# FUNDAMENTALS OF ELECTRONICS


***Department of Robotics and Mechatronics***

***Faculty of Mechanical Engineering and Robotics***

***AGH University of Science and Technology***



***Operational Amplifier***

LAB 9
LAB 10

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FUNDAMENTALS OF ELECTRONICS

## CONDITIONS FOR PASSING THE LABORATORY

- ***laboratory report: max 10p;***
- ***send the report to: ggora@agh.edu.pl***
- ***teams: two-person;***
- ***deadline: one week***.

## EXERCISE 1 – Measuring passive components *[1p]*

Measure the values of the passive components by using a multimetr: R18, R19, R20, R21, R22, R23, R24.

## EXERCISE 2 – Inverting Operational Amplifier *[2p]*

**PROCEDURE**

1. Make the connections according to the assembly schematic fig. 1. The circuit should be powered with + 12 $V_{DC}$ and – 12 $V_{DC}$.
2. Set generator to 500 $mV_{PP}$, 1 kHz sine wave, without DC level. Check the parameters by using an oscilloscope.

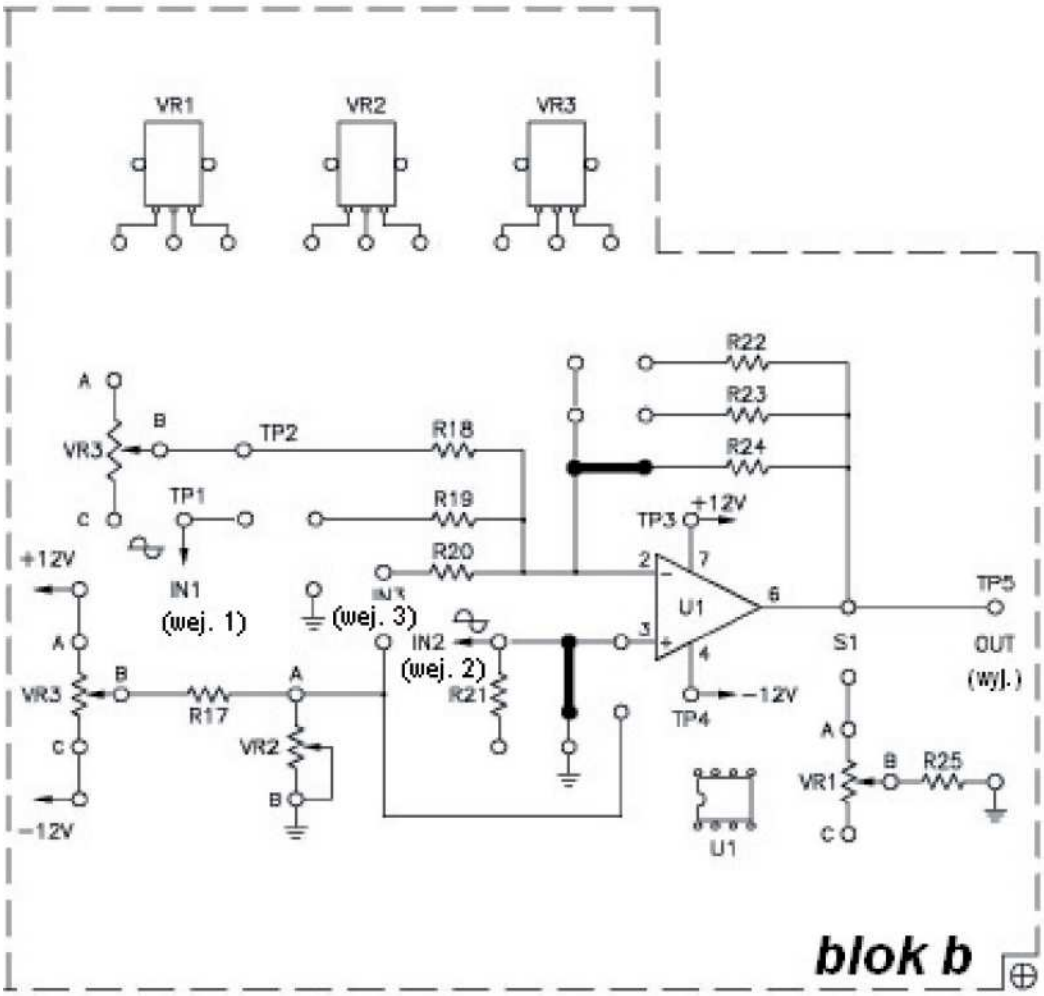


**Fig. 1: Electrical assembly schematic (KL-25006 part b) – Inverting Operational Amplifier [1]**

3. Connect the signal from the generator to the input (IN3) and the first channel of the oscilloscope. Connect the second channel of the oscilloscope to the output of the circuit (TP5).
4. Record the peak-to-peak values of the input and output signals. Based on this values calculate the voltage gain of the circuit. Compare this result with the gain calculated from the R20 and R24 resistance.
5. Check the maximum amplitude of the output signal without distortion (by slowly increasing the amplitude of the input signal). What causes distortion of the output signal? What can be done to increase the amplitude of the output signal without distortion?
6. Set again generator to 500 $mV_{PP}$, 1 kHz sine wave, without DC level.
7. Increase the frequency of the input signal until the amplitude of the output signal drops to the value of about 2 $V_{PP}$. Save the frequency. What parameters of the amplifier determine its upper cutoff frequency?

