ELECENG 2CF3: Assignment 1

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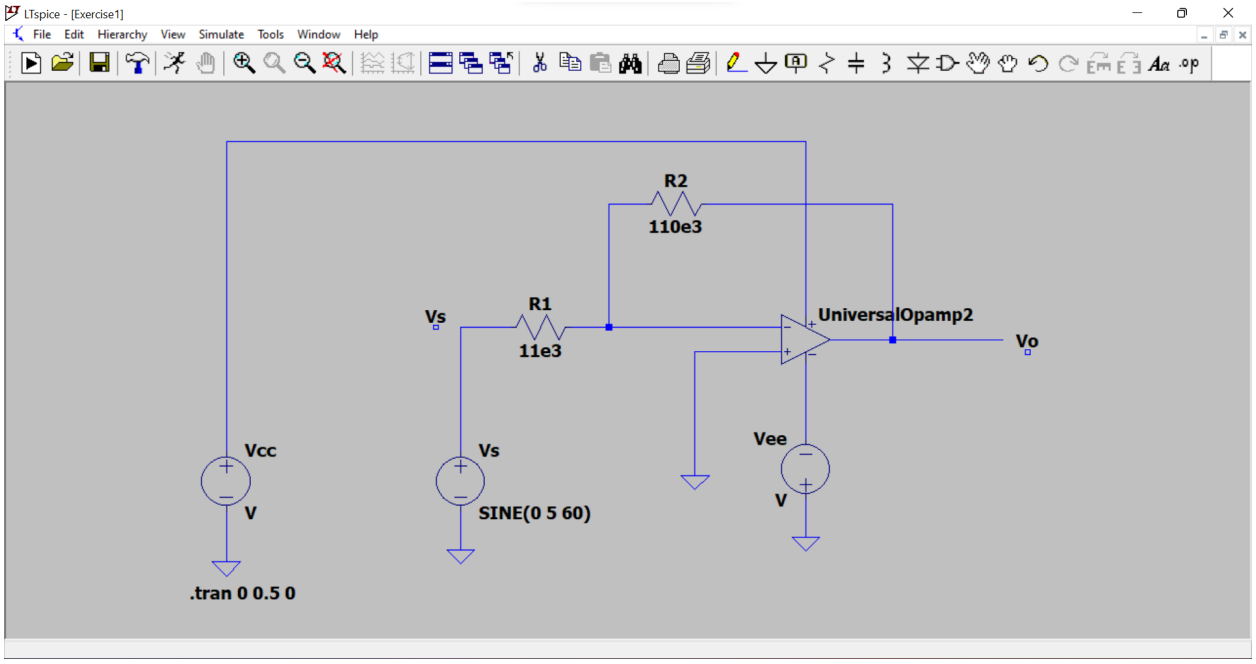
Exercise #1: Inverting Op-amp circuit

Section 1. A:

1. **Include an image of your schematic.**

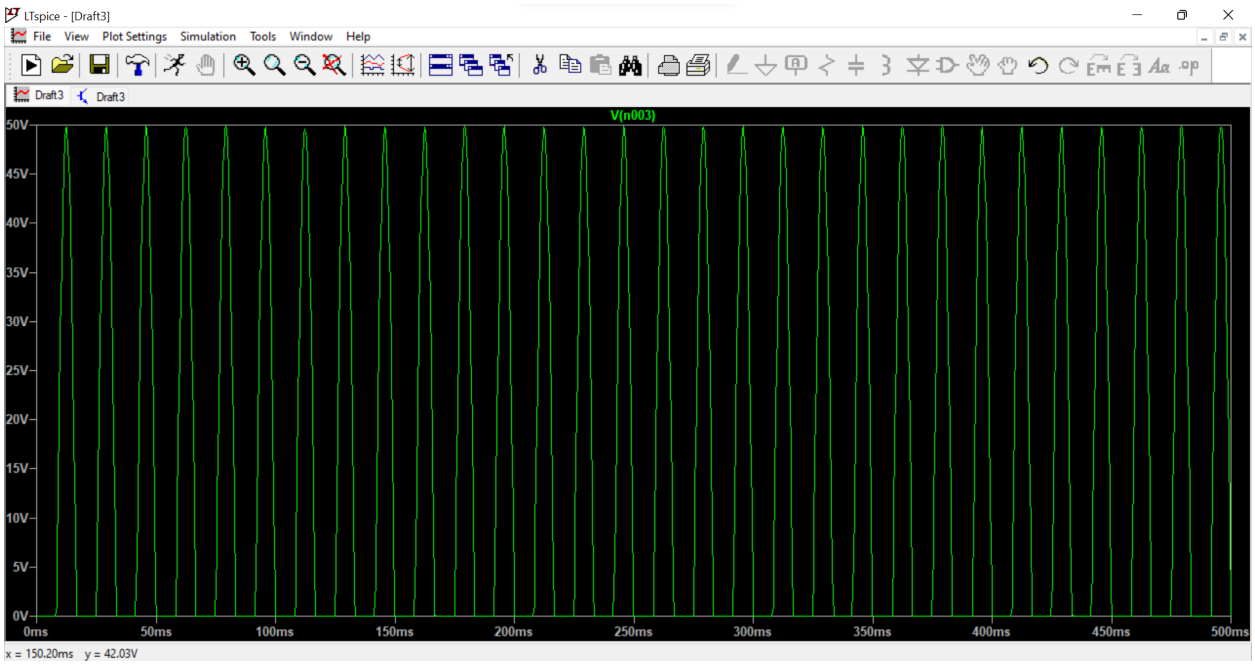


2. **Copy and Paste the complete netlist into your report. This serves as a textual summary of your circuit and thus helps with assigning part marks to incorrect submissions.**

Vs N004 0 SINE(0 5 60)
XUniversalOpamp2 0 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
R1 N002 N004 11e3
R2 N003 N002 110e3
Vee 0 N005 V
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end

Section 1. B

1. **Include the plot for *Vo* as a function of time.**



2. **Copy and Paste the complete netlist into your report.**

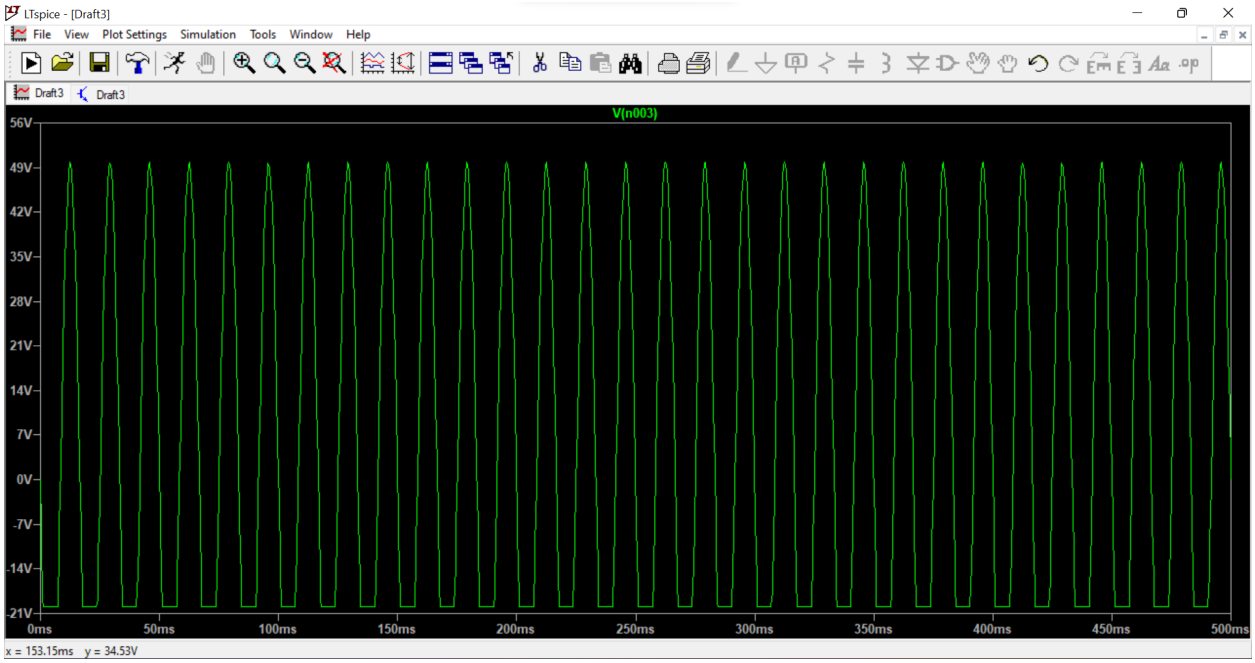
```
Vcc N001 0 100
Vs N004 0 SINE(0 5 60)
XU1 0 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg Slew=10Meg Ilimit=25m
Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
R1 N002 N004 11e3
R2 N003 N002 110e3
Vee 0 N005 0
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end
```

3. **Explain the behavior of *Vo*. State which half-periods of *Vs* (the positive or the negative) are amplified and transferred to the output and which are clipped.**

Vo receives a sinusoid input, but because Vcc is 100 V and Vee, the negative voltage, is zero, Vo does not receive a negative value. Only positive values and zero are available for Vo, except when a rectifier is involved and a negative value is intended. The positive values are trimmed for the graph above, while the negative values of the Vs scale are exaggerated.

