ITMO University

LABORATORY WORK REPORT №2
«Operational amplifiers circuits design»
Principles of Circuits

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1. Work purpose: to study parameters of Operational Amplifier and basis of Operational amplifiers circuits design

Goals:

1) Design amplifier model on the basis of operational amplifier «Inverting amplifier»

2) Simulate amplifier scheme and analyze dependencies of output voltage from load and resistor values variation

3) Analyze time domain and frequency domain of amplifier

4) Simulate underpower state/power supply check

2. Starting data

- **Required gain of amplifier** $K_{NI} = -2.000$
- **Required tolerance**: $\Delta K_{NI_{OPAMP}} = 3\%$
- **Operational Amplifier : Inverting amplifier**
- **Voltage source power supply** VPP+= 9 (V) / VPP−= 9(V)
- **Frequency for time domain simulation**

$f_{test\_1} = 100$ (Hz)

$f_{test_2} = 2000$ (Hz)

$f_{test_3} = 200000$ (Hz)

- **Test signal voltage magnitude**

$V_{test_{AC}} = V_{test} = 0.5$ (V)

- **Resistor parameters**

$R_1 = 11000$ (Ω)

$R_{fb} = 6000$ (Ω)

$R_3 = 19500$ (Ω)

$R_4 = 20001$ (Ω)

$R_{Load} = 1000000$ (Ω)

- **Amplifier scheme:** Inverting amplifier

3. Simulation

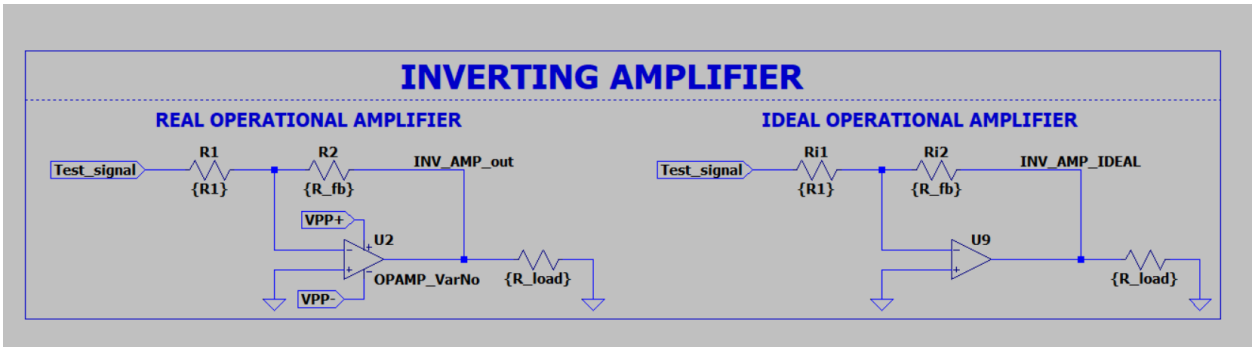

Figure 3.1 – Inverting amplifier scheme

3.1.Gain evaluation:

Gain evaluation with new resistors

$$K_{NI} = -\frac{R_{fb}}{R_1} = -0.5455$$

$$K_{NI_{max}} = -\frac{R_{fbmax}}{R_{1min}} = -\frac{R_{fb}(1+M)}{R_{1min}(1-M)} = -0.5565$$

$$K_{NI_{min}} = -\frac{R_{fbmin}}{R_{1max}} = -\frac{R_{fb}(1-M)}{R_{1min}(1+M)} = -0.5347$$

Define maximum deviation from K_{NI} defined by resistance tolerance

$$E_{NI_{R+}} = \left|\frac{K_{NI_{max}} - K_{NI}}{K_{NI}}\right| = 0.0202$$

$$E_{NI_{R-}} = \left|\frac{K_{NI_{min}} - K_{NI}}{K_{NI}}\right| = 0.0198$$

$$\Delta K_{NI_{OPAMP}} = \text{max of } E_{NI_{R+}} \text{ and } E_{NI_{R-}} = 0.0202$$