## EXERCISE 3 - Non-inverting Operational Amplifier *[2p]*

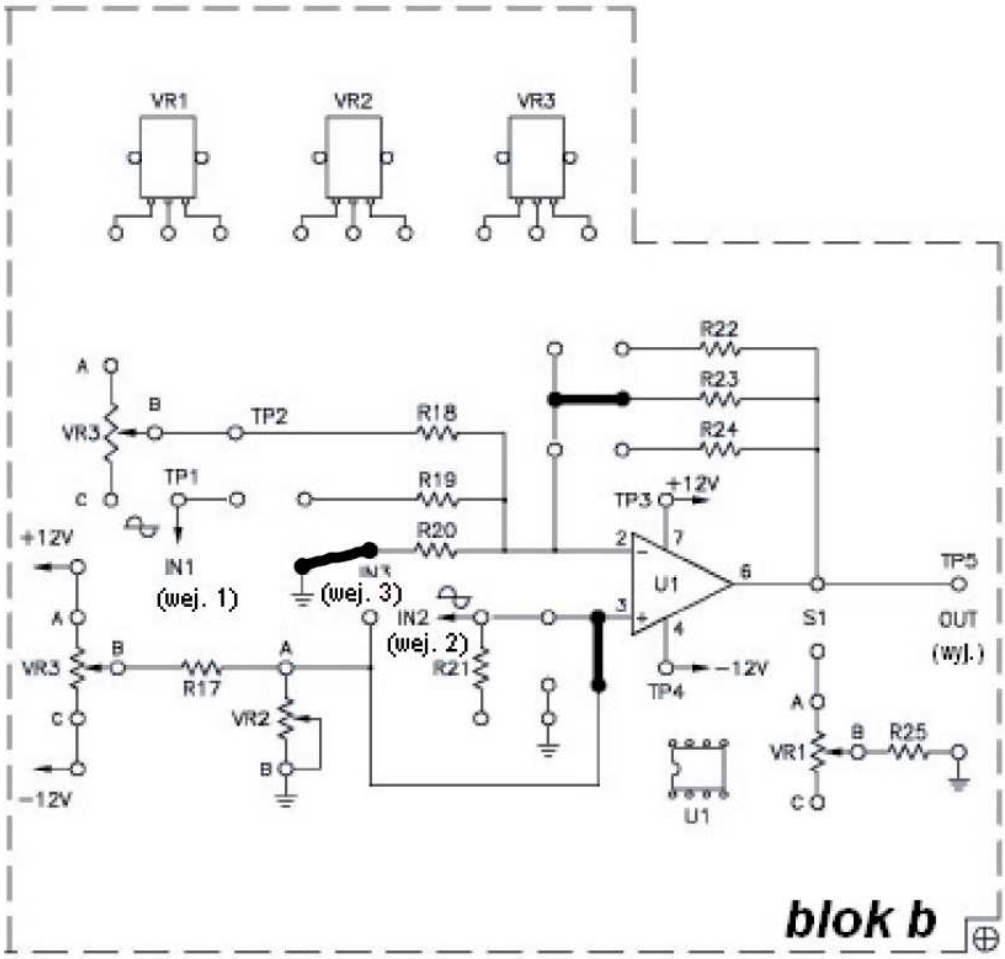


**Fig. 2: Electrical assembly schematic (KL-25006 part b) – Non-inverting Operational Amplifier [1]**

**PROCEDURE**

1. Make the connections according to the assembly schematic fig. 2. The circuit should be powered with + 12 $V_{DC}$ and – 12 $V_{DC}$.
2. Set generator to 500 $mV_{PP}$, 1 kHz sine wave, without DC level. Check the parameters by using an oscilloscope.
3. Connect the signal from the generator to the input (IN2) and the first channel of the oscilloscope. Connect the second channel of the oscilloscope to the output of the circuit (TP5).
4. Record the peak-to-peak values of the input and output signals. Based on this values calculate the voltage gain of the circuit. Compare this result with the gain calculated from the R20 and R23 resistance.