Section 1. C

1. **Include the plot for *Vo* as a function of time.**



2. **Copy and Paste the complete netlist into your report.**

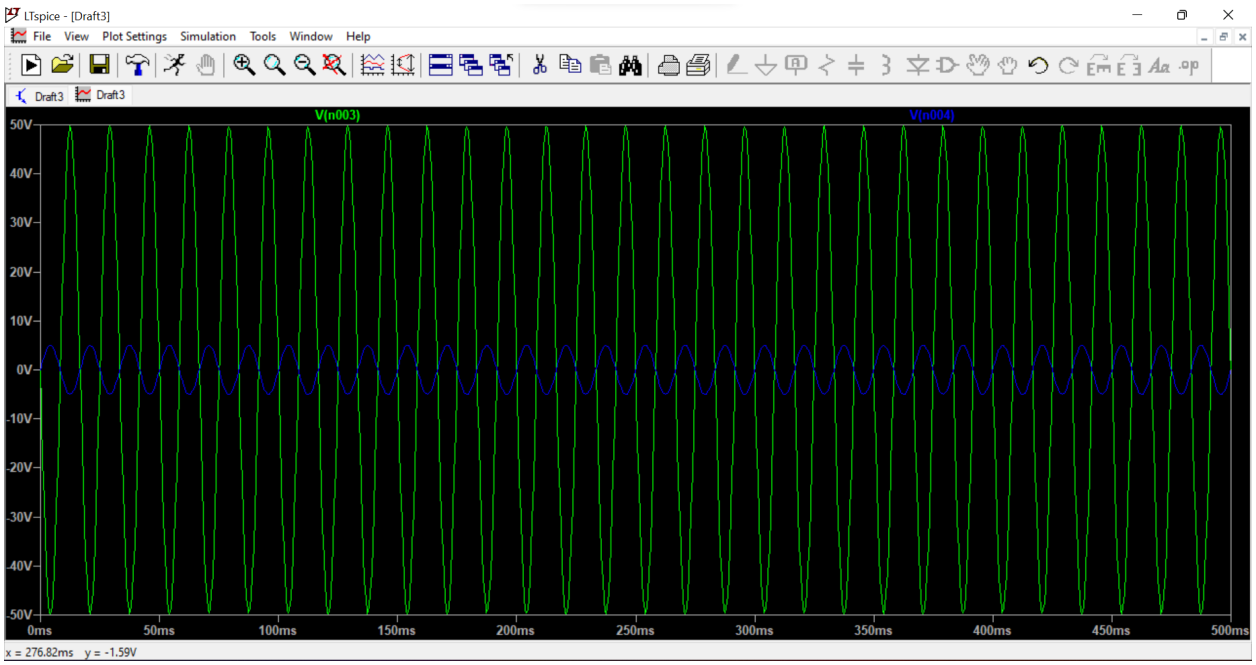
Vcc N001 0 100
Vs N004 0 SINE(0 5 60)
XU1 0 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
R1 N002 N004 11e3
R2 N003 N002 110e3
Vee 0 N005 20
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end

3. **Explain the behavior of *Vo*. State which half-periods of *Vs* (the positive or the negative) are amplified and transferred to the output and which are clipped.**

From the graph of Vo, it is seen that Vo has a sinusoidal behavior. The graph is clipped at -20 V and the values between +5 and -2 are amplified which is further transferred to the output of the circuit. The values that are clipped from the graph are -2 and -5.

Section 1. D

1. **Include the plot for both Vs and Vo as functions of time. Put both waveforms on the same plot.**