Table 1. Parameters of the amplifier

Обозначение	Simulation	
	Nominal	With tolerance variation
R_1, kΩ	11	1%
R_2, kΩ	6	1%
R_{Load}, kΩ	1 000 k (ideal)	100, 1000, 10000, 100000
K_{NI}	-0.5455	0.0202
$K_{NI_{max}}$	-0.5565	0.0202
$K_{NI_{min}}$	-0.5347	0.0198
$\Delta K_{NI_{OPAMP}}$	0.0202	0

3.2. Time domain simulation results

3.2.1. $f_{test\_1} = 100$ (Hz)

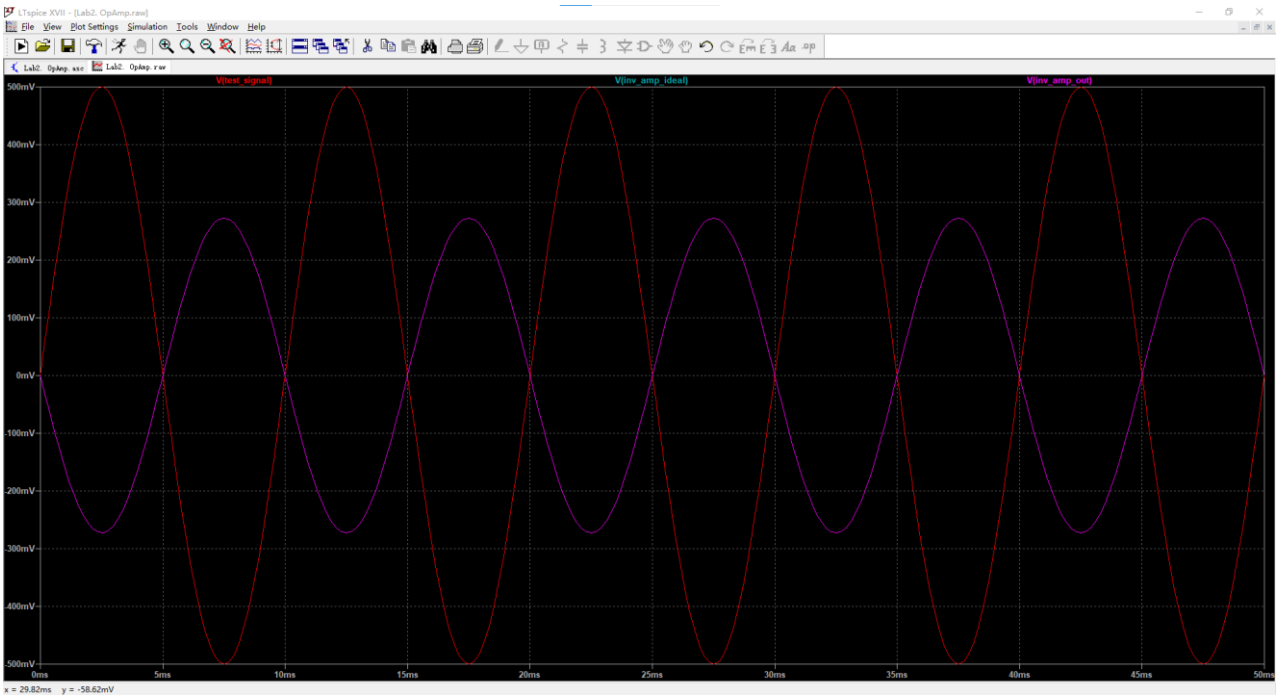

Figure 3.2 – Input and output voltages of ideal and real operational amplifiers

$f_{test\_1} = 100$, $K_{NI} = 4$, R_1 variation 1%, R_{fb} variation 1%

3.2.2. $f_{test\_2} = 2000$ (Hz)

