# PROJECT

**Course Title:** Electrical Circuits

**Course Code:** CSE-251

**Project Name:** Second order homogeneous Ordinary Differential Equation (with constant coefficient) solver

## Submitted By


Name: Sabbir Hossain Abir

ID: 2020-2-60-185

Name: Md Rezaul Hossain

ID: 2020-2-60-165

Name: Pulak Islam

ID: 2020-2-60-193

Name: Md. Farhad Billah

ID: 2020-2-60-213


## Submitted to

Touhid Ahmed

Lecturer

Department of CSE, East West University

**Submission Date:** 11/12/22

# Contents:

# Abstract

The op amp circuit is capable of quickly solving mathematical equations, such as differential equations in calculus. In this project we find the Second order homogeneous Ordinary Differential Equation solver with the help of Operational Amplifier. We will see how using the basic amplifiers we can build a circuit. We will first see the normal Second order Ordinary Differential Equation solver after that we will see the same thing for the Second order homogeneous Ordinary Differential Equation.

# Equipment Components

1.Resistors

2. Wires

4.Capacitor

5.µA741op-amp

6.Voltage source

## Objective

In this project our main objective is to generate a Second order homogeneous Ordinary Differential Equation(with constant coefficient) using capacitor , voltage source with µA741op-amp. Then we have to simulate the results then compare the results with the measurements.

## Discussion

To do this experiment first of all we need two different kinds of operational amplifiers. One is a summing amplifier and the other is an integrated amplifier. Using these two amplifiers we have to make a circuit that can solve the equation

$$\frac{d^2v}{dt^2} = -\ (k1\frac{dv}{dt} -\ v1) -\ k2v$$

Where k1, k2= real positive constants.

Let's assume $\frac{d^2v}{dt^2}$ is given as our input voltage for our integrating amplifier and we have to choose the value of R and C in such a way so that RC becomes 1.

If we integrate $\frac{d^2v}{dt^2}$ with respect to dt we will get $\frac{dv}{dt}$, and if we again integrate $\frac{dv}{dt}$ with respect to dt we will get v. That is why we need two integrating amplifiers. After that the whole equation is expressed through a summing operator that is why we need a summing amplifier as well.