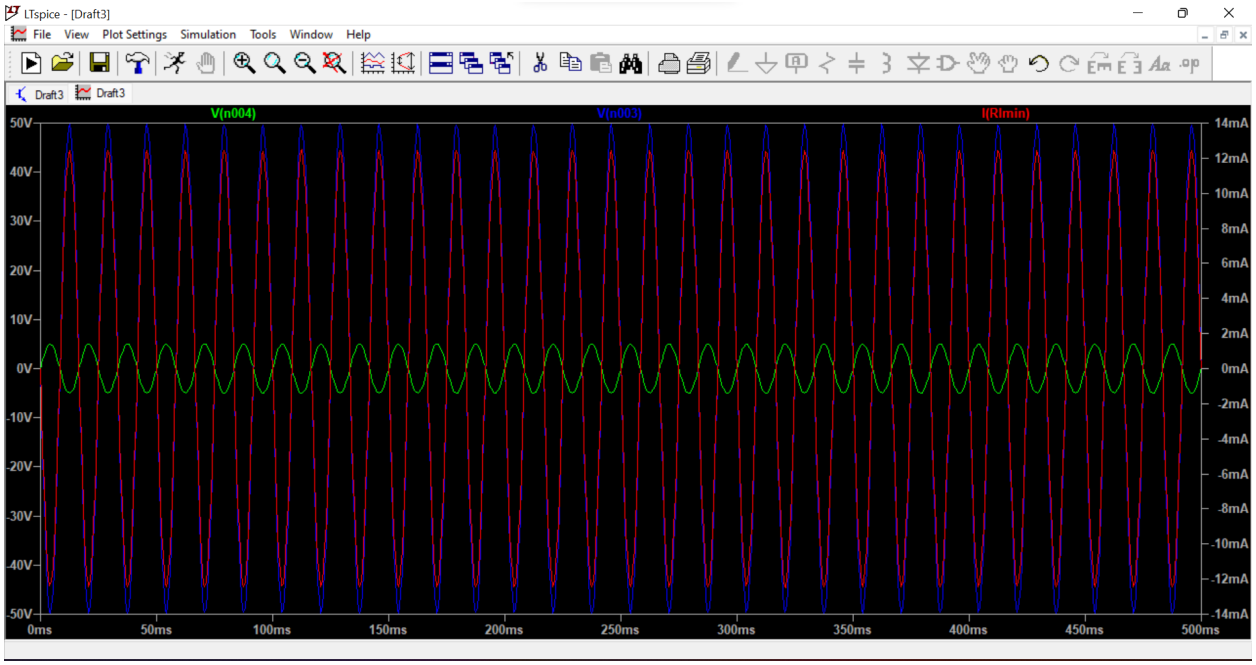
2. **Copy and Paste the complete netlist into your report.**

Vcc N001 0 100
Vs N004 0 SINE(0 5 60)
XU1 0 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg Slew=10Meg Ilimit=25m
Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
R1 N002 N004 11e3
R2 N003 N002 110e3
Vee 0 N005 100
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno

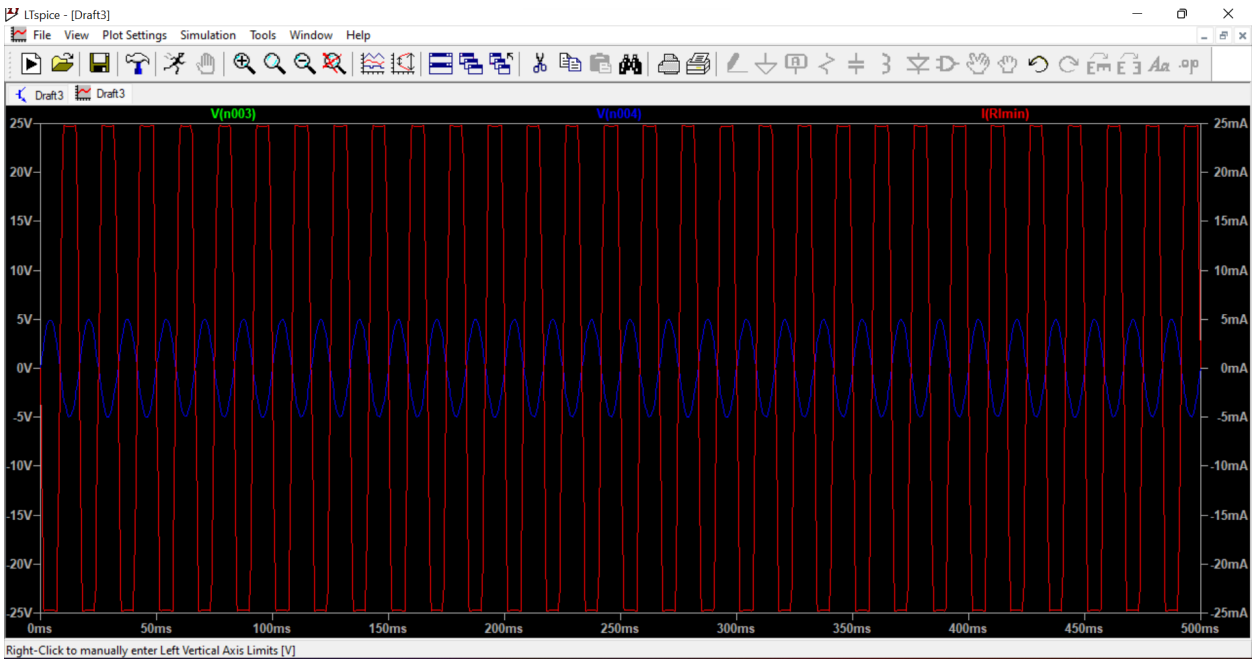
.end

Section 1. E

1. **For the case of $R_L = 2R_{L,\,min}$, include the plot of Vs, Vo, and Io as functions of time. Put all three waveforms in one plot.**



