RAIL TO RAIL OP AMP AMPLIFIER WITH UNIPOLAR SUPPLY

I. OBJECTIVES

a) Understanding the functioning of a rail-to-rail OP AMP amplifier.
b) Understanding the use of a rail-to-rail OP AMP amplifier with unipolar supply for input signals with a 0 DC voltage component.
c) Developing a general method for solving the unipolar rail-to-rail OP AMP amplifier problem regarding a 0 DC voltage component input signal.

II. COMPONENTS AND DEVICES

We will use the breadboard, an AD820 OP AMP rail-to-rail amplifier, resistors and capacitors. The circuit will be supplied using a double voltage source, the input voltage will be generated using the signal generator and the waveforms and voltage transfer characteristics will be visualized using a 2 channel oscilloscope.

III. PREPARATION

P.1. Noninverting rail-to-rail amplifier with unipolar voltage supply (+V_{PS})

a) For the circuit in Fig. 1:

- Draw the $v_O(t)$ waveform for $v_I(t)$ – triangular signal with 0.4V amplitude, frequency of 1kHz and a 0V DC component value.
- Which part of the input voltage does the circuit amplify? Explain.
- Draw $v_O(t)$ for $v_I(t)$ - triangular signal with 1.5V amplitude, frequency of 1kHz and a 0V DC component value.
- Draw the VTC $v_O(v_I)$ for $v_I(t)$ of amplitude 1.5V.

b) For the circuit in Fig.2., draw:

- Input voltage waveforms at the noninverting input of the OP AMP and $v_O(t)$ for $v_I(t)$- triangular voltage of amplitude 0.4V at 1kHz and a 0V DC component. Explain the shape of the output voltage.

c) For the circuit in Fig. 3:

- Draw the waveforms for the input voltage at the noninverting OP AMP input, the C_2 capacitor voltage and $v_O(t)$ for $v_I(t)$ - triangular voltage of 0.4V amplitude at 1kHz with a 0V DC component.
- What part of the input signal does the circuit amplify? Explain.

- Determine the AC gain value.-v_o/v_i.
- Determine the DC gain value – the DC component value of v_O/ the DC component value of v_I.
- Draw $v_O(t)$ and the VTC $v_O(v_I)$ for $v_I(t)$ of amplitude 1.5V.

P.2. Inverting amplifier with unipolar voltage supply (+V_{Al})

a) For the circuit in Fig. 4:

- Draw the $v_O(t)$ waveform for $v_I(t)$ – triangular signal with 0.4V amplitude, frequency of 1kHz and a 0V DC component value.
- Which part of the input voltage does the circuit amplify? Explain.
- Draw $v_O(t)$ for $v_I(t)$ - triangular signal with 1.5V amplitude, frequency of 1kHz and a 0V DC component value.
- Draw the VTC $v_O(v_I)$ for $v_I(t)$ of amplitude 1.5V.

b) For the circuit in Fig. 5:

- Draw the waveforms for the input voltage at the noninverting OP AMP input, the C_2 capacitor voltage and $v_O(t)$ for $v_I(t)$- triangular voltage of 0.4V amplitude at 1kHz with a 0V DC component.
- What part of the input signal does the circuit amplify? Explain.
- Determine the AC gain value.-v_o/v_i.
- Determine the DC gain value – the DC component value of v_O/ the DC component value of v_I.
- Draw $v_O(t)$ and the VTC $v_O(v_I)$ for $v_I(t)$ of amplitude 1.5V.

IV. EXPLORATION AND RESULTS

1. Noninverting rail-to-rail amplifier with unipolar voltage supply (+V_{PS})

Exploration

a) Build the circuit in Fig. 1 supplied with +12V. Apply at the input a triangular voltage of amplitude 0.4V at 1kHz and 0V DC component.

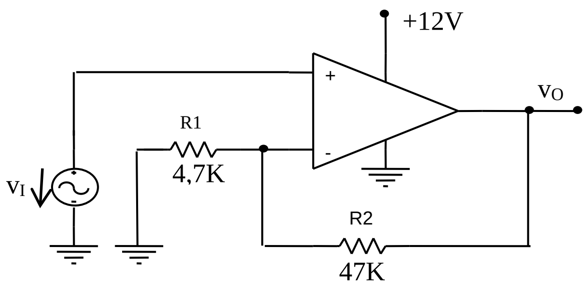

Fig. 1. Non inverting amplifier with unipolar supply

- Visualize on the oscilloscope the input and output voltages and draw their waveforms.

