

Analog Electronics I

Laboratory

Exercise 3

Operational Amplifier

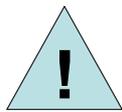
Aim of the exercise

The aim of this laboratory exercise is to become familiar with the operation of the basic circuits using operational amplifier.

Equipment

- Oscilloscope;
- Measurement set: function generator, digital multimeter, frequency meter, power supply;
- Soldering toolbox;
- Measurement toolbox;
- Soldering station;
- Prototype board.

Before the exercise please check the contents of the toolbox with the checklist on the box. If anything is missing report it to your teacher.



Warning! Soldering iron is heated to the temperature above 300°C. Please use it carefully in order to prevent getting burn.

Control questions

1. How do the resistors R_1, R_2 and R_f influence the voltage amplification coefficient of the amplifier with negative feedback?
2. What is the change of band and amplification?
3. How do you sum the currents and voltages in the summing amplifier? How do you determine the weights of this summation?

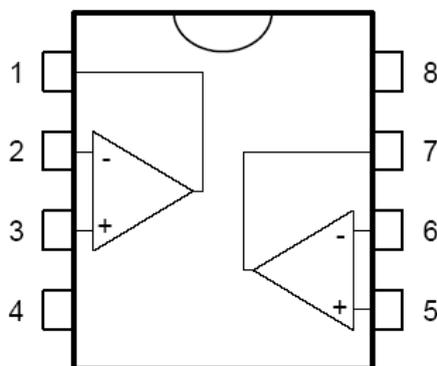


Fig. 1 TL072 operational amplifier pinning. Top view. Power supply: $4V_{CC-}$, $8V_{CC+}$

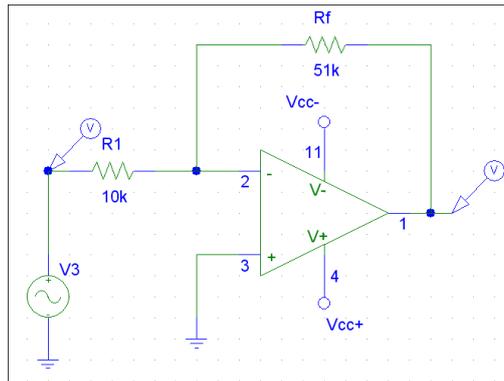


Fig. 2 Inverting amplifier.

Tasks

1. Inverting amplifier

1. Solder circuit illustrated in fig. 2 using one of the amplifiers from TL072. **Warning! The pinning in fig. 2 is incorrect. Please use fig. 1.**
2. Supply the circuit from the function generator $V_{CC+} = 15V$, $V_{CC-} = -15V$. To do this connect the (+) terminal of the nonregulated generator 15V with (-) terminal of the regulated generator. Set 15V on the regulated generator. The (+) terminal of the regulated generator becomes the V_{CC+} source, the (-) terminal is the V_{CC-} source. Connect the ground to the connected terminals (nonregulated (+) and regulated (-)).
3. Set the generator parameters: $f_G = 100Hz$ and $v_{in} = 1V$ (amplitude).
4. Set the oscilloscope format in the XY mode. **Warning! Channel B – X, Channel A – Y.**
5. Set both oscilloscope inputs to DC mode.
6. Check if the inner knobs of the amplification and time variable are turned fully clockwise. It will allow for reading the correct values from the oscilloscope scale.
7. Find the transfer characteristics of the amplifier $v_o = f(v_{in})$ using the oscilloscope.
8. Save the transfer characteristics of the amplifier for $f_G = 100Hz$.
9. Observe the influence of the frequency of the input signal on the transfer characteristics.
10. Based on the transfer characteristics find the voltage amplification coefficient $A_{vf} = \frac{V_o}{V_{in}}$. Compare this value with the one calculated using the formula: $A_{vf} = \frac{R_f}{R_1}$.
11. Set the oscilloscope to the dual channel mode.
12. Set the output signal of the generator to be sine signal with frequency $f_G = 1kHz$ and amplitude $v_{in} = 0.4V$.
13. Save the oscillograms of the input and output voltage v_{in} and v_{out} .
14. Determine the frequency characteristics $|k_u(f)|$ of the amplifier by changing the frequency of the generator and observing the output signal v_o .
15. Determine the frequency band of the amplifier B .
16. Repeat the procedure for $R_f = 200k\Omega$.

