped and record it

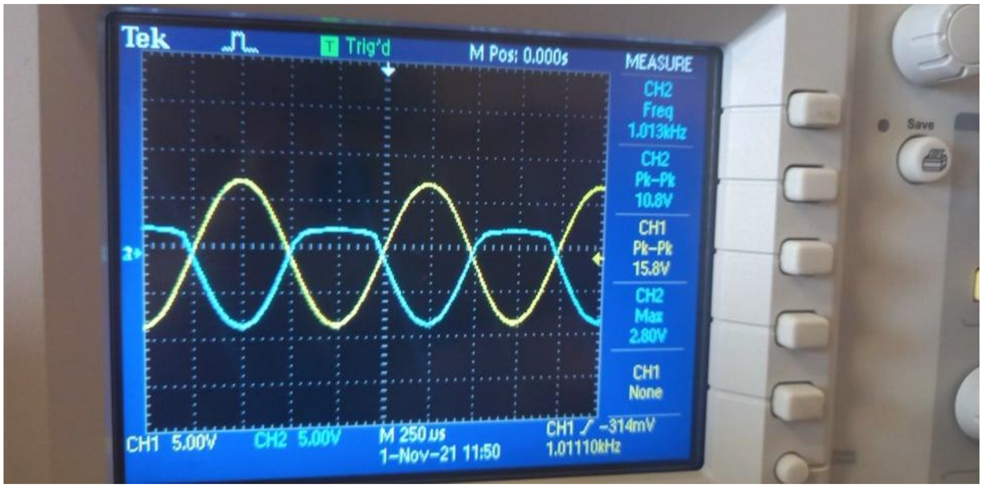


Figure 2. 18 Active Clipping with Vo positive clipped

4. The diodes should be reversed
5. The V(t) amplitude should be changed until Vo(t) is clipped and record it

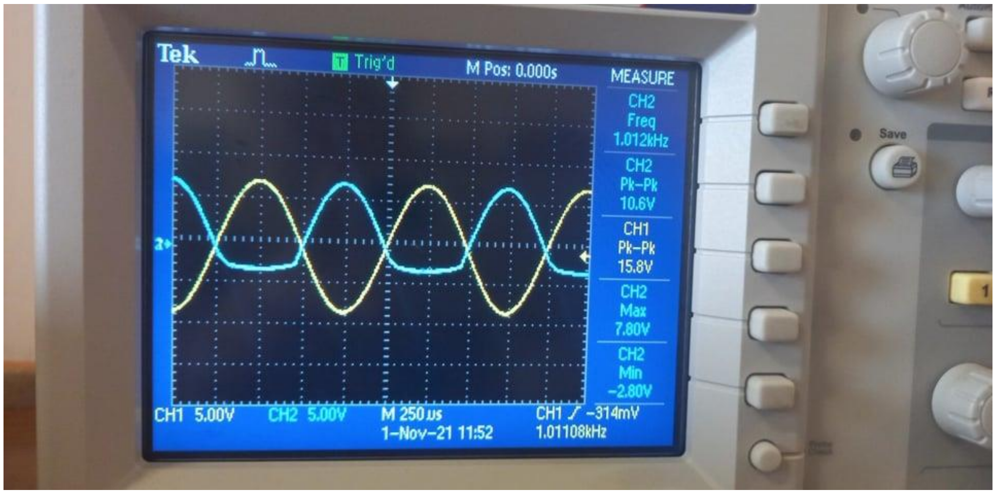


Figure 2. 19 Active Clipping with Vo negative clipped

Conclusion

The experiment showed how much the Operational amplifiers are powerfull, an how it can be used to perform certain mathematical and electrical functions, like adding, comparing, integral and differentiate Voltages, and also how to isolate circuits from others.

This also showed why the op amps where used in creating the early computers.

References

Theory:

https://www.tutorialspoint.com/

https://www.electronics-tutorials.ws/

https://www.allaboutcircuits.com/

Procedure:

Only the manual of the circuits and electronics lab from birzeit university was used