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Objectives

- To demonstrate the use of Operational Amplifier for performing mathematical operations of summation and difference.
- To implement Inverting Summing Amplifier
- To implement Difference Amplifier

Equipment

1. DC Power Supply
2. Oscilloscope
3. Function Generator

Components

1. LM 741 Op-amp
2. 47kΩ
3. 100kΩ

Part A

Inverting Summing Amplifier

Theory Overview

The most commonly used Summing Amplifier is an extended version of the Inverting Amplifier configuration i.e., multiple inputs are applied to the inverting input terminal of the Op Amp, while the non-inverting input terminal is connected to ground. Due to this configuration, the output of Voltage Adder circuit is out of phase by 180o with respect to the input.

A general design of the Summing Amplifier is shown in the following circuit. Normal Inverting Amplifier circuit has only one voltage / input at its inverting input terminal. If more input voltages are connected to the inverting input terminal as shown, the resulting output will be the sum of all the input voltages applied, but inverted.

Theoretically, we can apply as many input signals to the input of the summing amplifier as required. However, it must be noted that all of the input currents are added and then fed back through the resistor Rf, so we should be aware of the power rating of the resistors.

Figure 1 shows an example of how an operational amplifier is connected to perform voltage summation.

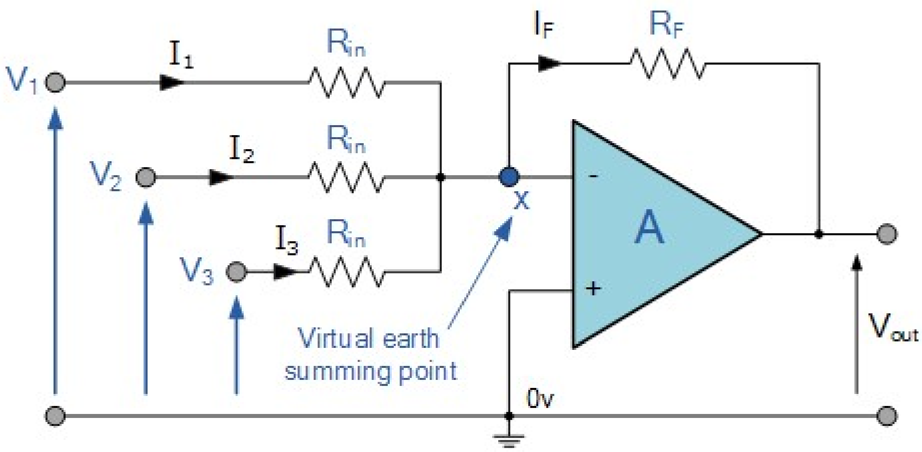


Figure 1

Inverting Summing Amplifier Equation

The Formula for calculating the Vout or voltage at output node is as follow:

$$-V_{OUT} = V_1\left(\frac{R_f}{R_1}\right) + V_2\left(\frac{R_f}{R_2}\right) + V_3\left(\frac{R_f}{R_3}\right) \ldots\text{etc}$$

Procedure

1. To demonstrate the use of an operational amplifier as a summing amplifier, connect the circuit of Figure 1.
2. With VS adjusted to produce a 1 V peak sine wave at 1 kHz, observe the output voltage VO (and VS
3. to note the phase relationship) on an oscilloscope set to dc input coupling.
4. Sketch the output voltage waveform. Be sure to note the dc level in the output.
5. Interchange the 5 V dc power supply and the 1 V peak signal generator.
6. Repeat procedure step 2 and observe the change in output waveform.