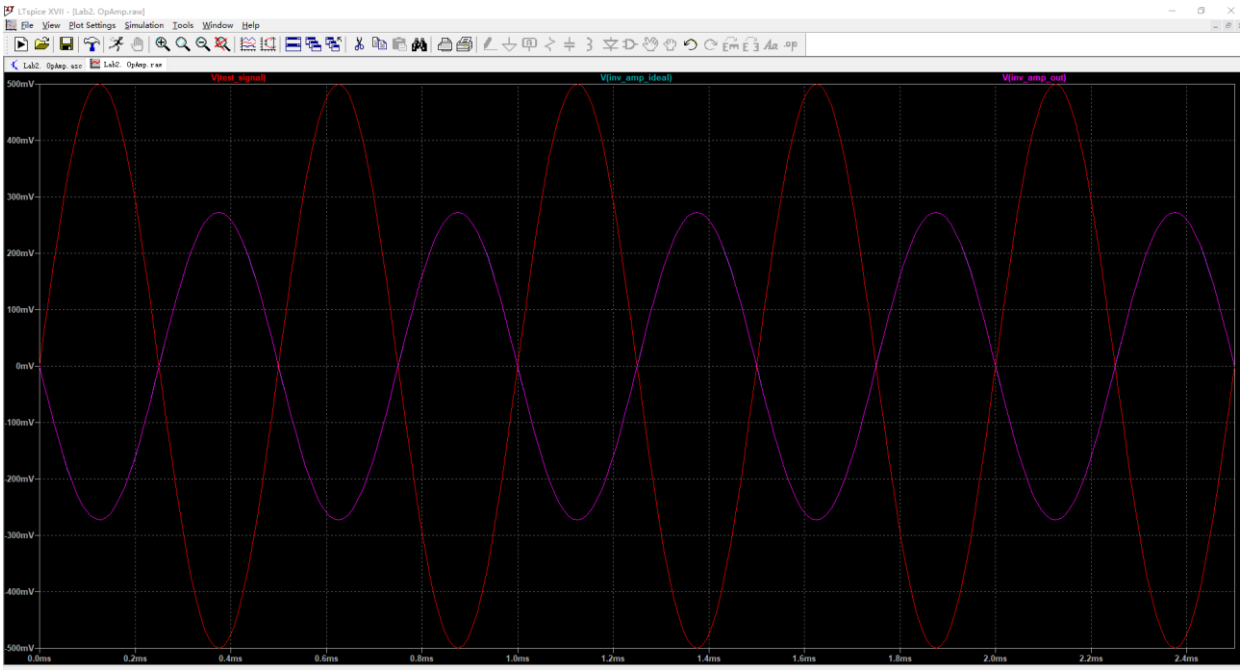

Figure 3.3 – Input and output voltages of ideal and real operational amplifiers

$f_{test_2} = 2000$, $K_{NI} = 4$, R_1 variation 1%, R_{fb} variation 1%

3.2.3. $f_{test\_3} = 200000$ (Hz)

