Analog Eletronik IE1202 - Home Laboratory 1

Student Name:

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1 Introduction

The following short experimental tasks have been designed to complement the knowledge that you acquired after reading the book, solving theoretical problems, and attending the lectures. One of the main objectives is that you quickly get familiar with electronics experimental work and become comfortable when working in an electronic lab environment.

This lab comprises 2 short tasks. You will design, simulate, build, and measure a non-inverting amplifier, and a summing amplifier. You will have to do some hand-calculations directly on a print-out of this lab manual. Screen-shots of simulations and measurement plots need to be added to a separate document. After finishing the lab, scan the lab manual and attach the document containing the screen shots as appendix. A single PDF file must be uploaded to Canvas.

NOTE1: Circuit schematics and simulation setups for all laborations are available as part of the QUCS material (project directory IE1202_HEMLAB_prj). All QUCS material can be downloaded from `https://github.com/saul-rodriguez/QUCS_ANALOG_ELEKTRONIK`

NOTE 2: To avoid any problems due to over-current and excessive loading, please use resistance values larger than 500 Ω!

NOTE 3: When you dimension the resistors, try to use the closest value that you have available in your kit.

2 Non-Inverting Amplifier

2.1 Circuit Theory

For the circuit in Fig. 1, calculate the value of R2 so that the voltage gain $A_V = V_{OUT}/V_{IN} = 11$.

Your hand calculation:

Answer: R2 =

What is approximately the minimum value of R2 that can be used before the output voltage is clipped?

Your hand calculation:

Answer: R2 =

2.2 Circuit Simulation

Open QUCS and set up a schematic like in Fig. 1. Replace R2 with the values that you calculated and run transient simulations. Save screen-shots of the simulation plots and add them to an appendix at the end of this lab. Is the simulated and calculated gain the same? Are the clipping points the same? Comment your findings:

Comments:

2.3 Circuit construction and measurements

Since this is the first time you will do these measurement, we will take it step by step. As you get familiar with the equipment, it will become intuitive.

Before starting this step, make sure that the 5V power bank batteries are fully charged. You can use a USB mobile charger for this purpose (when the batteries are fully charged a green led will turn-on). With the exception of the 5V power banks, connect all the other components of the inverting amplifier as shown in Fig. 2. If you are not sure about how to select the resistor values, check the chart in Fig. 3. Set the oscilloscope probes to 1X.

Important! Note how the 5V power bank will be connected in series in order to create +5V, 0V (ground), and -5V. It is very important that you understand this since we will use this configuration during the rest of the course. The power banks have limited thermal and short-circuit protection; therefore, it is highly recommended to connect them carefully in order to avoid that they get damaged. For internal connections, we will always use the color RED for 5V, BLACK for 0V (ground), and BLUE for -5V. Do not use these colors for other purposes!

Connect the USB cable from the PicoScope instrument to your computer and start the PicoScope software. Now, connect the 5V batteries. Configure the signal generator: select a Sine waveform, Start Frequency = 1 kHz, Amplitude = 100 mV, Offset = 0V. Enable the signal generator (do not enable the sweep option). Now, change the number of samples to 100 MS, and the time base to 500 μS/div. Click on Trigger and select Auto. Also, select channel A as source for the trigger. Make sure that the oscilloscope probes are set as 1X. You can do this by clicking on A and B and changing the settings if necessary. Likewise, you can change the resolution from 8 bits to, for instance, 10 bits (very recommendable). Now change the input