## EXERCISE 4 – Op-amp Voltage Follower (Buffer) *[1p]*

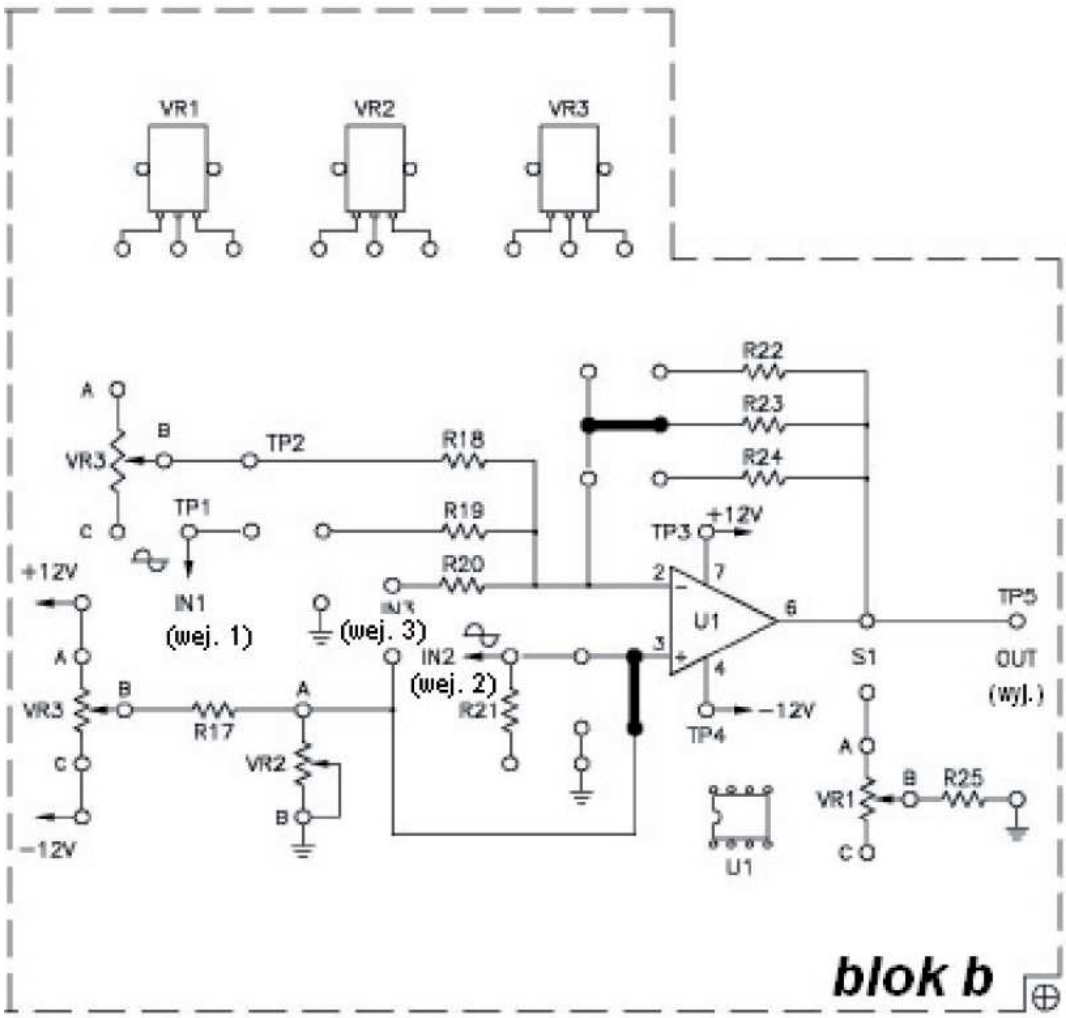


**Fig. 3: Electrical assembly schematic (KL-25006 part b) – Operation Amplifier as Voltage Follower (Buffer) [1]**

**PROCEDURE**

1. Make the connections according to the assembly schematic fig. 3. The circuit should be powered with + 12 $V_{DC}$ and – 12 $V_{DC}$.
2. Set generator to 500 $mV_{PP}$, 1 kHz sine wave, without DC level. Check the parameters by using an oscilloscope.
3. Connect the signal from the generator to the input (IN2) and the first channel of the oscilloscope. Connect the second channel of the oscilloscope to the output of the circuit (TP5).
4. Record the peak-to-peak values of the input and output signals. Based on this values calculate the voltage gain of the circuit. Compare this result with the theoretical gain of the voltage follower. What are the reasons for using voltage followers?