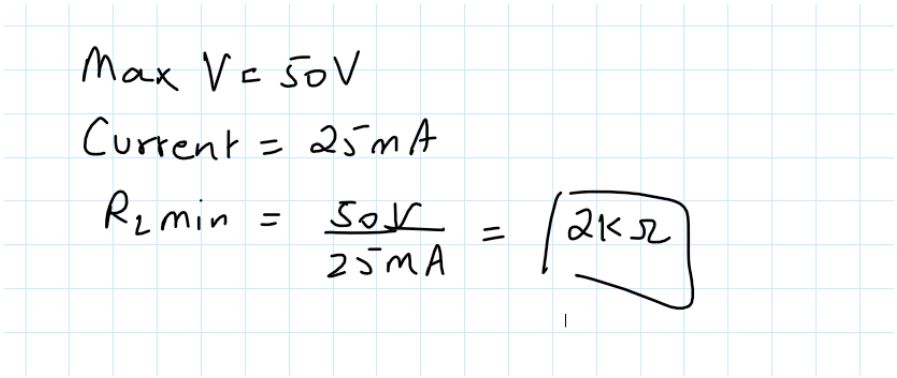
2. **For the case of $R_L = 0.5R_{L,\,min}$, include the plot of Vs, Vo, and Io as functions of time. Put all three waveforms in one plot.**



3. **Copy and paste the complete netlist into your report.**

Vcc N001 0 100
Vs N004 0 SINE(0 5 60)
XUniversalOpamp2 0 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
R1 N002 N004 11e3
R2 N003 N002 110e3
Vee 0 N005 100
RLmin N003 0 1e3
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end

4. **Show the derivation of $R_{L,\,min}$.**



5. **State the observed maximum value of Vo in the case of $R_L = 2R_{L,\,min}$.**

The observed maximum value of Vo is 50V.

6. **State the observed maximum value of Vo in the case of $R_L = 0.5R_{L,\,min}$.**

The observed maximum value of Vo is 25V.

7. **Comment on whether there is a difference between your observations in parts 5 and 6.**

Yes, there is a difference between my observations in both parts.

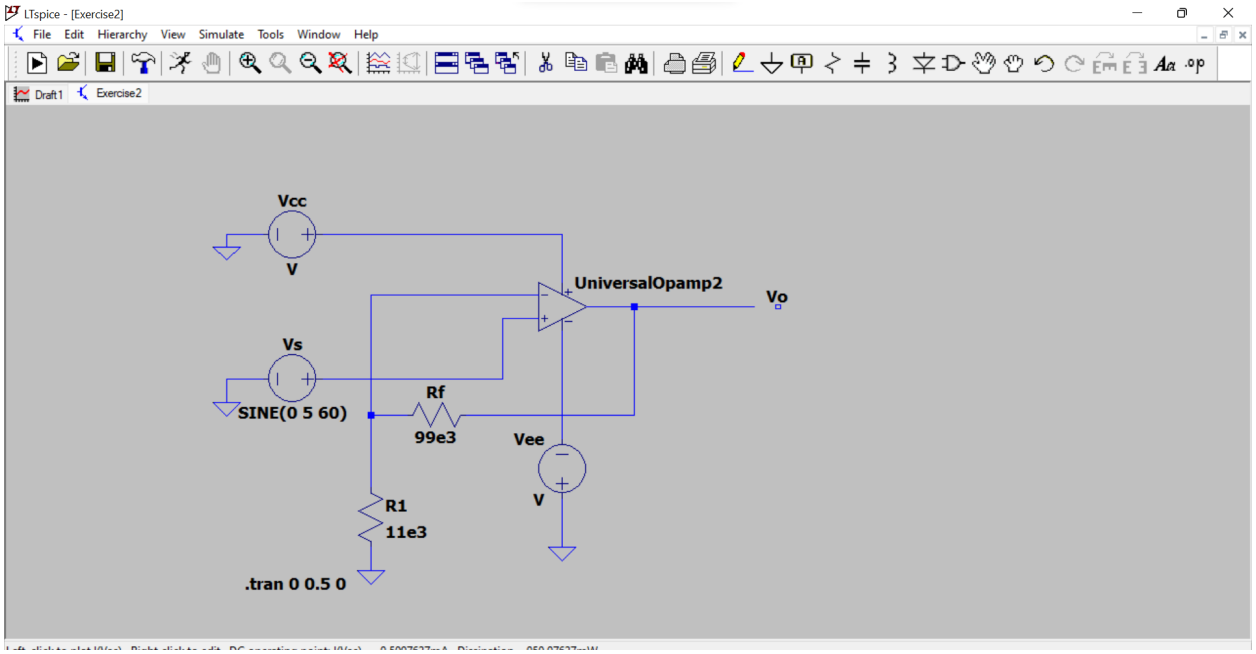
8. **Explain why you observe this difference (if any) referring also to the observed maximum values of Io in both cases.**

Because since RL was 2Rlmin, the current was equal to 12.5mA approximately. However when it changed to 0.5Rlmin, the current increased by 2 times and it was 13mA. This relates to Ohm's law since the voltage was held constant.