2. Summing amplifier

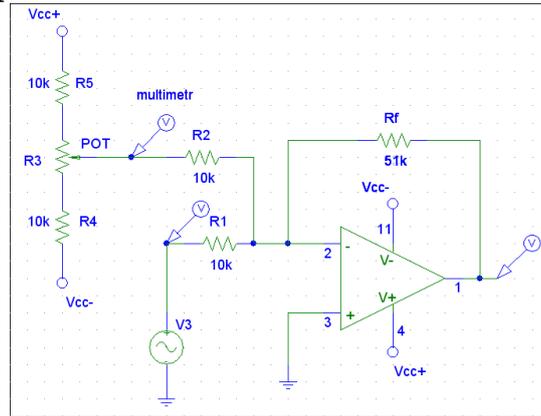


Fig. 3 Summing amplifier

1. Solder circuit illustrated in fig. 3. Potentiometer $R3 = 50k\Omega$.
2. Connect the digital multimeter to measure the voltage between the ground and a point marked on the schematic circuit.
3. Set the following parameters of the generator: $f_G = 100\text{Hz}$, $v_{in} = 1\text{V}$ (amplitude).
4. Connect the oscilloscope probes to the test points indicated by voltage markers.
5. Observe the changes in the output signal v_o when changing the potentiometer setting.

3. Non-inverting amplifier

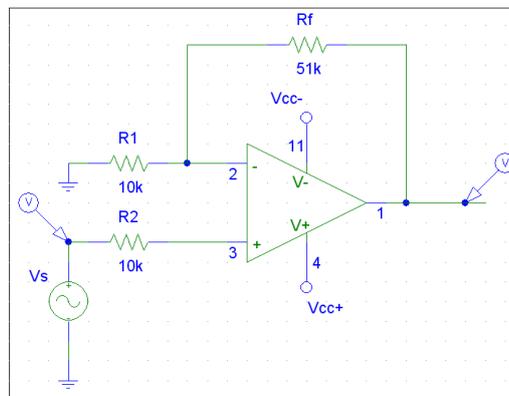


Fig. 4 Noninverting amplifier

1. Solder circuit illustrated in fig. 4.
2. Supply the circuit from the generator: $V_{CC+} = 15\text{V}$, $V_{CC-} = -15\text{V}$.
3. Set the following parameters of the generator: $f_G = 100\text{Hz}$, $v_{in} = 1\text{V}$ (amplitude).
4. Set the oscilloscope format in the XY mode.
5. Set the inputs of the oscilloscope channels to DC mode.
6. Check if the inner knobs of the amplification and time variable are turned fully clockwise. It will allow for reading the correct values from the oscilloscope scale.
7. Find the transfer characteristics of the amplifier $v_o = f(v_{in})$ using the oscilloscope.
8. Draw the transfer characteristics of the amplifier for $f_G = 100\text{Hz}$.
9. Observe the influence of the frequency of the input signal on the transfer characteristics.

10. Based on the transfer characteristics find the voltage amplification coefficient

$A_{vf} = \frac{V_o}{V_{in}}$. Compare this value with the one calculated using the formula:

$$A_{vf} = \frac{R_f}{R_1}.$$

11. Set the oscilloscope to the dual channel mode.

12. Set the output signal of the generator to be sine signal with frequency $f_G = 1\text{kHz}$ and amplitude $v_{in} = 0.4\text{V}$.

13. Make the oscillograms of the input and output voltage v_{in} and v_{out} .

14. Determine the frequency characteristics $|k_u(f)|$ of the amplifier by changing the frequency of the generator and observing the output signal v_o .

15. Determine the frequency band of the amplifier B .

Additional information

Parameters, documentation and SPICE models of TL072 operational amplifier:

<http://focus.ti.com/docs/prod/folders/print/tl072.html>

Report preparation

The report must be delivered in electronic form to your teacher. Each page in header should have named and id numbers of persons carried out the exercise. Oscilloscope plots should be drawn by hand on earlier prepared grid. Each report should include:

- schematics of the examined circuits (e.g. prepared in SPICE);
- measurements results;
- oscilloscope plots and marks of reference to appropriate plot in the report text;
- simulation results;
- comparison of the obtained measurement results and oscilloscope plots with SPICE simulation results;
- comments and conclusions;
- answers to control questions.