## EXERCISE 5 – The Summing Amplifier *[2p]*

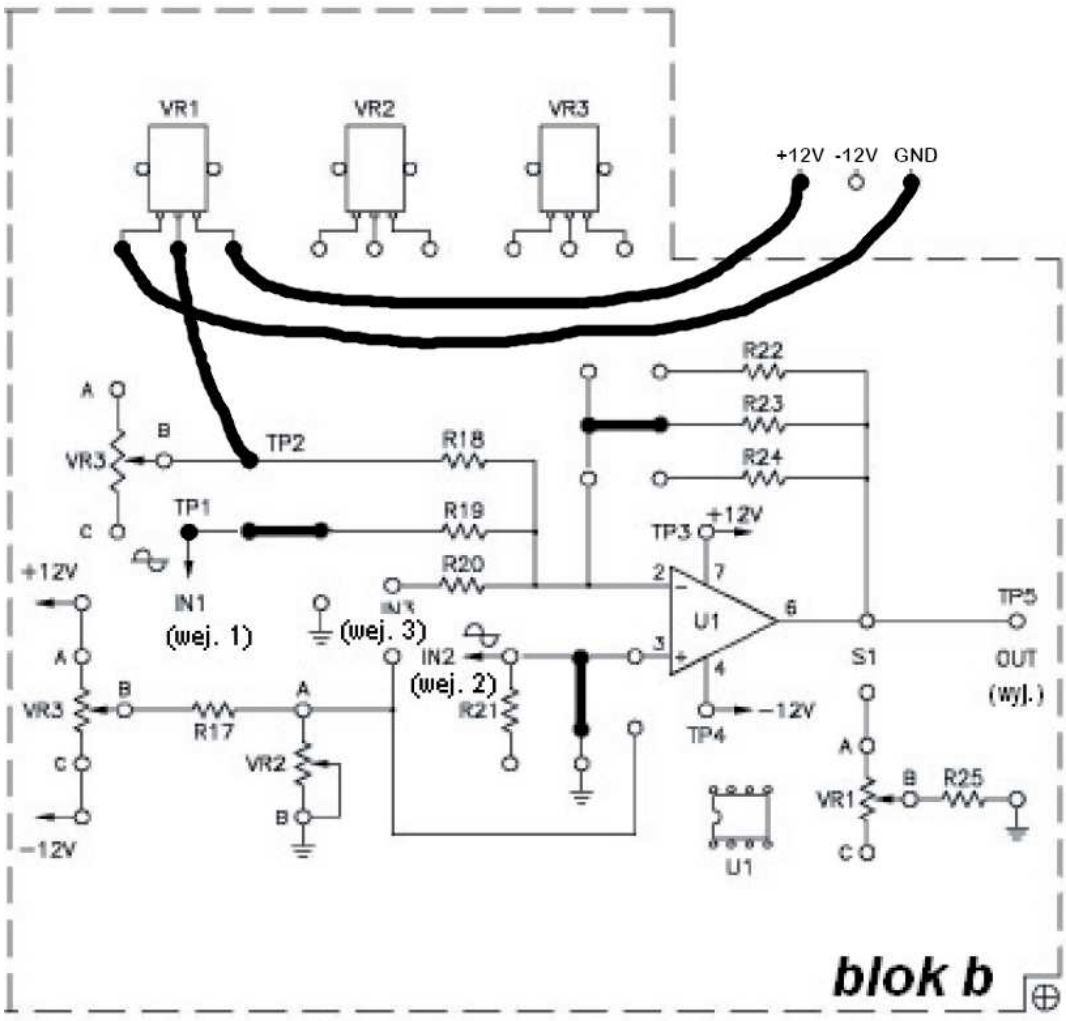


**Fig. 4: Electrical assembly schematic (KL-25006 part b) – The summing amplifier [1]**

**PROCEDURE**

1. Make the connections according to the assembly schematic fig. 4. The circuit should be powered with + 12 $V_{DC}$ and – 12 $V_{DC}$.
2. Set generator to 2 $V_{PP}$, 1kHz sine wave, without DC level. Check the parameters by using an oscilloscope.
3. Connect the signal from the generator to the input (IN1) and the first channel of the oscilloscope. Connect the second channel of the oscilloscope to the output of the circuit (TP5).
4. By adjusting the potentiometer, check the output signal.
5. For 3 cases: Measure the voltage value at TP2 with a multimeter and the input signal parameters (amplitude and DC level). Determine what parameters of the output signal should be (peak-to-peak value and DC level), based on the values of the resistors R18, R19 and R23. Do the calculated values agree with the measurements?

## EXERCISE 6 – Op-amp Comparator *[2p]*

**PROCEDURE**

1. Make the connections according to the assembly schematic fig. 5. The circuit should be powered with + 12 $V_{DC}$ and – 12 $V_{DC}$.
2. Set generator to 5 $V_{PP}$, 1kHz sine wave, without DC level. Check the parameters by using an oscilloscope.
3. Connect the signal from the generator to the input (IN2) and the first channel of the oscilloscope. Connect the second channel of the oscilloscope to the output of the circuit (TP5).
4. Use the VR3 potentiometer to change the reference voltage value of the comparator. Record the input (from the generator) signal and the output signal for the duty cycle about 25%, 50%, 75% and 100%. Use a multimeter to measure the reference voltage values for the above cases. What are the output signal voltages for high and low state? What determines these values?