Observation and Calculation

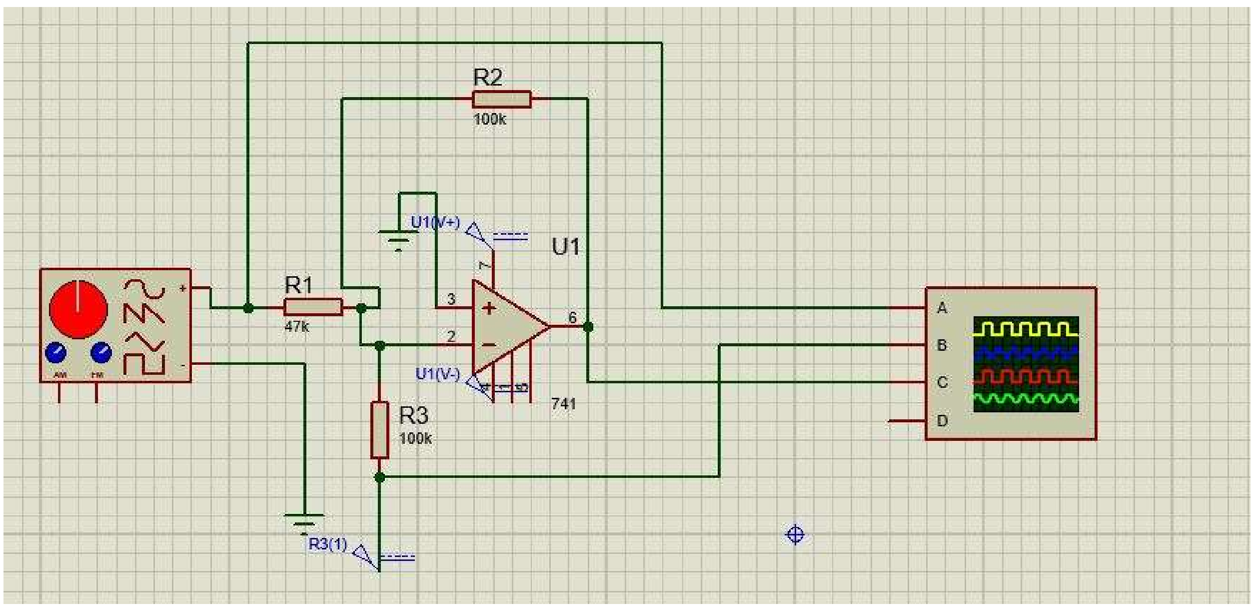
The calculated values are as follow:

		Calculated		Measured		% Error	
v1 AC	v2 DC	Vout AC	Vout DC	Vout AC	Vout DC	Vout AC	Vout DC
1	5	-2.1276596	-5	-2.1	-5	1.30	0.00
1	4	-2.1276	-4	-2.1	-4	1.30	0.00
1	6	-2.12	-6	-2.1	-6	0.94	0.00
2	5	-4.2553191	-5	-4.1	-5	3.65	0.00
3	5	-6.3829787	-5	-6.2	-5	2.87	0.00

Data Table for Inverting summing Amplifier

Proteus Implementation

Circuit Schematics:



Proteus Implementation

Output Waveform:

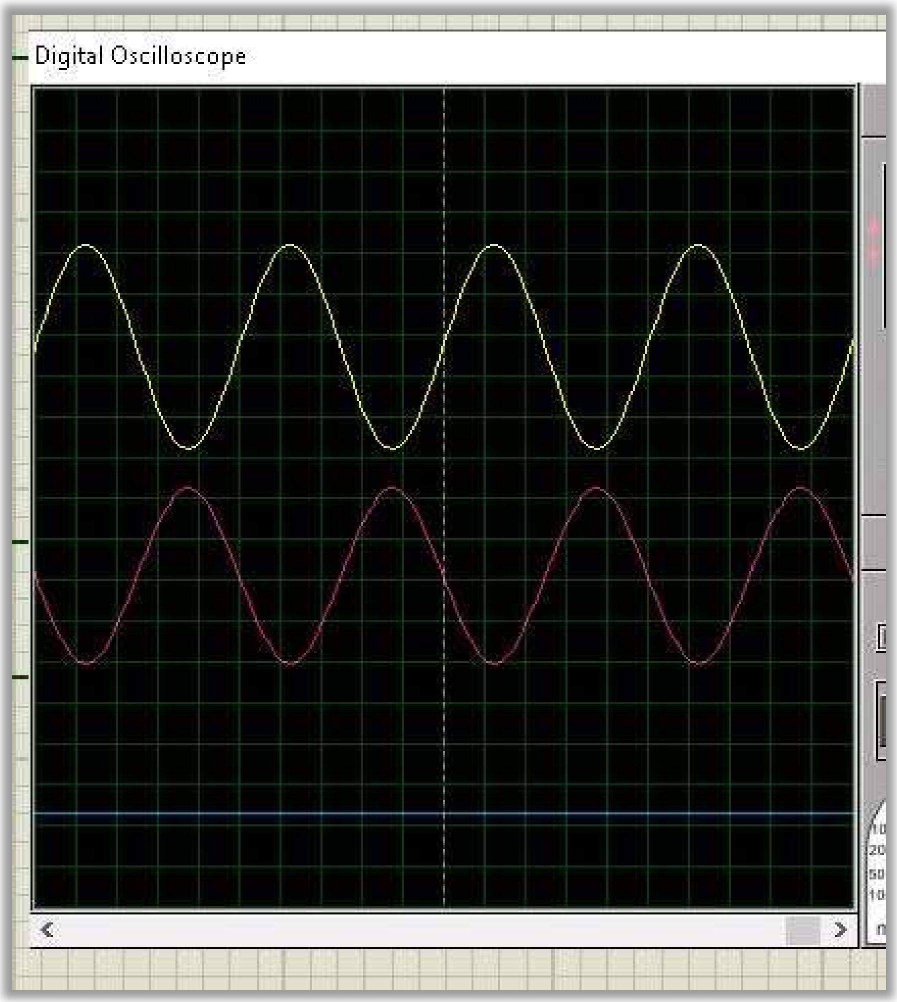
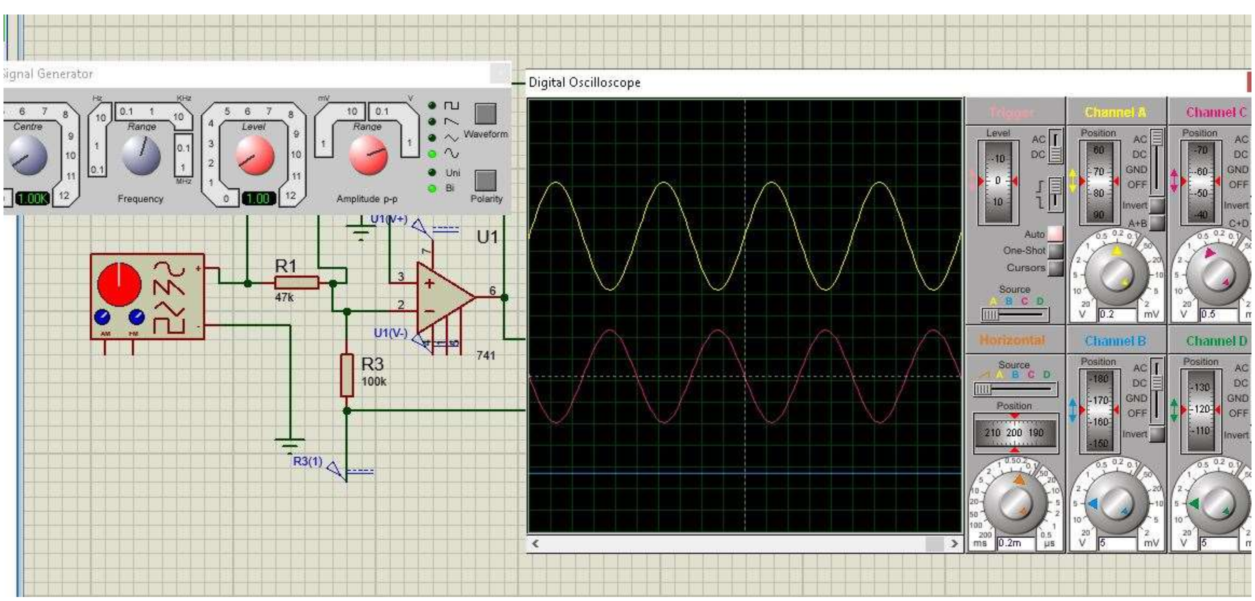