Exercise #2: Non-Inverting Op-amp circuit

Section 2. A

1. **Include an image of your schematic.**

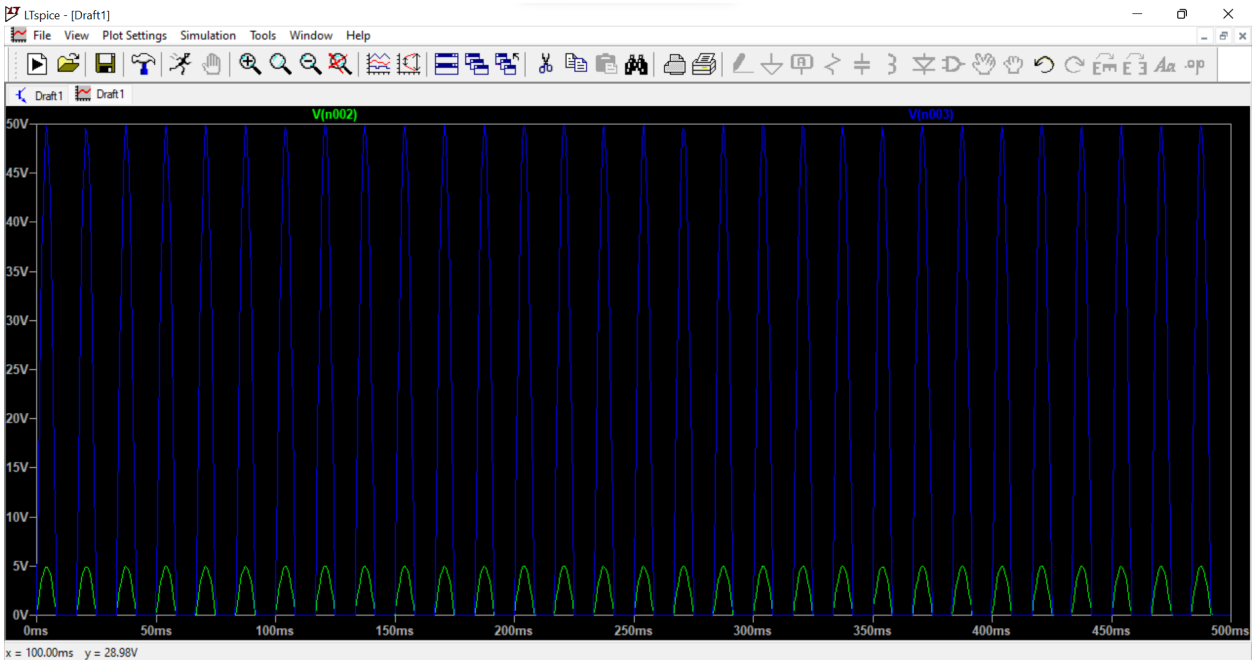


2. **Provide the complete netlist.**

Vcc N001 0 V
XUniversalOpamp2 N004 N002 N001 N005 N003 level2 Avol=100 GBW=10Meg Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
Vee 0 N005 V
R1 N002 0 11e3
Rf N003 N002 99e3
Vs N004 0 SINE(0 5 60)
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end

Section 2. B

1. **Include the plot of *Vs* and *Vo*. Put both waveforms in one plot.**



2. **Provide the complete netlist.**

Vcc N001 0 100
Vs N004 0 SINE(0 5 60)
XUniversalOpamp2 N004 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg
Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
Vee 0 N005 0
R1 N002 0 11e3
Rf N003 N002 99e3
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end

