BASIC AMPLIFIERS WITH OP-AMP

I. OBJECTIVES

a) Determination of the gain and the input resistance for the inverting, non-inverting and differential amplifiers.
b) Determination of the causes that lead to the limitation of the amplifiers output voltage (saturation of the amplifier).

II. COMPONENTS AND INSTRUMENTATION

You will use the experimental board containing a 741 OP-AMP, an 10K potentiometer and different resistors. In order to compute the input resistance you will use a decadic resistor. The differential supply of the board is achieved using a double dc regulated voltage supply. The input voltage is obtained from the signal generator. To visualize the voltages waveforms you will use a dual-channel oscilloscope and for measuring the dc voltages, a dc voltmeter is used.

The connection diagram of the 741 IC terminals is given in Experiment no.7.

III. PREPARATION

1.P. INVERTING AMPLIFIER

1.1.P. WAVEFORMS. THE SATURATION OF THE AMPLIFIER

For this paragraph you will use the circuit from Fig 9.1.

a)

- Which is the value of the voltage gain A_v?
- What does $v_O(t)$ look like for $v_I(t)$ a sinusoidal voltage with 1KHz frequency and 1V amplitude? How about for 2V amplitude?

b)

- Which is the value of A_v, if R^- is 44K ?
- What does $v_O(t)$ look like for R^-=44K and v_I=2sin2π1000t[V][Hz]?

c)

- The dc voltage supply is changed to ±10V.
- Find the input voltage value for which the op-amp enters the saturation region.
- What does $v_O(t)$ look like, in this case, for R^-=22K, v_I=sin2π1000t[V][Hz] ?

1.2.P. VTC

- What does the VTC look like for the circuit in Fig. 9.1?
- What does the VTC change if R^- = 44KΩ ?
- What is the range of v_O values?

2.P. NON-INVERTING AMPLIFIER

2.1.P.WAVEFORMS

- What is the value of the voltage gain for the circuit from Fig. 9.3?
- Determine the output voltage $v_O(t)$ waveform for $v_I(t)$ a sinusoidal voltage with 1V amplitude and 1KHz frequency? What about for a input voltage of 2V amplitude?
- If R=0 what is the value of the voltage gain?

2.2.P. VOLTAGE TRANSFER CHARACTERISTIC (VTC)

- What does the VTC look like for the circuit in Fig. 9.3?
- What does the above VTC change if $R^- = 44K\Omega$?

3.P. THE DIFFERENTIAL AMPLIFIER

3.1.P. WAVEFORMS

For the differential amplifier from Fig. 9.4 the differential input voltage is: $v_{Id}=v_{I1}-v_{I2}$.

- What is the value of $A_v=v_O/v_{Id}$ for the circuit in Fig. 9.4 ?
- Determine the output voltage $v_O(t)$ waveform if $v_{I1}=0.5\sin2\pi1000t$[V][Hz] and v_{I2}=0.5V-dc ? What about for v_{I1}=0.5V-dc and $v_{I2}=0.5\sin2\pi1000t$[V][Hz]?

3.2.P. VOLTAGE TRANSFER CHARACTERISTIC (VTC)

- What does the VTC $v_O(v_{ID})$ look like?

IV. EXPLORATION AND RESULTS

1.INVERTING AMPLIFIER

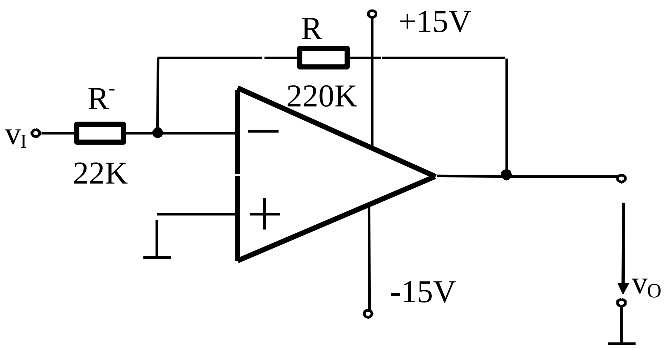

Fig. 9.1. Inverting amplifier

1.1. WAVEFORMS. THE SATURATION OF THE AMPLIFIER

Exploration

a)

- Build the circuit shown in Fig. 9.1.
- $v_I(t)$-sinusoidal signal with 1KHz frequency, obtained from the signal generator.
- With the oscilloscope on the Y-t mode, you will visualise $v_I(t)$ and $v_O(t)$ for the amplitude of v_I equal with 1V and 2V.

b)

- R^- = 44K (by connecting in series two 22KΩ resistance).
- You will visualise $v_I(t)$ and $v_O(t)$ for $v_I(t) = 2\sin2\pi1000t$ [V][Hz].

c)

- The voltage supply is changed to ±10V.
- You will visualise $v_I(t)$ and $v_O(t)$ for $v_I(t)$-sinusoidal voltage with 1KHz frequency and 1V amplitude ; R^- = 22Kohm.

Results

a)

- Draw the waveforms of $v_I(t)$ and $v_O(t)$ for v_I with amplitude of 1V and 2V.

- For v_I with 1V amplitude you will determine the voltage gain, $A_v = v_O/v_I$. What is the sign of the gain? Why?
- Compare the waveforms of v_O for v_I's amplitude values of 1V and 2V.
- How can you explain the fact that v_O is distorted for 2V amplitude of v_I
- From the waveform obtained for v_I with 2V amplitude find the range of values for v_I in order to avoid the saturation of the op-amp (the maximum undistorted output signal).

b)

- Draw the waveforms of v_I and v_O.
- How can you explain the fact that v_O is not distorted for 2V amplitude of v_I?
- What is the value of the voltage gain?

c)

- Draw the waveforms of $v_I(t)$ and $v_O(t)$.
- Compare the shape of $v_O(t)$ with the one obtained in paragraph a) for the amplitude of v_I equal with 1V.
- How does the voltage supply influence the range of v_O values?