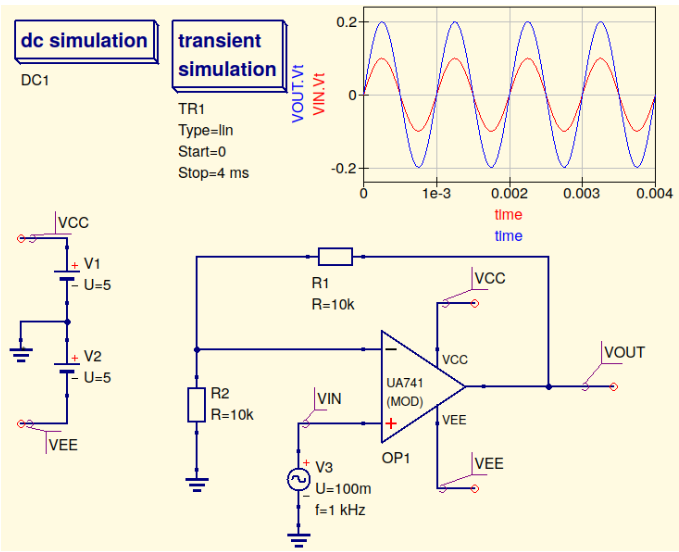


Figure 1: Non-Inverting Amplifier

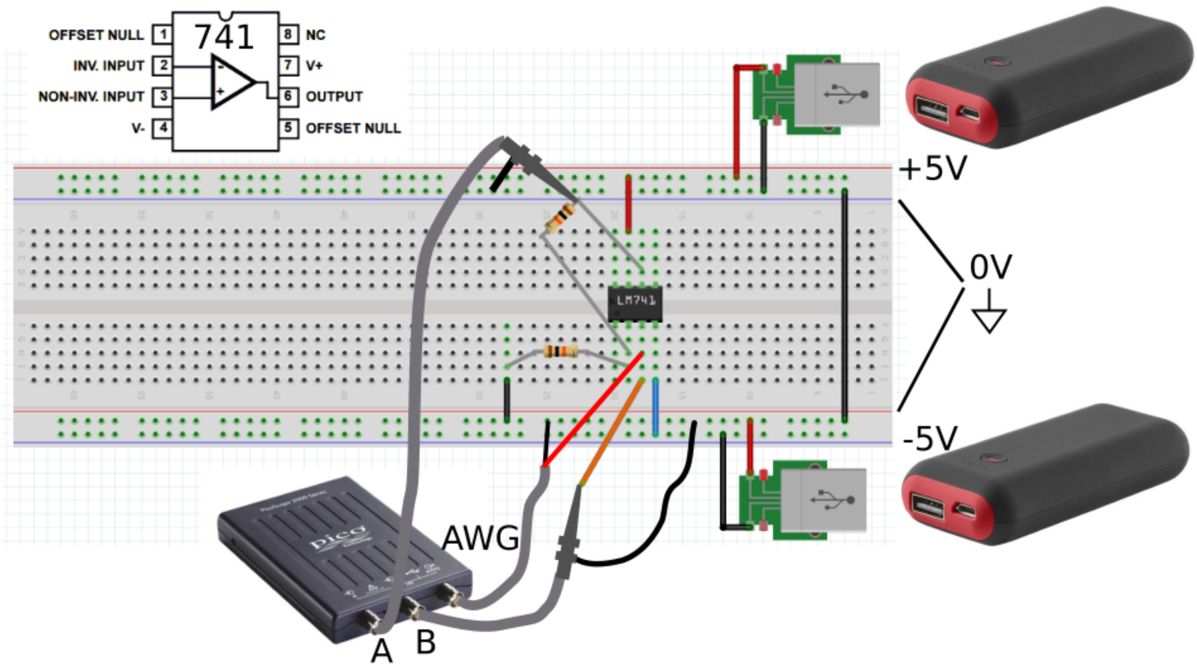
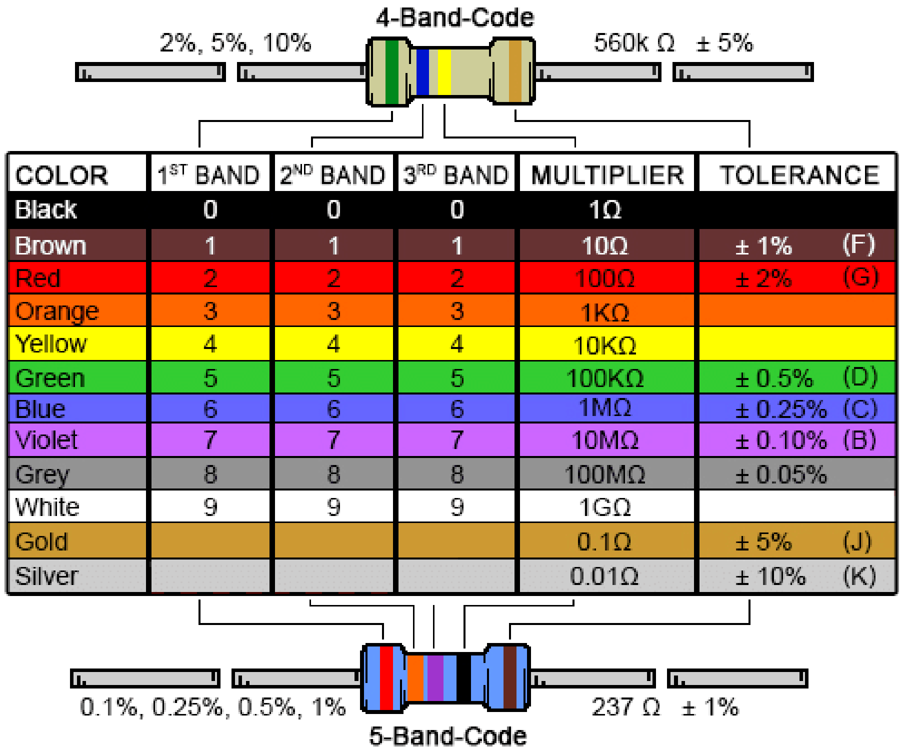