3. **State whether your circuit achieved the required gain of 10.**

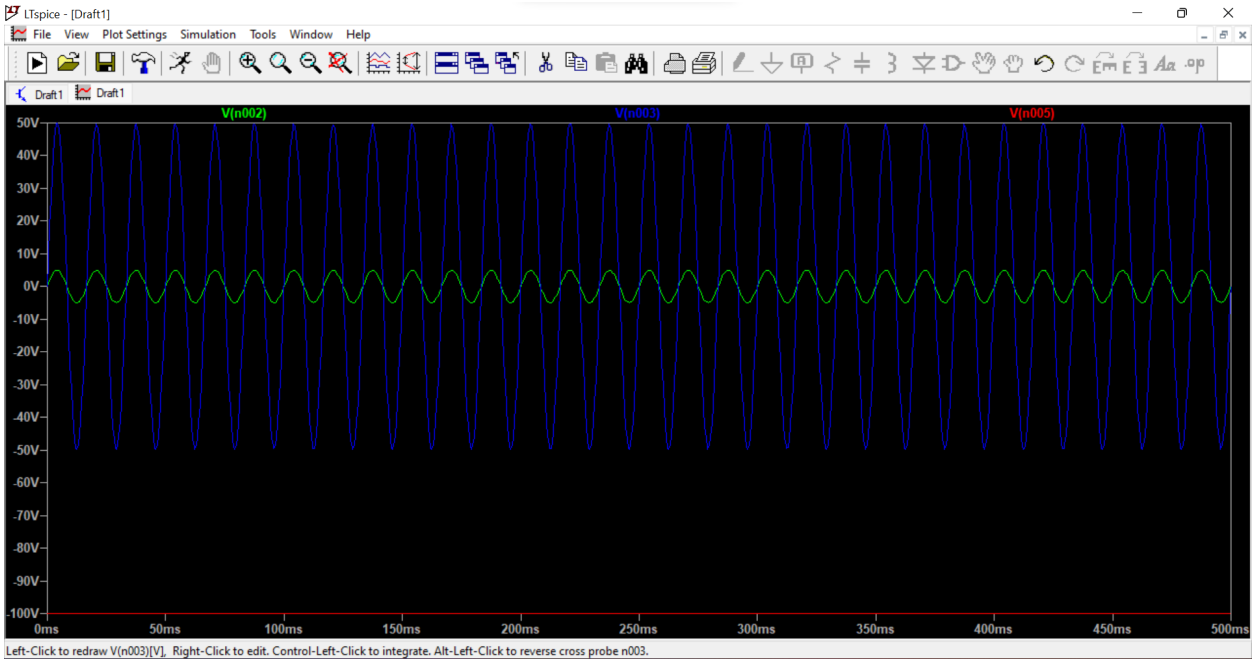
Yes, the circuit has achieved the required gain of 10 since the max value of Vs is 50V and that of Vo is 5 V. Therefore, Vs is 10 times that of Vo.

4. **State whether it is operating in a nonlinear regime. Justify your statement.**

It is not operating in a nonlinear regime because the voltage of output to input is constant which is the required gain of 10.

Section 2. C

1. **Include the plot of *Vs* and *Vo*. Put both waveforms in one plot.**



2. **Provide the complete netlist.**

```
Vcc N001 0 100
Vs N004 0 SINE(0 5 60)
XUniversalOpamp2 N004 N002 N001 N005 N003 level2 Avol=1Meg GBW=10Meg
Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
Vee 0 N005 100
R1 N002 0 11e3
Rf N003 N002 99e3
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end
```

3. **State whether your circuit achieved the desired gain of 10.**

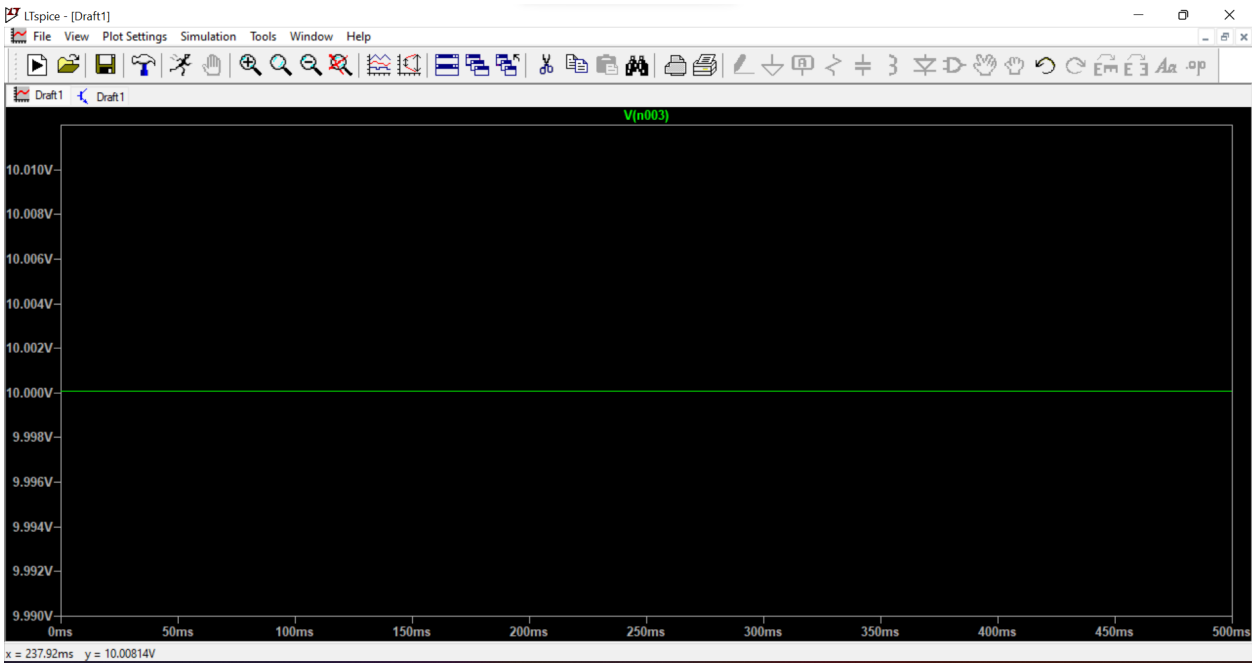
Yes, the circuit has achieved the desired gain of 10 as we can see that in the graph Vs is 50 V and Vo is approximately equal to 5 V.