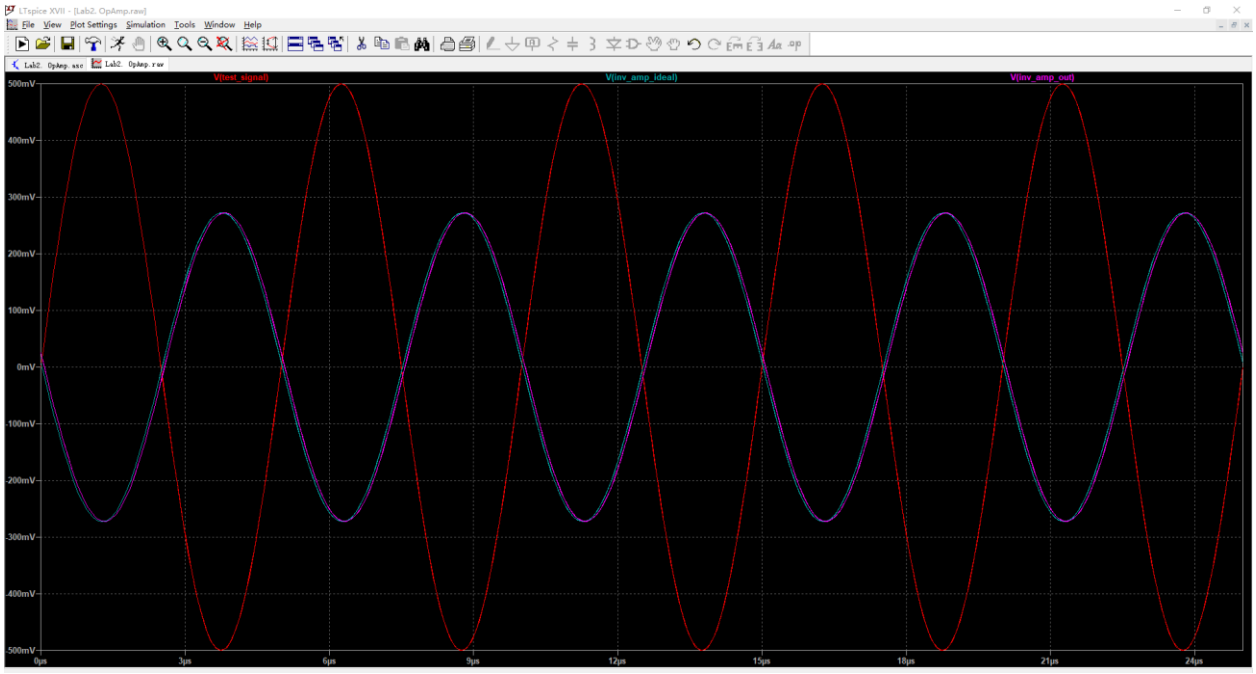

Figure 3.4 – Input and output voltages of ideal and real operational amplifiers

$f_{test\_3} = 200000$, $K_{NI} = 4$, R_1 variation 1%, R_{fb} variation 1%

3.3.Frequency domain simulation results

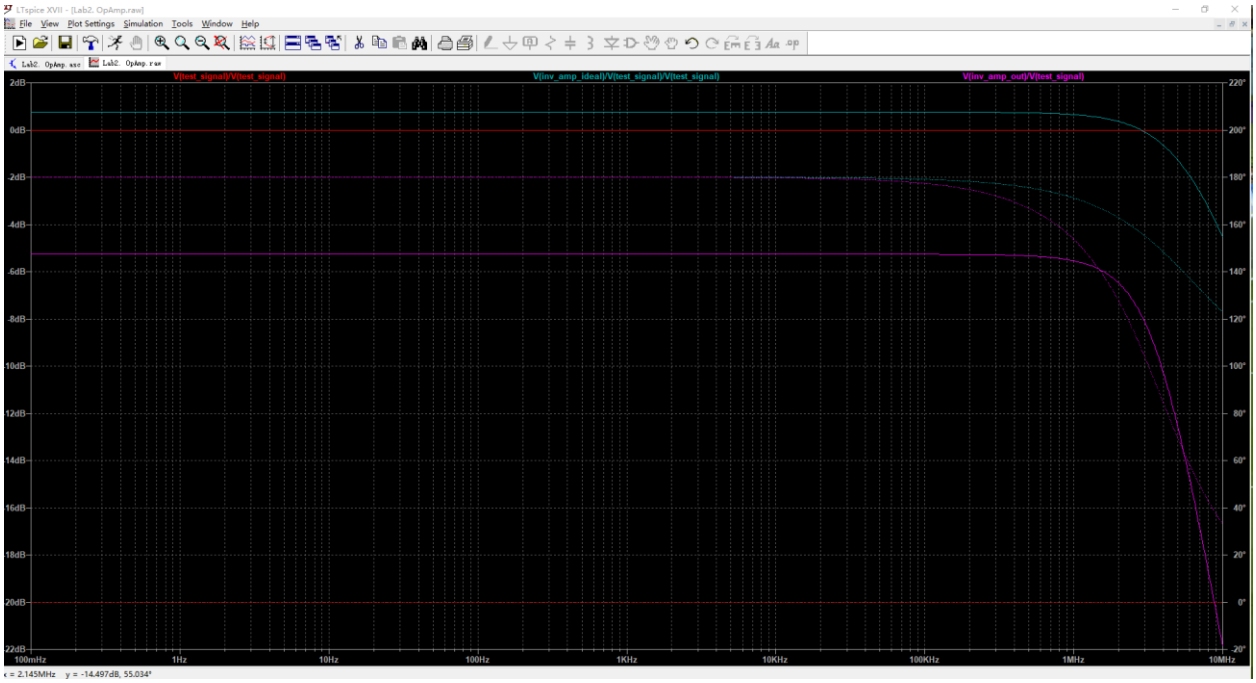

Figure 3.5 – Input and output voltages of ideal and real operational amplifiers

$K_{NI} = -0.5455$, R_1 variation 1%, R_{fb} variation 1%

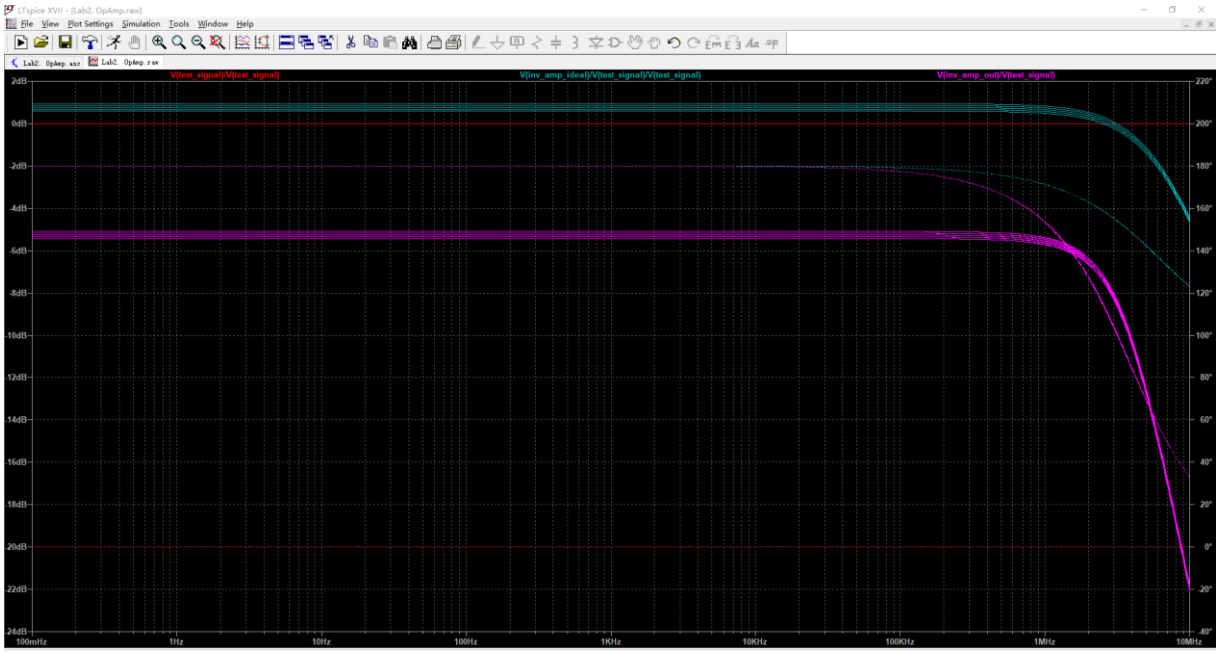

Figure 3.6 – Input and output voltages of ideal and real operational amplifiers

$K_{NI} = -0.5455$, R_1 variation 1%, R_{fb} variation 1% and R_{Load} variation

3.3.1. Simulation results

	Ideal	VarNo	Ideal	VarNo	Ideal	VarNo
frequency, kHz	100		2000		200000	
V_{test}, V	0.5	0.499	0.5	0.501	0.5	0.5
Vout, V	-0.27	0.269	-0.27	0.271	-0.27	0.27
K_{NI_exp}	-0.55	-0.54	-0.55	-0.54	-0.55	-0.55
ΔK_{NI}	0.0202	0.0182	0.0202	0.0182	0.0202	0.0202
$E_{NI_{max}}$	0.0202	0.0182	0.0202	0.0182	0.0202	0.0202
K_{OL}	-27.23	-15.13	-27.23	-15.13	-27.23	-27.72

4. Conclusions

Conclusions should contain:

1) Is it possible to realize amplifier with defined gain and gain tolerance?

   Yes.

2) In which range can be load resintace R_{Load} variated?

   10k ~ 100k

3) How was operational amplifier power supply modified?

   By using vpp.