1.2. VOLTAGE TRANSFER CHARACTERISTIC (VTC)

Exploration

Build the circuit shown in Fig. 9.1

- $v_I = 5\sin 2\pi 500t$[V][Hz] obtained for the signal generator.
- With the oscilloscope on the Y-X mode you will visualise $v_O(v_I)$.
- You will modify R^- to 44KΩ by connecting in series two resistances of 22KΩ
- You will visualise $v_O(v_I)$.

Results

- Draw the VTC for $R^- = 22K\Omega$ and $R^- = 44K\Omega$.
- Determine the voltage gain and the slope of VTC for $R^- = 22K\Omega$ and $R^- = 44K\Omega$,.$A_v = \Delta v_O / \Delta v_I$
- Which are the maximum and the minimum values of v_O ?

2.NON-INVERTING AMPLIFIER

2.1.WAVEFORMS

Build the circuit shown in Fig. 9.3.

Exploration

- $v_I(t) = \sin 2\pi 1000t$[V][Hz]-from the signal generator.
- With the oscilloscope on the Y-X mode, you will visualise $v_I(t)$ and $v_O(t)$.
- You will repeat the visualisation for v_I with 2V amplitude.
- You will draw the circuit that results by short circuiting R(R = 0).
- With the same v_I as above you will visualise $v_I(t)$ and $v_O(t)$.

Results

- Draw the $v_I(t)$ and $v_O(t)$ waveforms for v_I with 1V and 2V amplitudes and R=220KΩ, R^-=22KΩ.
- Determine the gain of the circuit
- How you can explain the v_O distorsion when v_I amplitude is 2V?
- Draw the waveforms for v_I and v_O for R=0; $R^- = \infty$.
- Determine the voltage gain.
- What is the name of the amplifier?

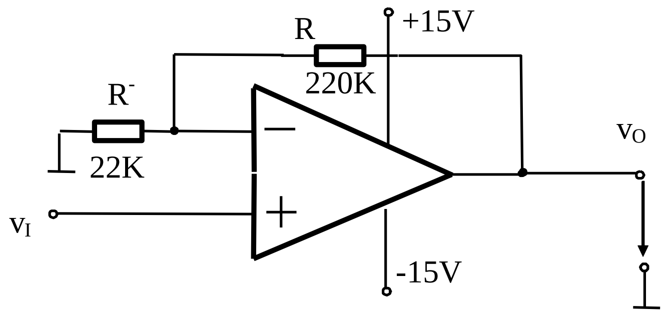

Fig. 9.3 Non-inverting amplifier

2.2.VOLTAGE TRANSFER CHARACTERISTIC (VTC)

Build the circuit shown in Fig. 9.3.

Exploration

- You will visualise on the oscilloscope $v_O(v_I)$ for: R^-=22KΩ and R^-=44KΩ (You will work as in 1.3.Exploration).

Results

- Draw the VTC for R^-=22KΩ and R^-=44KΩ.
- What are the voltage gains for both situations mentioned above?
- What are the output voltage values for which the op-amp is saturated? Compare these values with the ones obtained for the inverting amplifier.

3.THE DIFFERENTIAL AMPLIFIER

3.1. WAVEFORMS

Exploration

Build the circuit shown in Fig. 9.4

- $v_{I1}=0.5\sin2\pi1000t$[V][Hz]; v_{I2}=0.5Vdc .
- With the oscilloscope on Y-t mode you will visualise $v_I(t)$ and $v_O(t)$.
- You will exchange the voltages applied to the inputs.
- You will visualise $v_{I1}(t)$ and $v_O(t)$.

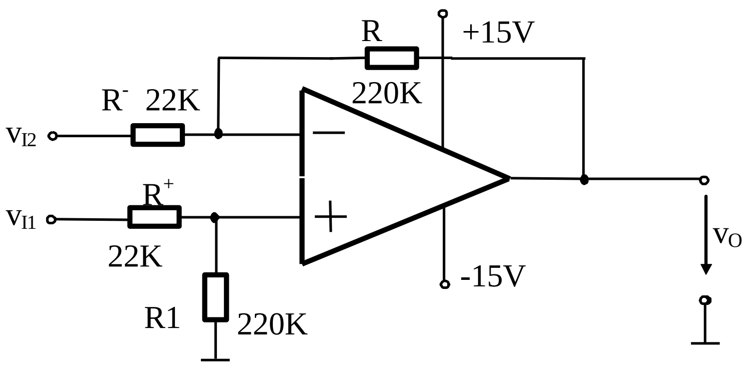

Fig. 9.4 Differential amplifier

Results

- Draw the waveforms for v_{I1},v_{I2} and v_O in both situation mentioned above.

- Why the dc component of the output voltage is different for the two situations?
- What is the value of the voltage gain?

3.2. VOLTAGE TRANSFER CHARACTERISTIC (VTC)

Haven't we already experimentally determined the VTC for the differential amplifier? If it is so, then let's not stress ourselves and get on with our lab!

Results

For the case: $v_{I1}=0$; $v_{ID} = -v_{I2}$.

- What does the VTC $v_O(v_I)$ look like deduced from the VTC $v_O(v_I)$ of the non-inverting amplifier?
- Compute the voltage gain, $A_v=v_O/v_{ID}$ beeing the slope of the VTC.