ELECTRONICS

Practical work 2

APPLICATIONS OF OPERATIONAL AMPLIFIERS

1. Study of inverting operational amplifier.

1.1. Compose the inverting operational amplifier (OA) circuit according to the schematic in Fig.1.

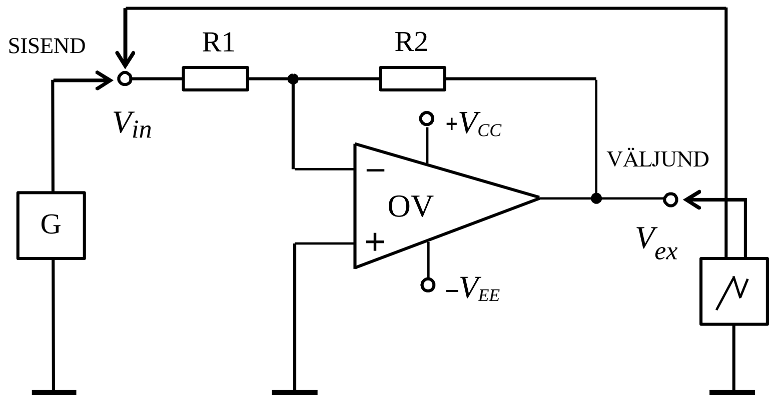

Fig. 1 Schematic of the inverting OA.

Check the power supply voltage on the pins 4 and 8: $+V_{CC}$ = 10,   [**V**]; $-V_{EE}$ = -10,   [**V**].

Adjust the input source on 400 Hz sine wave signal.

Determine by means of the oscilloscope and voltmeter the transfer response $V_{ex\,m} = f\,(V_{in\,m})$ for inverting circuit.

Complete the Table 1 with the results of measurements V_{in} and V_{ex}.

Calculate the voltage gain A_v for the amplifier and compare it with the theoretical value:

$A_{v\,th}$= -R2/R1.

Plot the transfer response curve for the inverting OA in Fig. 2.

Determine the phase shift φ for output voltage:

φ =   °.

Table 1

R1 = kΩ ; R2 = kΩ .				
V_{in} [V]	V_{ex} [V]	$V_{in\,m}$ = =$V_{in}\sqrt{2}$ [V]	$V_{ex\,m}$ = =$V_{ex}\sqrt{2}$ [V]	A_v

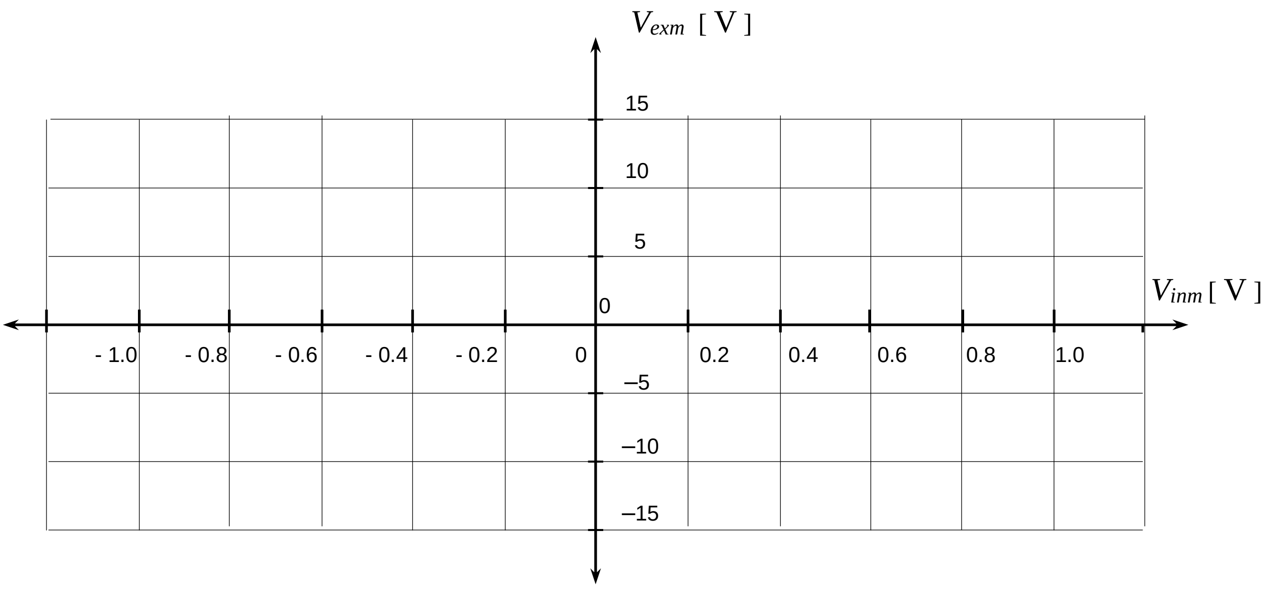

Fig. 2 Transfer responses for the inverting and noninverting OA.