The circuit will look like this-

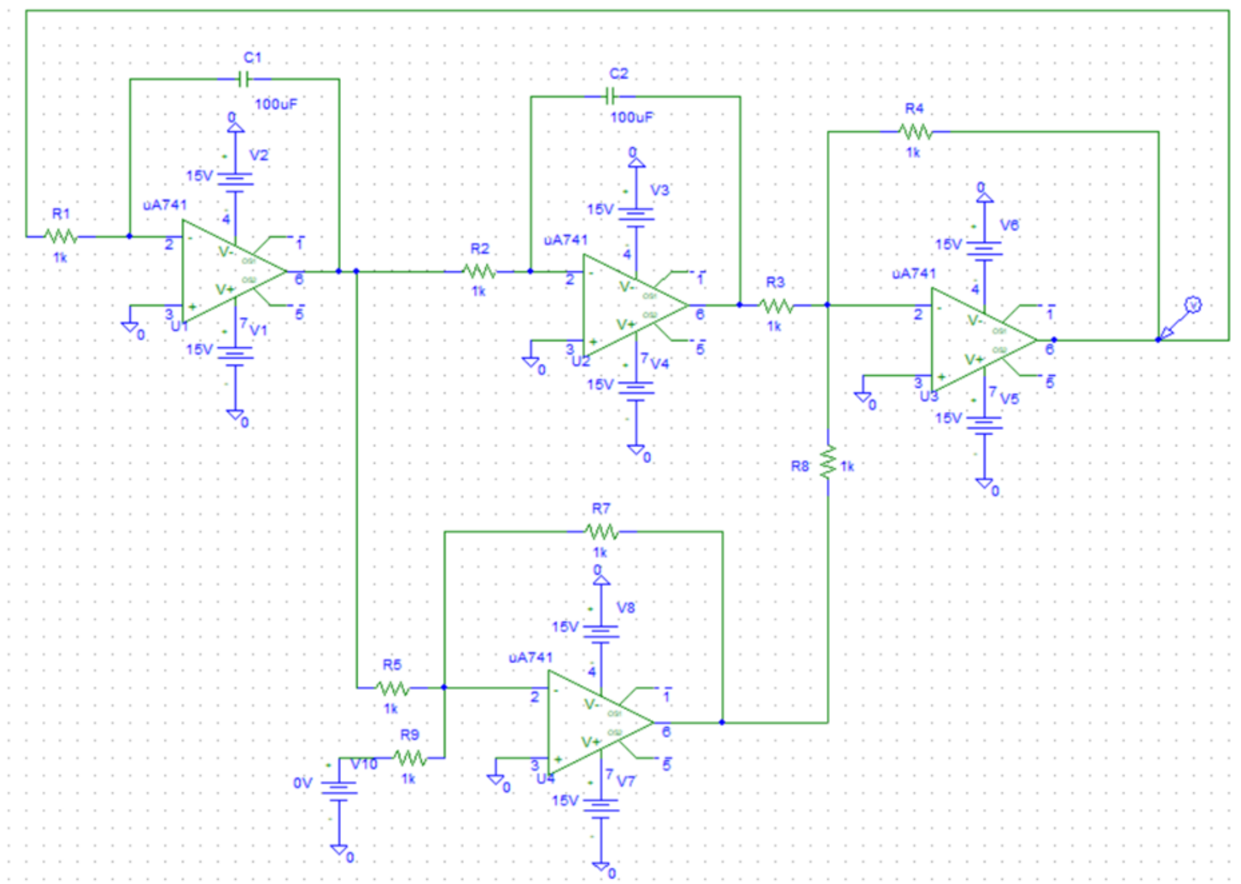



Figure: Differentiation solver circuit

First of all we have to use an integrator amplifier and the output of that amplifier will be connected to another integrator amplifier. At the same time the output will also be connected to a summing amplifier. If we look carefully at the equation there is a voltage source v1 with $\frac{dv}{dt}$. We will apply v1 as another input to that summing amplifier. Now the output of the second integrating amplifier and the summing amplifier will be applied in another summing amplifier as inputs and the final output will be our desired output.

## Now let's break down how this works

**1st integrating amplifier:** Here we choose R and C in such a way that RC=1. If this becomes 1 the output will be $V_{out} = -\int$(input)dt. Here the input is $\frac{d^2v}{dt^2}$. So the output will be $V_{out} = -\int(\frac{d^2v}{dt^2})$dt= $-\frac{dv}{dt}$.

**2nd integrating amplifier:** The output the first integrating amplifier will be the input of second integrating amplifier which is $-\frac{dv}{dt}$. From this we get the output

$V_{out} =- \int - \frac{dv}{dt}dt = v$

**1st summing amplifier:** At the same time we will apply $-\frac{dv}{dt}$ as an input of the first summing amplifier and V1 as another input. So the output will be $-\ (\frac{R}{R1}\left(-\ \frac{dv}{dt}\right) + \frac{R}{R}v1)\ =\ \frac{R}{R1}\frac{dv}{dt} - \ v1$

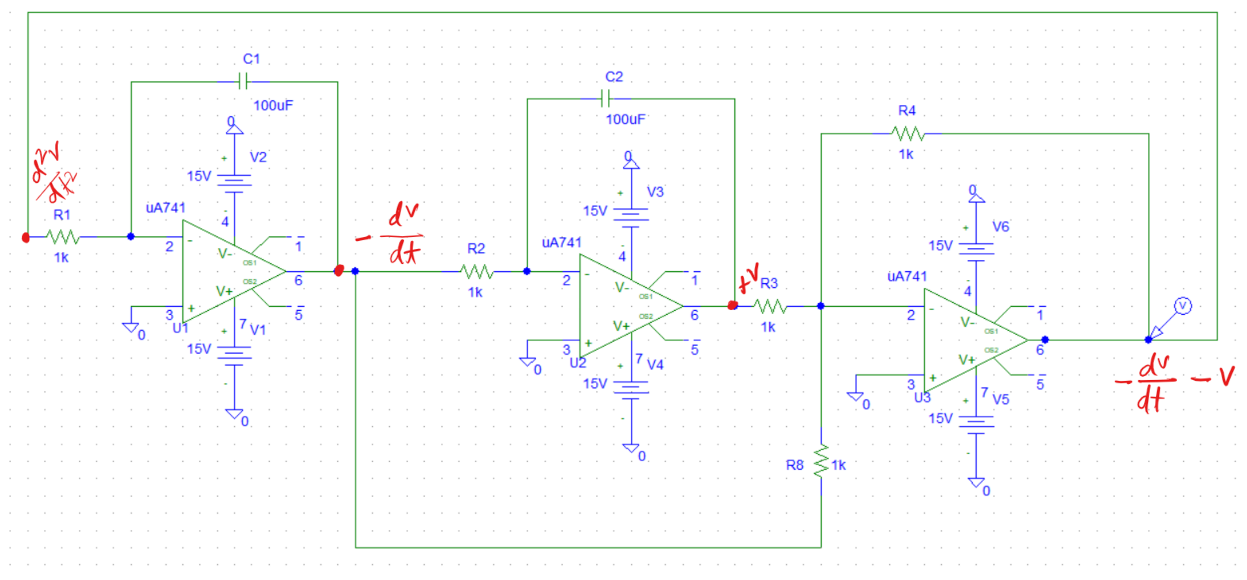
**2nd or final summing amplifier:** In this amplifier we will apply the output of the second integrator amplifier and the first summing amplifier as its inputs. So the output becomes $v_{out} =- \left(\frac{R}{R2}v + \frac{R}{R}\left(\frac{R}{R1}\frac{dv}{dt} - \ v1\right)\right) = \ -\frac{R}{R2}v - \frac{R}{R1}\frac{dv}{dt} + \ v1$