Figure 2: Non-Inverting Amplifier, prototype on breadboard



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Figure 3: Resistor color chart

range for channel A to ±2 V and for channel B to ±200 mV. Fig. 4 shows the PicoScope setup and the input voltage (channel B) and output voltage (channel A) waveforms.

Measure the amplitude of the input and output voltage waveforms. Is the simulated and measured gain the same?

Answer:

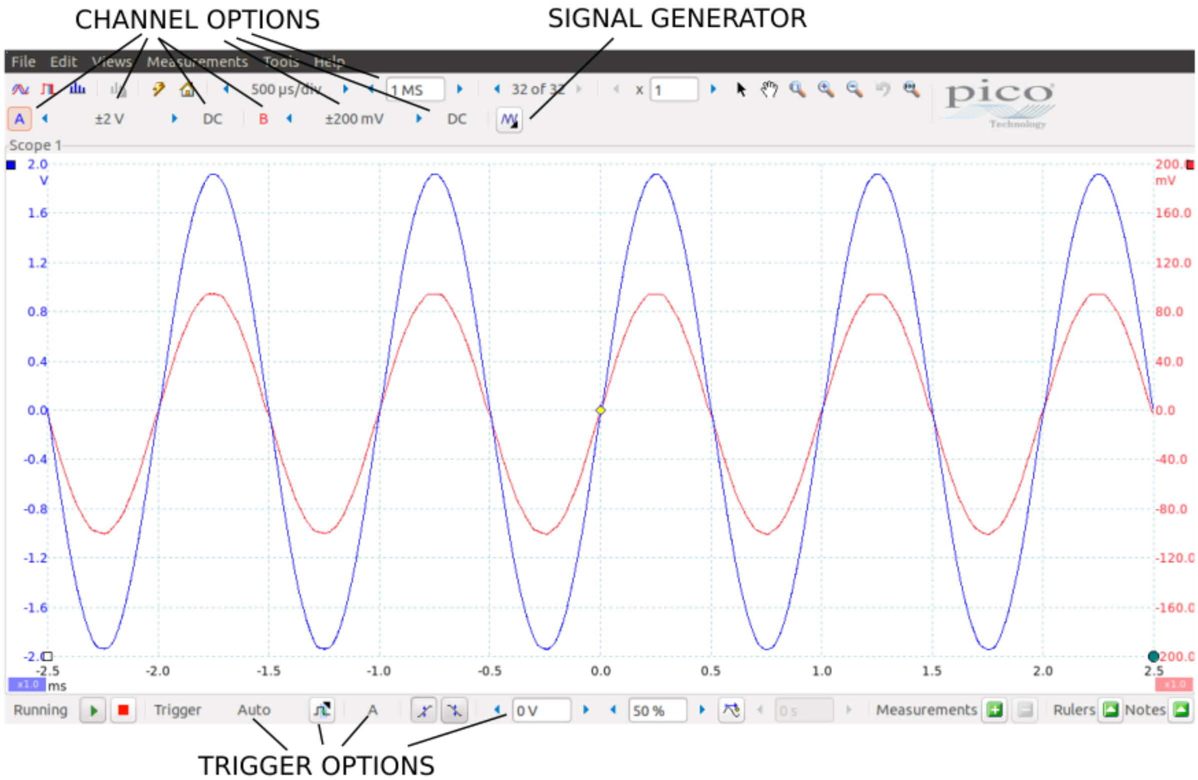


Figure 4: PicoScope setup

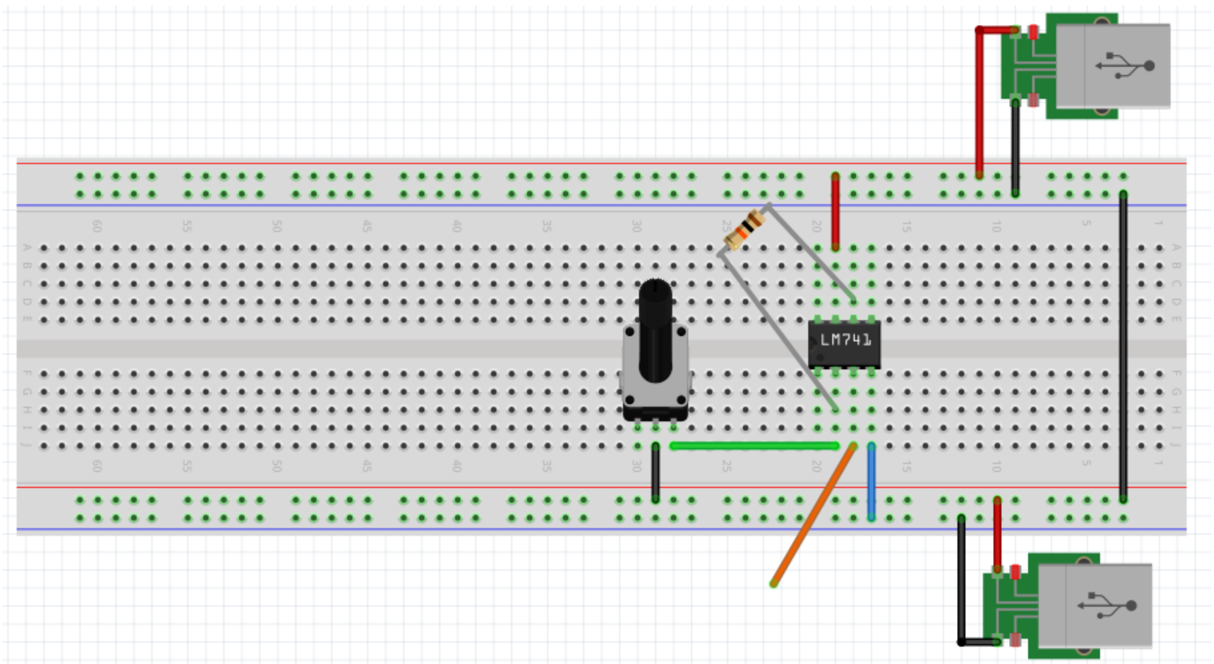


Figure 5: non-inverting amplifier with variable gain

Disconnect the power banks batteries. Replace R2 by a potentiometer as shown in Fig. 5 and connect the power banks batteries again. Now the amplifier has variable gain! Move the potentiometer and experiment with different gains. Increase the gain until the output starts to clip.