1.2. Adjust the input square wave signal v_{IN} on the base unit at the maximum frequency .
Measure the durations of rise t_r and fall t_f times .
Note the rise time t_r , fall time t_f and add the missing parts to output voltage curve in Fig. 3

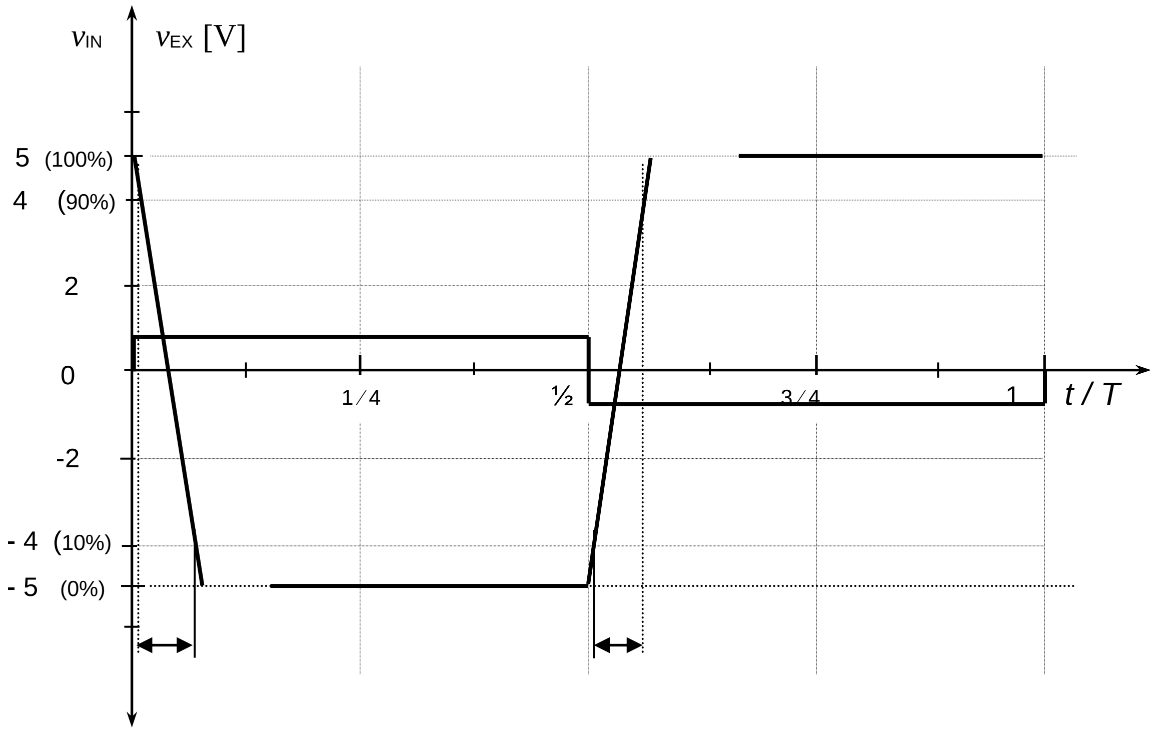

Fig. 3 Inverting OA input and output voltage curves for slew rate measurement.

Calculate the slew rate *(SR)* for OA, using Δv_{EX} and durations of rise t_r and fall t_f times:

$$SR = \frac{\Delta v_{EX}}{t_{(r,f)}} = \frac{\qquad}{\qquad} = \qquad [\mathrm{V}/\mu\mathrm{s}];$$

2. Study of noninverting operational amplifier.

Compose the noninverting OA circuit according to the schematic in Fig.4.