Figure: Output wave form

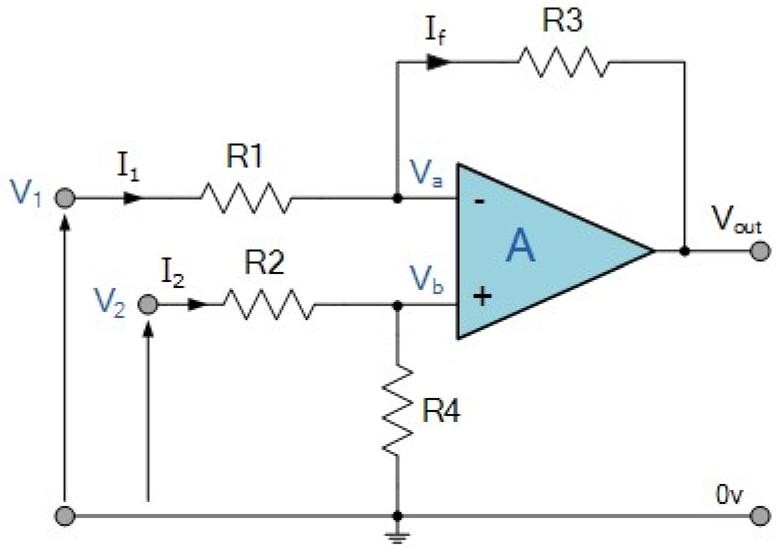


Part B

Difference Amplifier

Theory Overview

The differential amplifier amplifies the voltage difference present on its inverting and non-inverting inputs. Then differential amplifiers amplify the difference between two voltages making this type of operational amplifier circuit a Subtractor unlike a summing amplifier which adds or sums together the input voltages. This type of operational amplifier circuit is commonly known as a Differential Amplifier configuration and is shown below:



Difference Amplifier Equation

It can be shown that the gain of the difference amplifier can be calculated using the following:

$$V_{out} = -V_1\left(\frac{R_3}{R_1}\right) + V_2\left(\frac{R_4}{R_2+R_4}\right)\left(\frac{R_1+R_3}{R_1}\right)$$

This equation can be simplified by making R3= Rf= R1= R2, yielding a simple differential amplifier with unity gain: V0=V2-V1

Procedure

1. To investigate the use of an operational amplifier in a difference amplifier configuration, connect
2. the circuit of Figure .
3. With V S adjusted to produce a 1 V peak sine wave at 1 kHz, observe the output voltage VO(and VS
4. to note the phase relationship) on an oscilloscope set to dc input coupling.
5. Sketch the output voltage waveform. Be sure to note the dc level in the output.
6. Interchange the 5 V dc power supply and the 1 V peak signal generator.
7. Repeat procedure step 2 and observe the change in output waveform.

Observation and Calculation

The calculated values are as follow :

		Calculated		Measured		% Error	
v1 AC	**v2 DC**	**Vout AC**	**Vout DC**	**Vout AC**	**Vout DC**	**Vout AC**	**Vout DC**
1	5	-2.1276596	5	-2.12	5	0.36	0.00
1	6	-2.1276596	6	-2.12	6	0.36	0.00
1	4	-2.12766	4	-2.12	4	0.36	0.00
2	5	-4.2553191	5	-4.2	5	1.30	0.00
3	5	-6.3829787	5	-6.3	5	1.30	0.00