Let's assume, $\frac{R}{R1}$=k1 and $\frac{R}{R2}$=k2. So $v_{out} =- \ (k1\frac{dv}{dt} - \ v1)\ - \ k2v.$ This is how we solve the equation.

| Amplifier | Input | Output |
| --- | --- | --- |
| 1st integrating amplifier | $\frac{d^2v}{dt^2}$ | $-\frac{dv}{dt}$ |
| 2nd integrating amplifier | $-\frac{dv}{dt}$ | v |

| | | |
|---|---|---|
| 1st summing amplifier | $-\frac{dv}{dt}$ and v1 | $\frac{R}{R1}\frac{dv}{dt} - v1$ |
| final summing amplifier | $\frac{R}{R1}\frac{dv}{dt} - v1$ and v | $-\frac{R}{R2}v - \frac{R}{R1}\frac{dv}{dt} + v1$ |

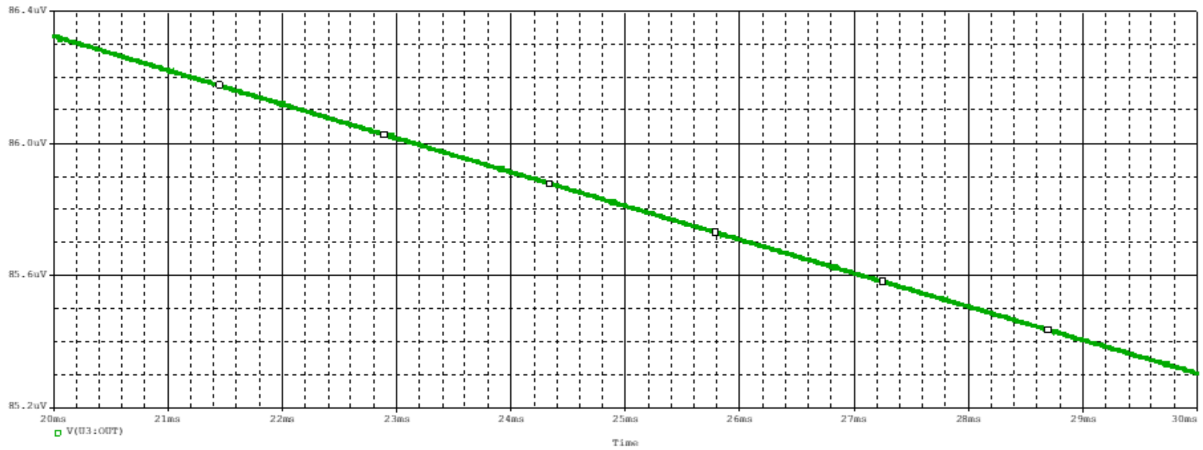
For Second order homogeneous Ordinary Differential Equations we can say that v1=0 in this case. So we do not need the extra summing amplifier.




In the final out for homogeneous equation we get ,Vo = $-\frac{dv}{dt}$-v

Which is our desired solved equation.

# Graphical Representation




# Conclusion

We can see that we can make a Second order homogeneous Ordinary Differential Equation (with constant coefficient) solver with operational amplifiers. We can make higher order differential equation solvers just like this, adding additional integrator operational amplifiers.

# Limitations

This differential equation can also be obtained with a computer which contains differentiators instead of integrators. However, integrators are preferred over differentiators because of the following reasons -

- Gain of the integrators decreases with increase in frequency while gain of differentiators increases with increase in frequency. Thus it is easier to stabilize the integrator as compared to differentiators.

- As a result of limited bandwidth an integrator is less sensitive to noise as compared to a differentiator.
- Finally, it is convenient to introduce initial conditions in an integrator.

Thus integrator is preferred over differentiator.