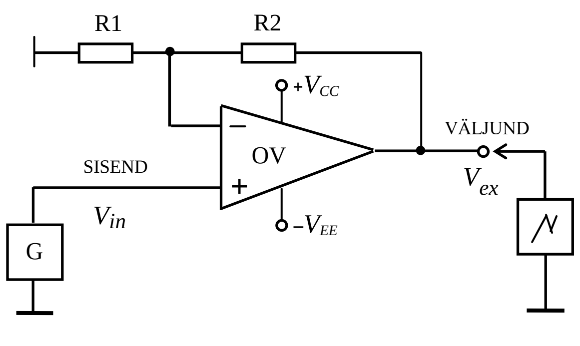

Fig. 4 Schematic of the noninverting OA.

2.1. Set the input source on 400 Hz sine wave signal and determine by means of the oscilloscope and voltmeter the transfer response for noninverting circuit $V_{ex\,m} = f\,(V_{in\,m})$.

Write the results into the Table 2. Calculate the voltage gain A_v for the circuit and compare it with the theoretical value $A_{v\,th}$.

$$A_{vni\,th} = v_{ex} / v_{in} = \qquad = \qquad = \qquad ;$$

Tabel 2.

R1 = kΩ ; R2 = kΩ ;				
V_{in} [V]	V_{ex} [V]	$V_{in\,m}$ = $=V_{in}\sqrt{2}$ [V]	$V_{ex\,m}$ = $=V_{ex}\sqrt{2}$ [V]	A_{vni}

Plot the transfer response curve for the noninverting OA in Fig. 2.

Determine the phase shift φ for output voltage:

$$\varphi = \qquad °.$$

2.2. Adjust the input square wave signal v_{IN} on the base unit at the maximum frequency .
Measure the durations of rise t_r and fall t_f times .
Note the rise time t_r , fall time t_f and add the missing parts to output voltage curve in Fig. 5.

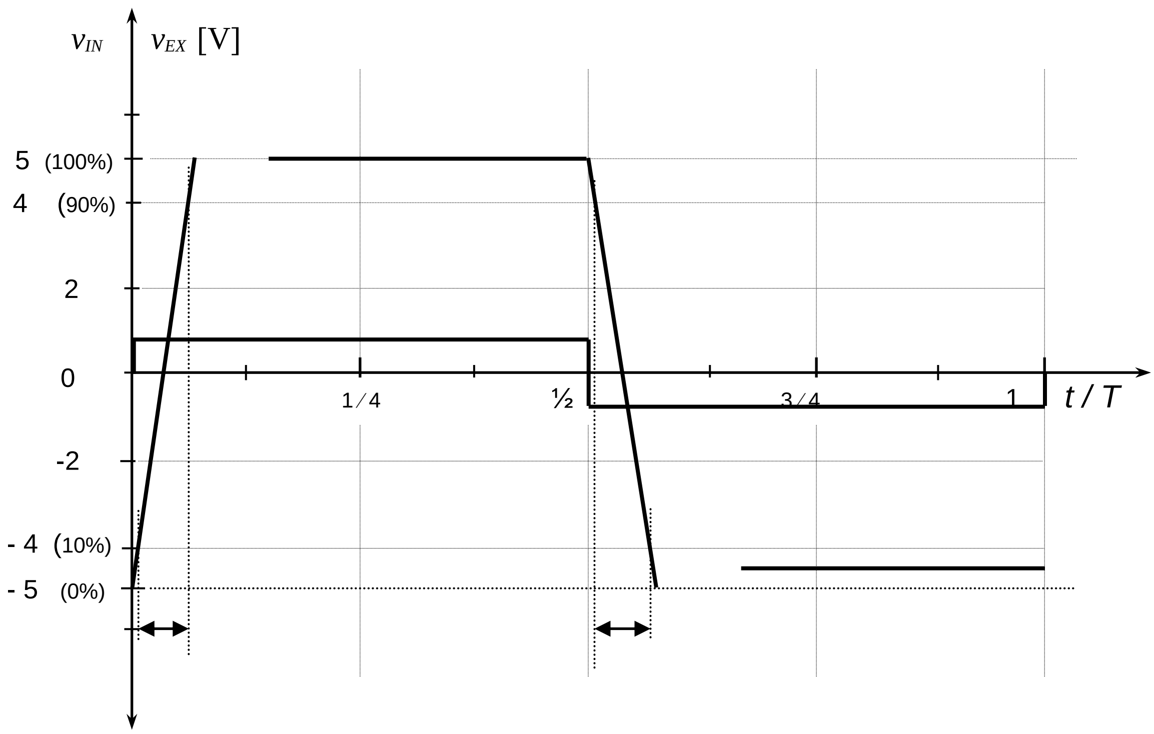

Fig. 5 Noninverting OA input and output voltage curves for slew rate measurement.