4. **State whether it is operating at a nonlinear regime. Justify your statement.**

It is not operating at a nonlinear regime because the voltage of output to input is constant which is equal to 10, the same as the required gain.

Section 2. D

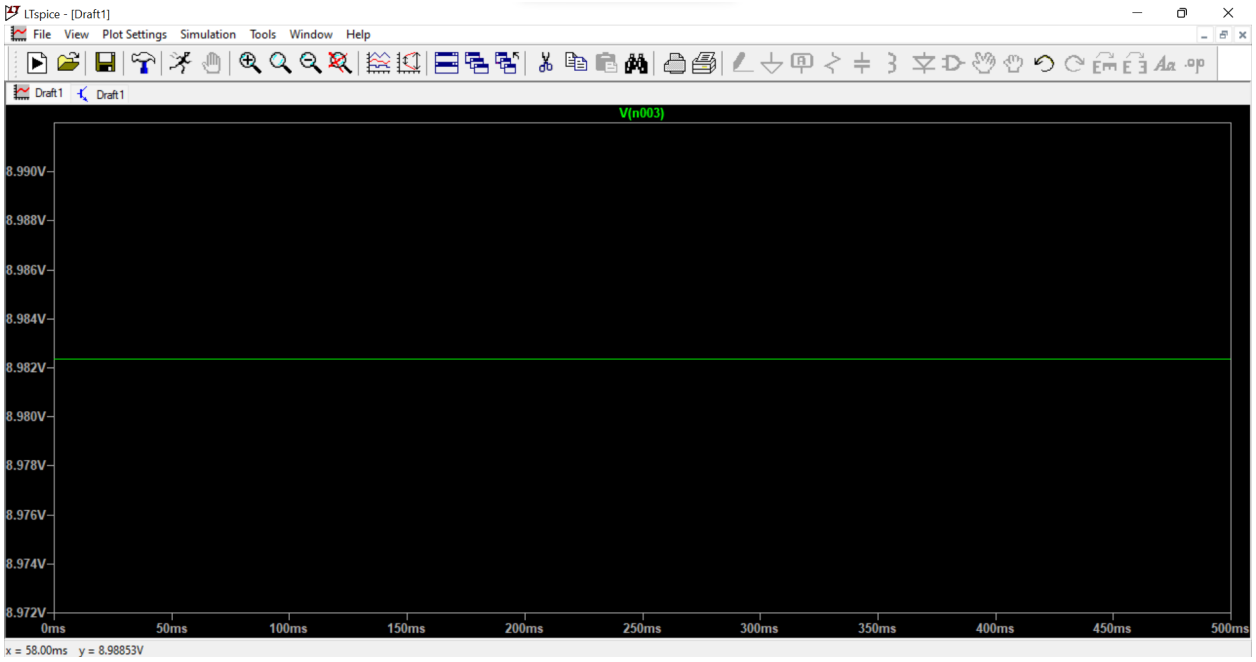
1. **Include the plot for *Vo* for the case of $A_o = 10^6$.**



2. **Provide the complete netlist for the case of $A_o = 10^6$.**

```
Vcc N001 0 100
XUniversalOpamp2 N004 N002 N001 N005 N003 level2 Avol=1meg GBW=10Meg
Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
Vee 0 N005 100
R1 N002 0 11e3
Rf N003 N002 99e3
Vs N004 0 1
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end
```

3. **Include the plot for *Vo* for the case of $A_o = 100$.**



4. **Provide the complete netlist for the case of A_o = 100.**

Vcc N001 0 100
XUniversalOpamp2 N004 N002 N001 N005 N003 level2 Avol=100 GBW=10Meg Slew=10Meg Ilimit=25m Rail=0 Vos=0 En=0 Enk=0 In=0 Ink=0 Rin=500Meg
Vee 0 N005 100
R1 N002 0 11e3
Rf N003 N002 99e3
Vs N004 0 1
.tran 0 0.5 0
.lib UniversalOpAmp2.lib
.backanno
.end

5. **State the simulated circuit gain in the case when A_o = 100.**

The simulated circuit gain in the case when A_o = 100 is approximately 8.983.

6. **State the gain error percentage compared to the ideal gain of 10.**

Gain error percentage = ((Actual gain - ideal gain) / ideal gain) * 100%
= ((8.983 - 10) / 10) * 100 = **10.17%**