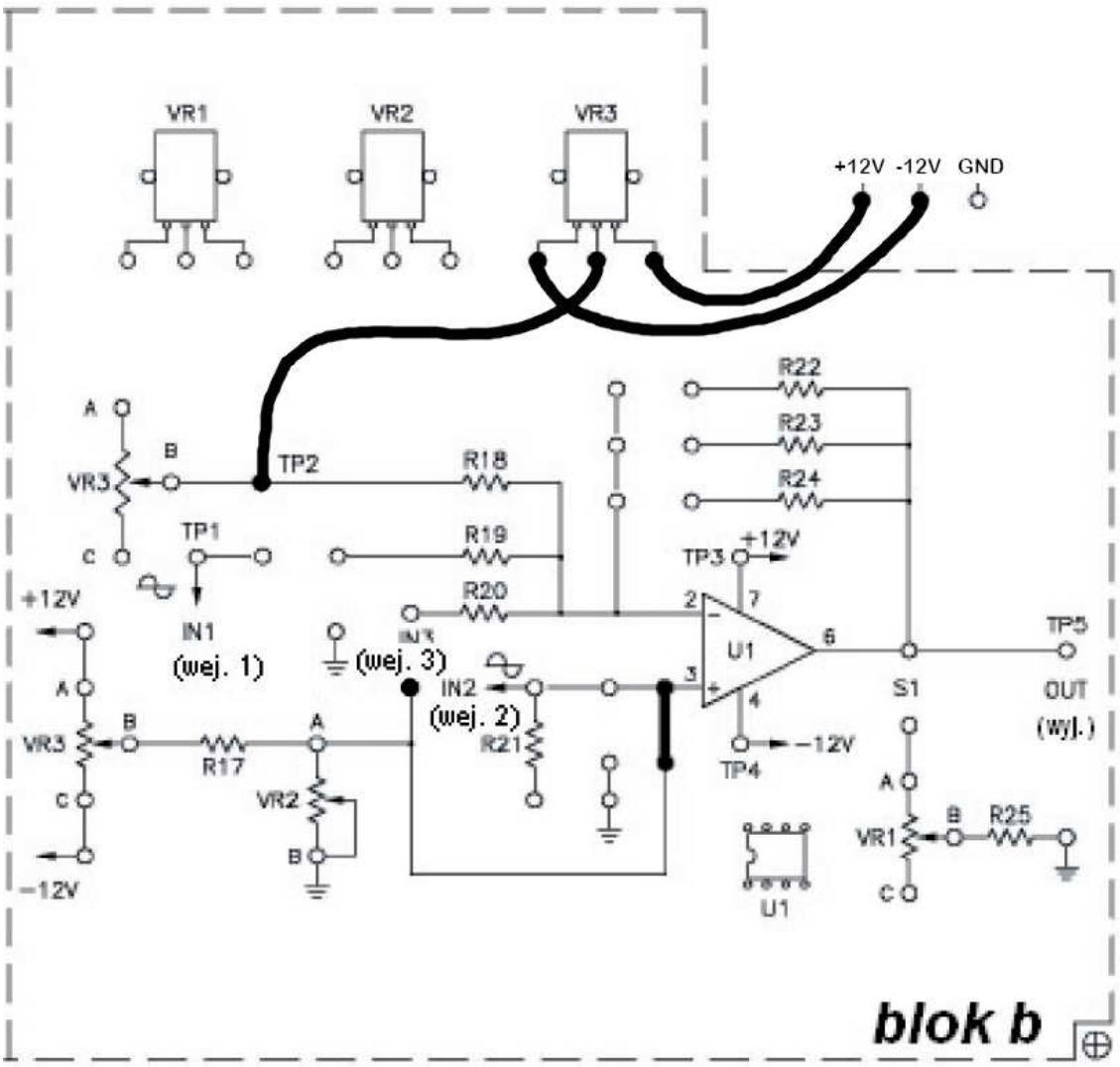


**Fig. 5: Electrical assembly schematic (KL-25006 part b) – Operation Amplifier as Comparator [1]**

# REFERENCES

[1] Laboratorium z podstawowych układów elektronicznych KL-210: Rozdział 11 – Podstawowe układy ze wzmacniaczem operacyjnym