NF EFFECTS ON THE PARAMETERS OF AMPLIFIERS

I. OBJECTIVES

a) To determine, experimentally, the relationship between the feedback factor, *(1+ar)*, and the effects of the negetive feedback on the parameters of the basic amplifier: gain, active region of the OpAmp, 3dB bandwidth.

II. COMPONENTS AND INSTRUMENTATION

We use a breadboard, a TL081 OpAmp (see Fig. 1), and various resistors. The schematic is supplied using the tripple power supply. The signal generator provides the input signal and the oscilloscope is used for signal visualization.

NC - not connected
NUL - offset compensation
IN- - inverting input
IN+ - noninverting input
-PS - negative power supply
+PS - positive power supply
OUT - output

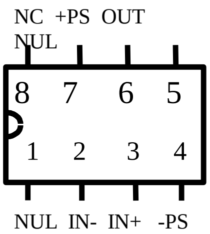

Fig. 1. TL081 connection diagram

III. PREPARATION

P.1. Basic amplifier and feedback two-port network

P1.1. Gain of the basic amplifier

- For the circuit in Fig. 2, called *basic amplifier*, compute the value of the voltage gain, *a*.
- Plot v_o for v_i - sine wave, 1kHz frequency and 50mV amplitude.
- Plot the VTC $v_o(v_i)$, for v_i in [-500mV; 500mV]. What is the range of values for v_i for which the OpAmp works in the active region?

P1.2. Transmittance of the feedback network

- The circuit in Fig. 3 is obtained by adding resistor R_r between the inverting input and the output of the OpAmp (in parallel with R_2). For the new circuit, the feedback network consists of resistors R_1 and R_r. the circuit in Fig. 3 is consequently called the *negative feedback circuit*.
- What is the value of the transmittance of the feedback network, $r = v^-/v_o$?

- What is the value of the amount of feedback, *(1+ar)*?

P2. NF effects

P2.1. Gain, OpAmp active region

- For the circuit in Fig. 3, compute the gain, *A=a/(1+ar)*. Compare this value with the one obtained for the circuit in Fig. 2.
- Plot v_o for v_i sine wave, 1kHz frequency and 1V amplitude.
- Plot the VTC $v_o(v_i)$, for v_i in [-2V; 2V]. What is the range of values for v_i for which the OpAmp works in the active region? Compare this domain with the one obtained for the circuit in Fig. 2.

P2.2. Bandwidth

- What is the relationship between the bandwidth at 3dB, *B*, for the basic amplifier, and the bandwidth for the negative feedback circuit, B_r? What about the gain-bandwidth product, for both circuits?

IV. EXPLORATIONS AND RESULTS

The results of the experiments will be filled in Table 1.

Table 1

Parameter	Basic amplifier	NF circuit
Gain		
Range of values of v_i for which OpAmp works in the active region		
Bandwidth		
Gain-bandwidth product		

1. Basic amplifier and feedback two-port network

1.1. Gain of the basic amplifier

Exploration

Build the circuit in Fig. 2.

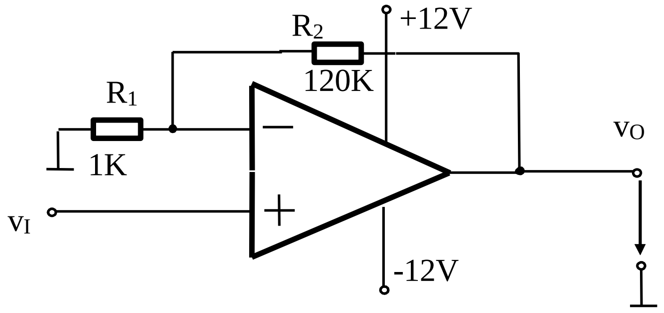

Fig. 2. Basic amplifier

- Supply the circuit with $+V_{PS}$=12V, $-V_{PS}$=-12V from the tripple power supply.
- v_i - sine wave, 1kHz frequency and 50mV amplitude, from the signal generator.
- Using the oscilloscope in Y-t mode, visualize $v_I(t)$ and $v_O(t)$.
- Increase the amplitude of v_i until OpAmp enters the saturation region (v_o is distorted).
- View VTC $v_O(v_I)$.