At what positive and negative voltage does the output of the amplifier clips?

Answer:

Reduce the gain so that the amplification remains in the linear region. Change the view to spectrum mode and reduce the frequency span to 10 kHz. Identify the fundamental and harmonics both at the input and output. Take a screenshot of the spectrum.

Is there a visible distortion deterioration between the input and output? Explain.

Answer:

Change the view to the time domain and increase the gain so that the output voltage starts clipping. Change the view to the spectrum mode. Check the levels of the fundamental and harmonics. Take a screenshot of the spectrum.

Question 6: Is there a visible distortion deterioration between the input and output? Explain.

3 Summing Amplifier

3.1 Circuit Theory

Fig. 6 shows a summing amplifier. The objective of this circuit is to amplify V3 a factor of 10 and provide a 1.5V DC offset to the amplified so that it can be connected to an analog-to-digital (ADC) converter which accept signals from 0 V-3.3 V. Your task is to find values of R2 and R3 that accomplish these requirements.

Your hand calculation:

Answer: R2 =

Answer: R3 =

3.2 Circuit Simulation

Open QUCS and set up a schematic like in Fig. 6. Replace R2 and R3 with the values that you calculated and run a transient simulation. Save a screen-shot of the simulation plot and add it to an appendix at the end of this lab. Is the simulated and calculated gain the same?

Comments:

3.3 Circuit construction and measurements

Mount the circuit of Fig. 6 on the breadboard (you just need to do small modifications to what you did in Section 3). Connect the PicoScope to the circuit: channel A to VOUT, channel B to VIN, and AWG to VIN. Connect the 5V power bank batteries, and start the PicoScope software. Configure the generator and oscilloscope settings in the same way we did in Section 2. Observe the input and output waveforms. Save a screenshot and append it to the end of the lab. Are your measurements consistent with your simulations?

Comments:

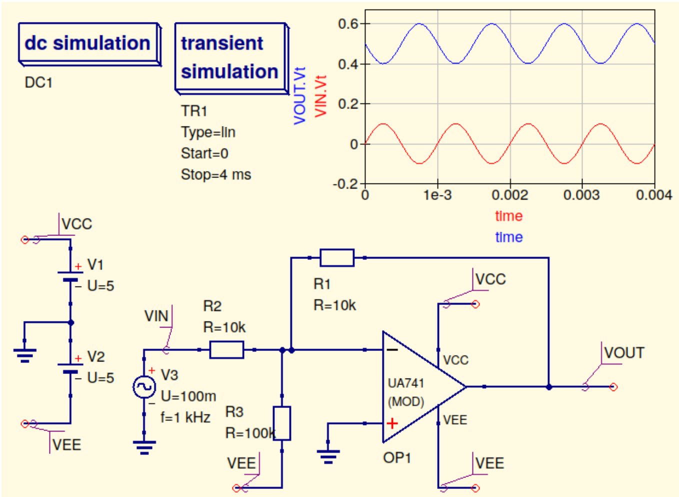


Figure 6: Summing Amplifier

4 Comments on the laboration

Here you can give as much feedback as possible on this lab. How long time did it take you to complete this lab? Did you find this lab useful to reinforce underlying concepts such as inverting/non-inverting amplifier, summing amplifier? Did the practical experimentation on the breadboard clarify concepts from the book and lectures?