2.3. Compose the OA unit-gain follower circuit according to the schematic in Fig. 6. Input and output connections of amplifier must remain as were used earlier.

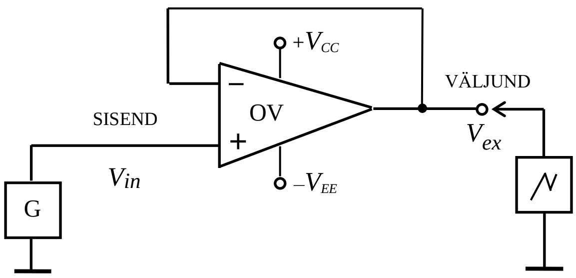

Fig. 6 Schematic of the OA unit-gain follower.

Set the input source on 400 Hz and about 1 - 2 V amplitude sine wave signal.

Determine the input and output *rms* voltages by means of the voltmeter.

Calculate the voltage gain A_v for the circuit and compare it with the theoretical value $A_{v\,th}$.

$$A_v = \frac{V_{ex}}{V_{in}} = \rule{4cm}{0.4pt} = \qquad ;$$

Theoretically: $A_{v\,th} = \dfrac{A}{A+1} = \rule{4cm}{0.4pt} = \qquad$; where:

A = ... is the open-loop gain of OA (MC33282P).

<u>3. Study of integrator on operational amplifier.</u>

Compose the integrator circuit according to the schematic in Fig. 7.

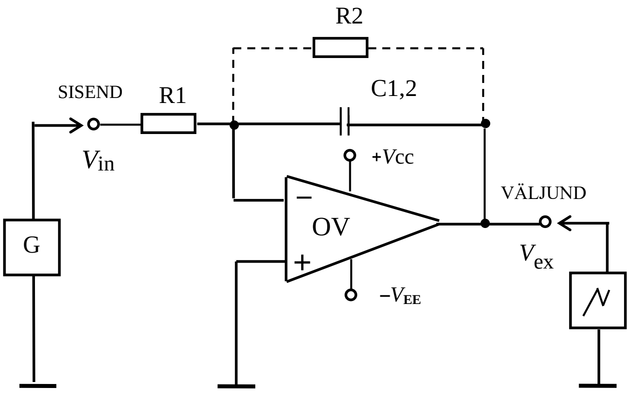

Fig. 7 Schematic of the OA integrator.

3.1. Find theoretically the logarithmic gain - frequency response for integrators R1,R2,C1 and R1,R2,C2.

Detect from the components the nominal values of the resistors:

R1 =……kΩ, R2 =……kΩ, C1 = 1nF, C2 =10 nF.

- calculate the gain value for integrators (for low frequencies region);
- calculate the critical (cutoff) frequencies for integrators;
- put the results into the Table 3 and Fig. 8 and draw the smooth curves of gain – frequency responses.

Table 3

	Integrator R1R2C1	Integrator R1R2C2
Integrator`s gain at low frequencies region;	A_{v1}[dB]	A_{v2}[dB] =
Critical (cutoff) frequencies	f_{c1} = lg f_{c1} =	f_{c2} = lg f_{c2} =