Proteus Implementation

Circuit Schematics

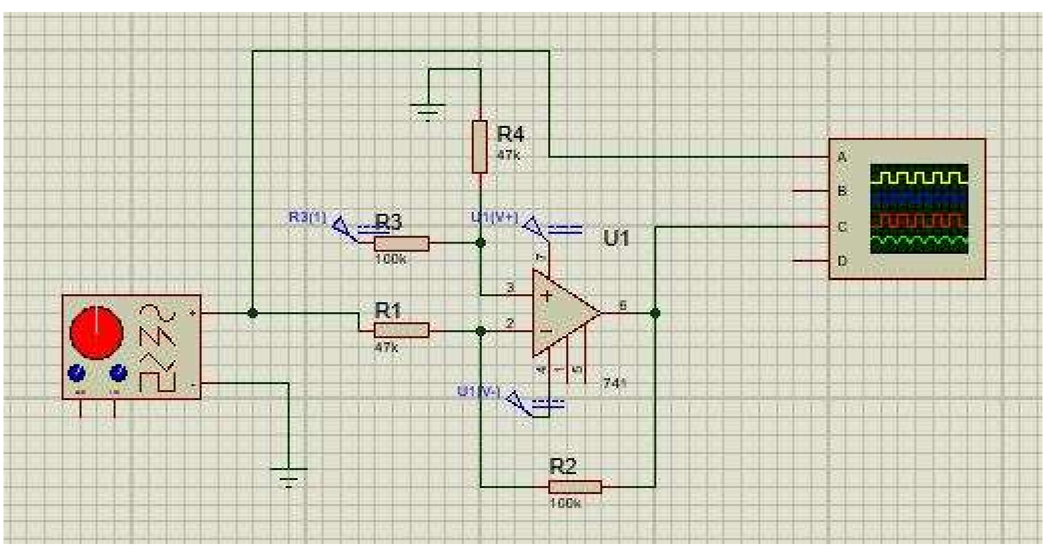


Figure : Circuit Schematics

Circuit Output Waveform:

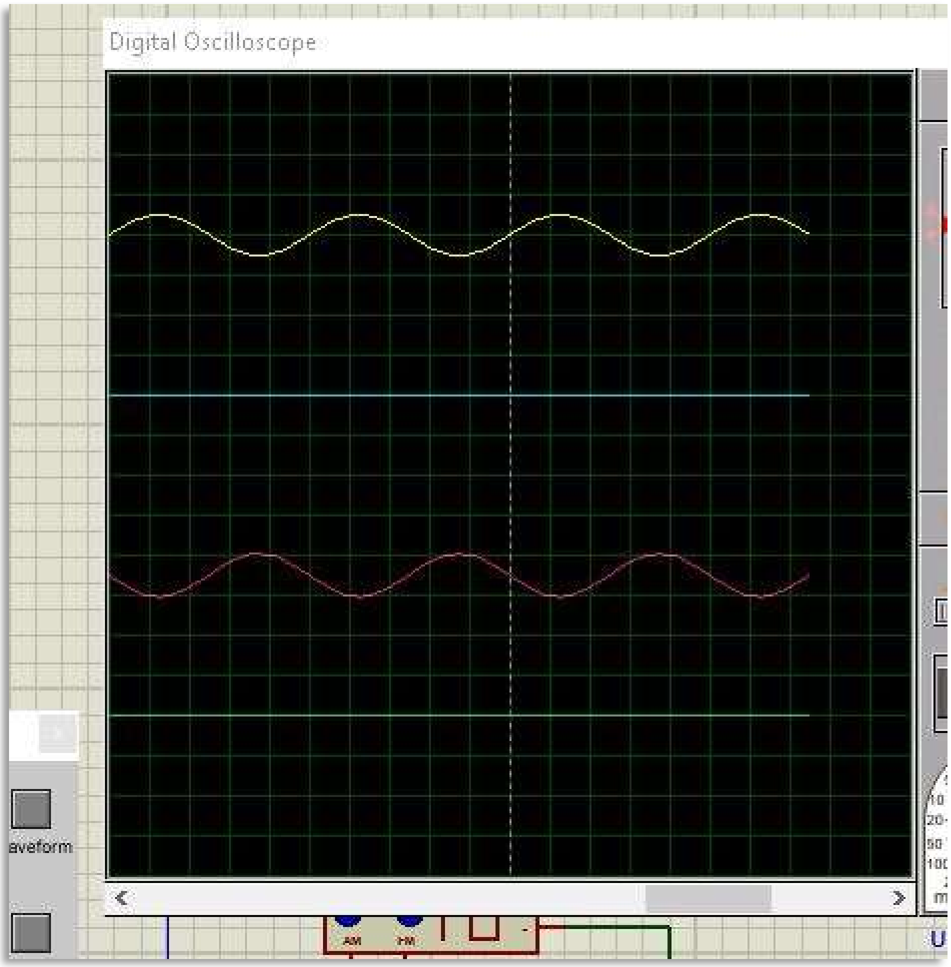


Figure : Output Waveform

Difference Amplifier Output Waveform:

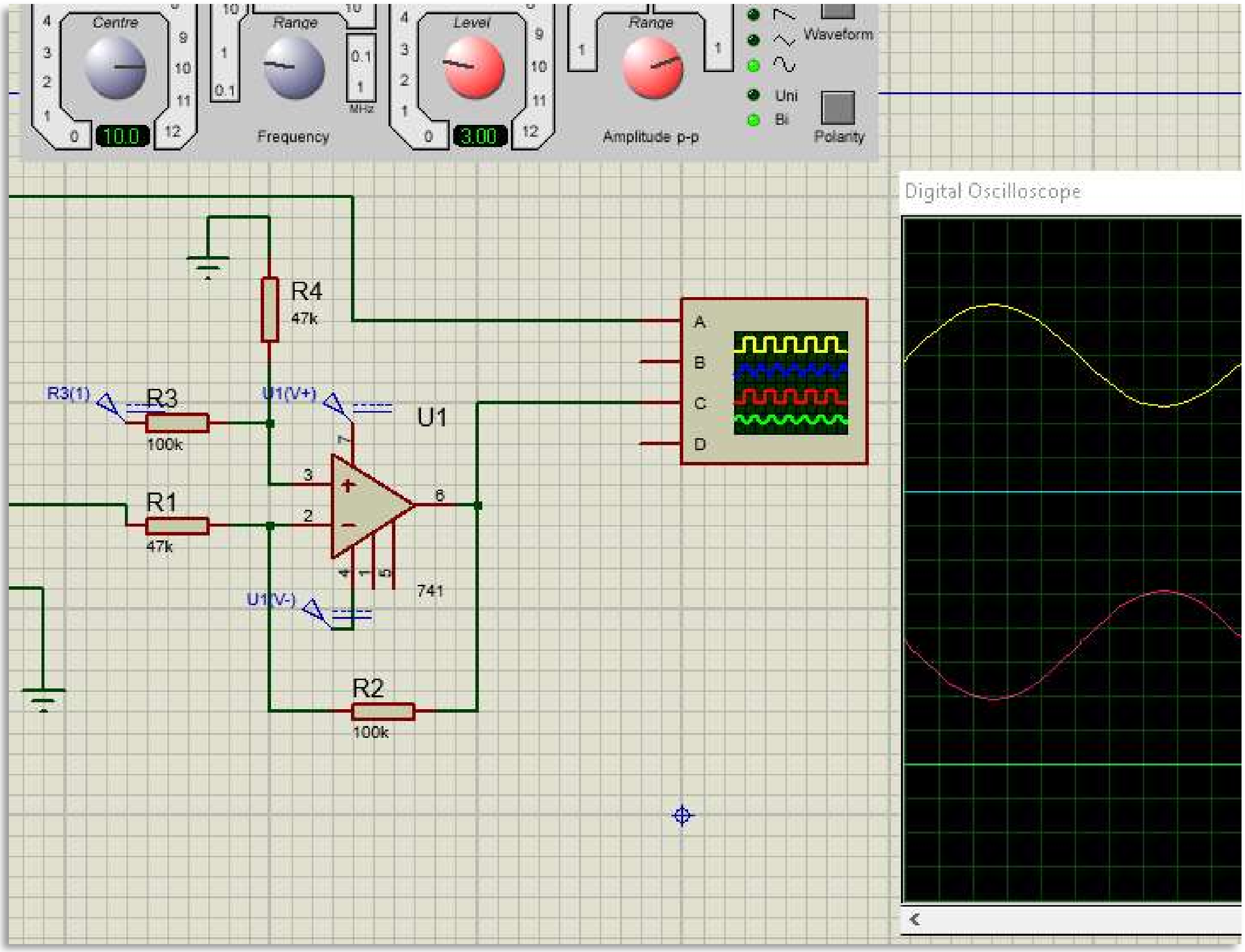


Figure : Difference Amplifier