- Raise the input amplitude up to 1.5 V, observe it on the oscilloscope and draw the waveforms for the input and output signals (Y-t mode).
- With the oscilloscope in X-Y mode, observe and draw the VTC $v_O(v_I)$.

b) In order to amplify the whole input signal (and not just half of it) build the circuit in Fig 2. The input voltage is triangular, 0.4V amplitude at 1kHz and 0V DC component.

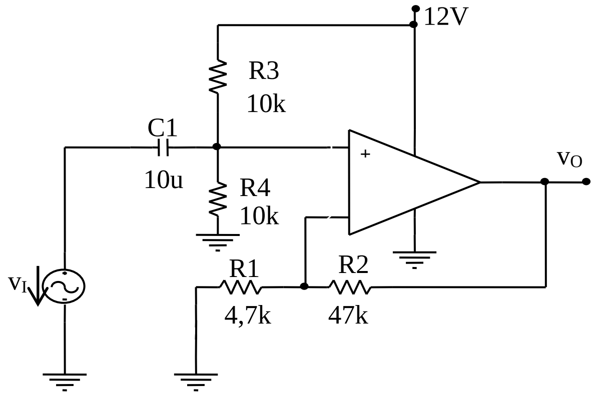

Fig. 2. Noninverting amplifier after applying a polarization voltage

- Visualise on the oscilloscope (DC button switched ON) in Y-t mode the input and output voltages, and then draw the waveforms.

c)

By different values of the AC and DC gains, the limiting of the output voltage is avoided. The circuit is modified with respect to b) by introducing the C_2 capacitor, resulting the circuit in Fig. 3. The input is a triangular voltage of amplitude 0.4V at 1kHz and 0V DC component.

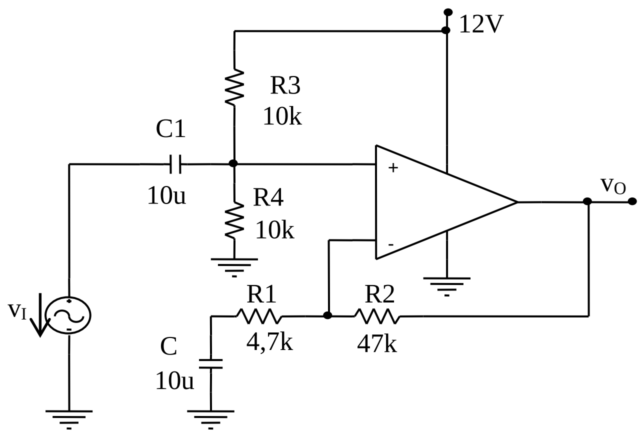

Fig. 3. Noninverting amplifier final circuit

- Visualise on the oscilloscope (DC button switched ON) in Y-t mode and draw the waveforms for the input and output voltages.
- Raise the input voltage amplitude up to 1.5V, visualise the waveforms for the input and output (Y-t mode) on the oscilloscope, the VTC $v_O(v_I)$ (X-Y mode) and draw them.

Results

a)

- $v_I(t)$, $v_O(t)$ waveforms as shown on the oscilloscope and pointing out their amplitudes; $v_I(t)$ of amplitude 0.4V. Explain why we obtain only positive values for the output voltage. Can the voltage gain value be determined? Why?
- $v_I(t)$ and $v_O(t)$ with their amplitudes; $v_I(t)$ of amplitude 1.5V.
- VTC $v_O(v_I)$ with point coordinates that determine the active region.

b)

- $v_I(t)$, $v_O(t)$ waveforms drawn as they appear on the oscilloscope and write down the amplitudes. How can you explain the fact that the output of the amplifier is always limited?

c)

- $v_I(t)$, $v_O(t)$ waveforms drawn as they appear on the oscilloscope and write down the amplitudes.
- AC gain sign and value determined from the oscilloscope.
- DC gain sign and value determined from the oscilloscope.
- $v_I(t)$, $v_O(t)$ and VTC $v_O(v_I)$ for $v_I(t)$ of amplitude 1,5V.