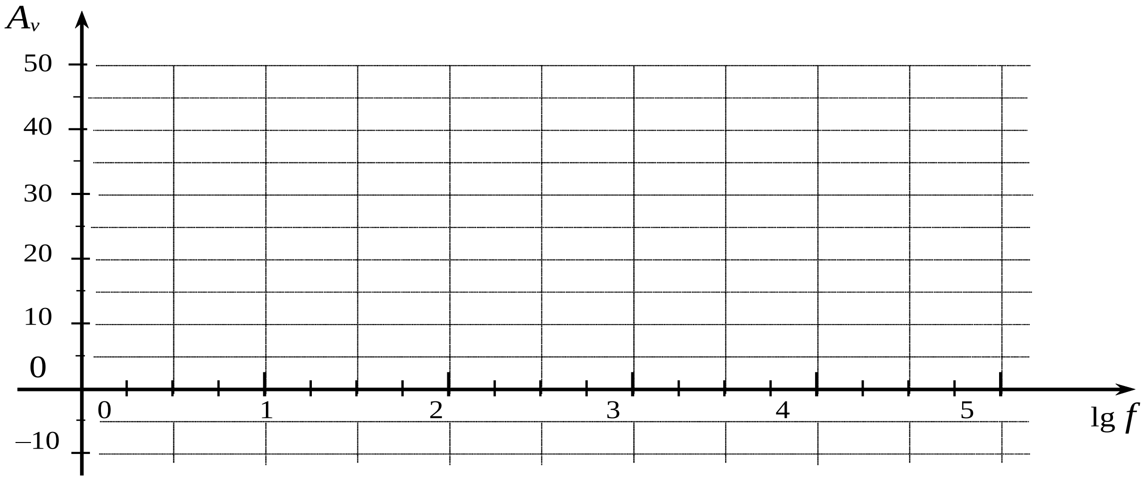

Fig. 8 Logarithmic gain - frequency response for OA integrator.

3.2. Assuming that the input source is square wave signal, determine the curve of the output voltage Δv_{EX} in response to a square wave input v_{IN} = const = ±2V; (the output voltage Δv_{EX} cannot exceed the Fig. 9 limits +2.5V and – 2.5V);

Δv_{EX} is calculated as:

$$\Delta v_{EX} = \frac{1}{R1\ C1} \int v_{IN}\, dt + v(t{=}0) = \frac{v_{IN} \cdot t}{R1\ C1} = \text{-----------------} = \qquad ;$$

The period T of the input sine wave equals:

T = 2t = ; where t is the duration of the input half-period;

and the frequency of the input sine wave equals:

f = 1/T = [Hz; c/s]

Draw the integrator`s output voltage waveforms v_{EX} in Fig.9 and record the calculated end points for half-period and full period on this curve;
Add the durations of half-period and full period in microseconds on this curve.

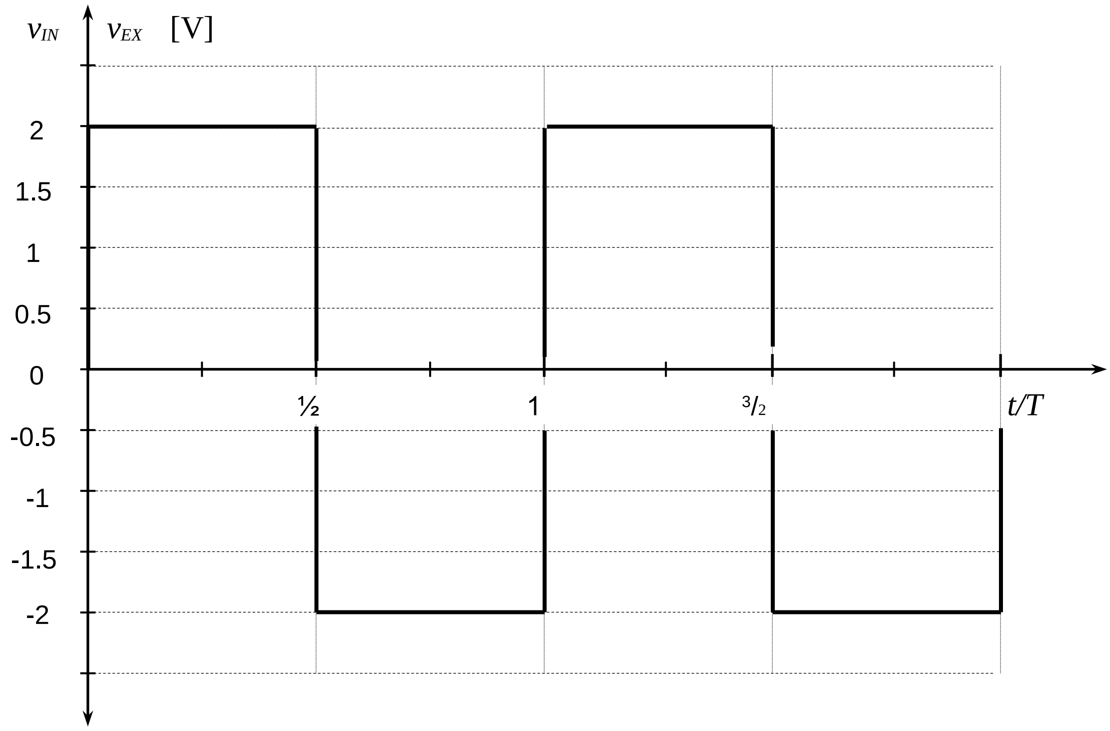

Fig. 9 Input voltage v_{IN} and output voltage v_{EX} waveforms of the OA integrator

Conclusions:
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