Results

- $v_i(t)$ and $v_o(t)$.
- The value of the gain *a* as $v_o(t)/v_i(t)$.
- What is the range of values of v_i for which the OpAmp works in the active region?
- VTC $v_O(v_I)$.

1.2. Transmittance of the feedback network

Exploration

Add a new resistor R_r to the previously built circuit, between the inverting input and the output of the OpAmp (in parallel with R_2). The circuit in Fig. 3 is obtained.

- v_i - sine wave, 1kHz frequency and 1V amplitude, from the signal generator.
- Using the oscilloscope in Y-t mode, visualize $v_O(t)$ and $v_-(t)$, the voltage at the inverting input of the OpAmp, which is now the feedback voltage, v_r.

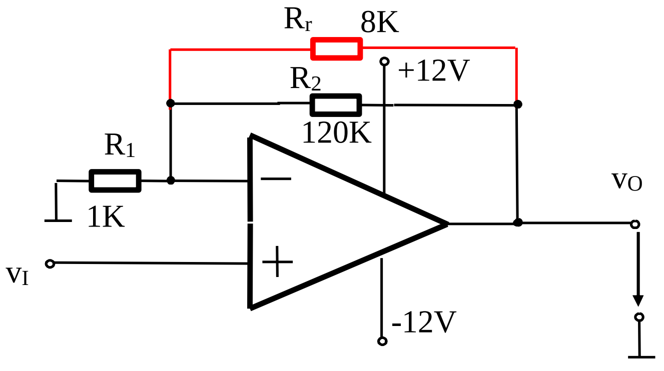

Fig. 3. Negative feedback circuit

Results

- $v_o(t)$ and $v_r(t)$.
- The value of the transmittance of the feedback network, *r*, as $v_r(t)/v_o(t)$.

- Compute the amount of feedback, *(1+ar)*.

2. NF effects

2.1. Gain, OpAmp active region

Exploration

The VTC $v_o(v_i)$ for the circuit in Fig. 3.

- v_i - sine wave, 1kHz frequency and 1V amplitude, from the signal generator.
- Using the oscilloscope in Y-t mode, visualize $v_I(t)$ and $v_O(t)$.
- Increase the amplitude of v_i until OpAmp enters the saturation region (v_o is distorted).
- View VTC $v_O(v_I)$.

Results

- $v_i(t)$ and $v_o(t)$.
- The value of the gain *A* as $v_o(t)/v_i(t)$.
- What is the range of values of v_i for which the OpAmp works in the active region?
- VTC $v_O(v_I)$.
- Compare *A* and *a*. What is the effect of the negative feedback on the gain of the basic amplifier, *a*?
- Compare the range of values for v_i for which the OpAmp works in the active region for the circuits in Fig. 2 and Fig. 3.

2.2. Bandwidth

Exploration

- For the circuit in Fig. 2, v_i sine wave, 1kHz frequency and 50mV amplitude, from the signal generator.
- For this frequency, the OpAmp is inside the frequency band.
- Read the amplitude of v_o from the oscilloscope.
- Deduce the 3dB bandwidth, *B*, for the basic amplifier. Since the low cutoff frequency, f_L, is very low, the 3dB bandwidth will be determined only by the high cutoff frequency, f_H.
  The high cutoff frequency f_H is obtained as follows:
  - read the amplitude of v_o from the osciloscope, for the v_i specified above.
  - Increase the freqeuncy of v_i until the amplitude of v_o drops to $\frac{1}{\sqrt{2}} = 0{,}707$ of the previously read value.
  - Read the frequency from the signal generator. This is the high cutoff freqeuncy, f_H.

- Fiind the 3dB bandwidth for the negative feedback circuit, B_r.

- Repeat the previously described procedure for the circuit in Fig. 3, using v_i sine wave, 1kHz frequency and 1V amplitude, from the signal generator.

Results

- B, B_r
- Is it true that $B_r = B \cdot (1 + ar)$?
- The 3dB bandwidth for the negative feedback circuit is ………….. than the one of the basic amplifier.
- What about the gain-bandwidth product?

REFERENCES

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2. Dascălu, D., ş.a., Dispozitive şi circuite electronice, Editura Didactică şi Pedagogică, Bucureşti, 1982.

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