2. Inverting amplifier with unipolar voltage supply ($+V_{PS}$)

Exploration

a) Build the circuit in Fig. 4, supplied with +12V, by applying at the input a triangular voltage of amplitude 0.4V at 1kHz, 0V DC component.

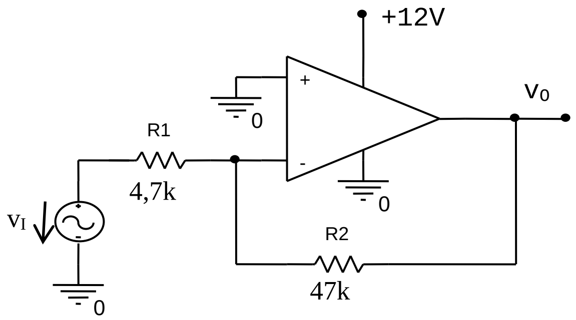

Fig. 4. Inverting amplifier with unipolar supply

- Visualise on the oscilloscope, in Y-t mode, the input and output voltages and draw them.
- Raise the value of the input up to 1.5V, visualise on the oscilloscope and then draw the waveforms for the input and output voltages.
- With the oscilloscope in X-Y mode, visualise and draw the VTC $v_O(v_I)$.

b) b) Build the circuit in Fig. 5, supplied with +12V, by applying at the input a triangular voltage of amplitude 0.4V at 1kHz, 0V DC component.

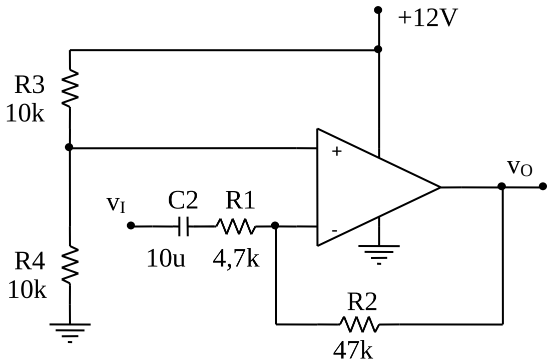

Fig. 5. Final circuit for the inverting amplifier

- Visualise on the oscilloscope (DC button is pushed), in Y-t mode, and draw the input and output voltage waveforms.
- Raise the input amplitude up to 1.5V, visualise the input and output voltage waveforms (Y-t mode) and the VTC (X-Y mode).

Results

a)

- $v_I(t)$, $v_O(t)$ waveforms drawn from the oscilloscope with their values written down for $v_I(t)$ of 0.4V amplitude. Explain why the output voltage has only positive values. Can the voltage gain be determined? Why?
- $v_I(t)$ and $v_O(t)$ with their amplitudes written down for $v_I(t)$ of amplitude 1.5V.
- VTC $v_O(v_I)$ with the point coordinates that determine the active region.

b)

- $v_I(t)$, $v_O(t)$ waveforms as they appear on the oscilloscope with their amplitudes written down.
- AC gain sign and value determined from the oscilloscope.
- DC gain sign and value determined from the oscilloscope.
- $v_I(t)$, $v_O(t)$ and CSTV $v_O(v_I)$ for $v_I(t)$ of amplitude 1.5V.

Bibliography

1. Oltean, G., Sipos, Emilia, Oltean, Ioana – A New Approach of Op-Amp Amplifier Biasing, Buletinul Ştinţific al Universităţii Politehnica din Timişoara, Simpozionul de Electronică şi telecomunicaţii - ETc, 2004, Octombrie 22-23, Timişoara, Romania, ISBN – 1583-3380, Tom 49, Fascicola 2, pag. 328-331
2. Oltean, G., ş.a. - Electronic devices and circuits, Electronic devices, Laboratory manual, UT Pres, Cluj-Napoca, 2004.
3. Oltean, G. - Dispozitive şi circuite electronice, Ed. Risoprint, Cluj-Napoca, 2003.
4. http://www.bel.utcluj.ro/dce/didactic/ed/ed.htm