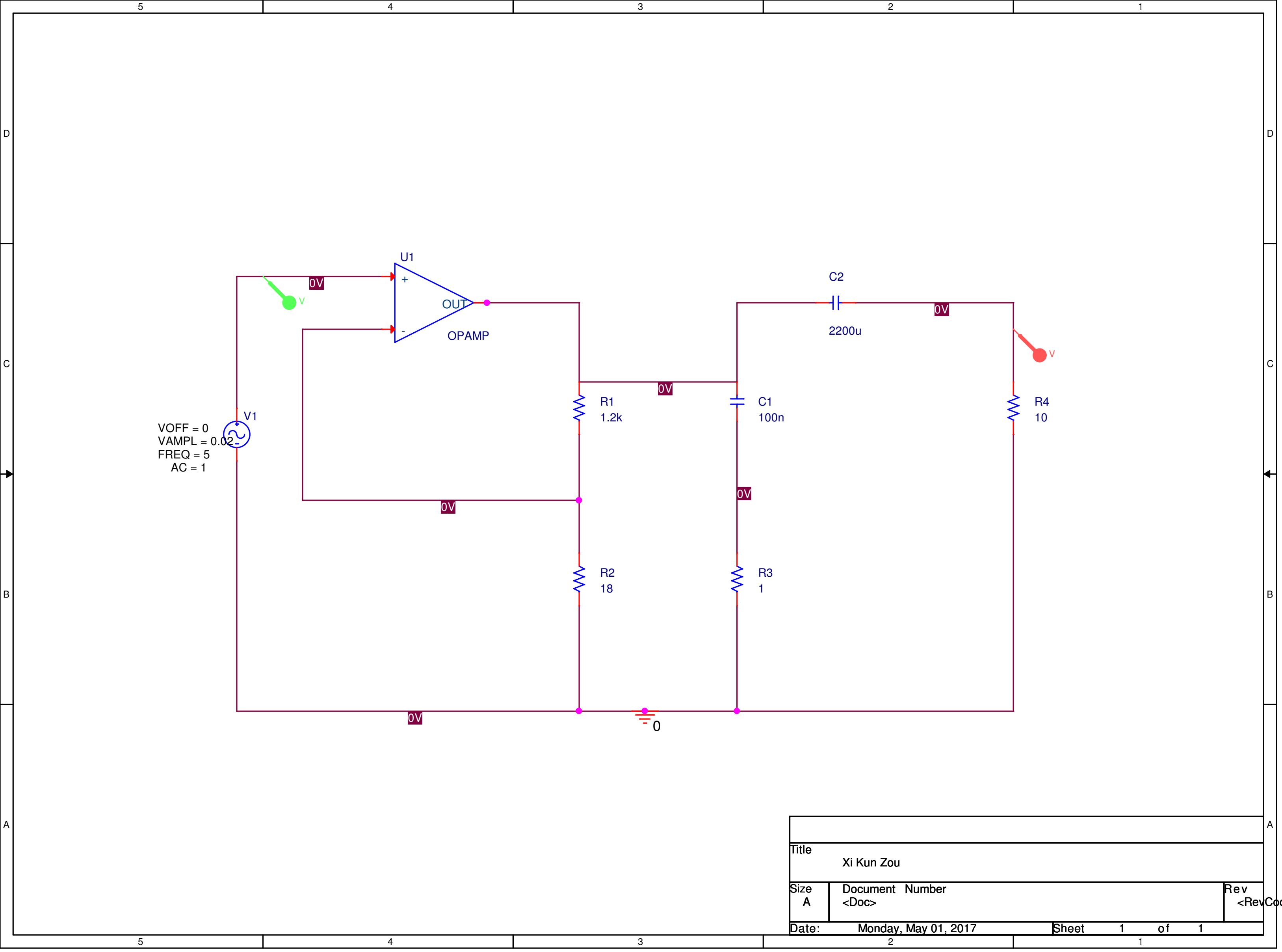
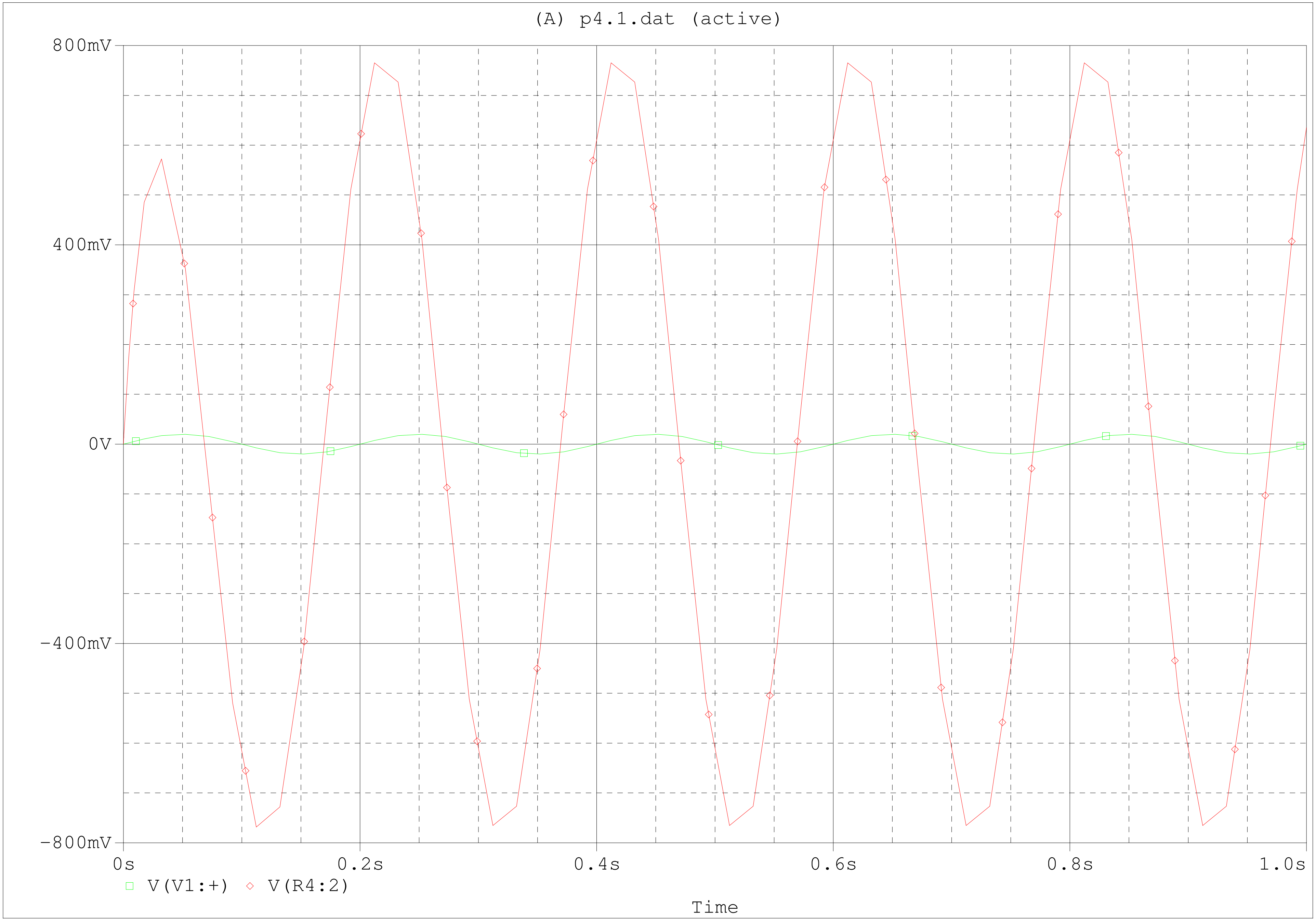

U1
OUT
OPAMP
0V
C2
2200u
V1
VOFF = 0
VAMPL = 0.02
FREQ = 5
AC = 1
R1
1.2k
C1
100n
R4
10
R2
18
R3
1
0
Title
Xi Kun Zou
Size
A
Document Number
<Doc>
Rev
<RevCod
Date: Monday, May 01, 2017
Sheet 1 of 1

Xi Kun Zou

** Profile: "SCHEMATIC1-p4.1" [C:\PExcercise\plab4-PSpiceFiles\SCHEMATIC1\p4.1.sim]

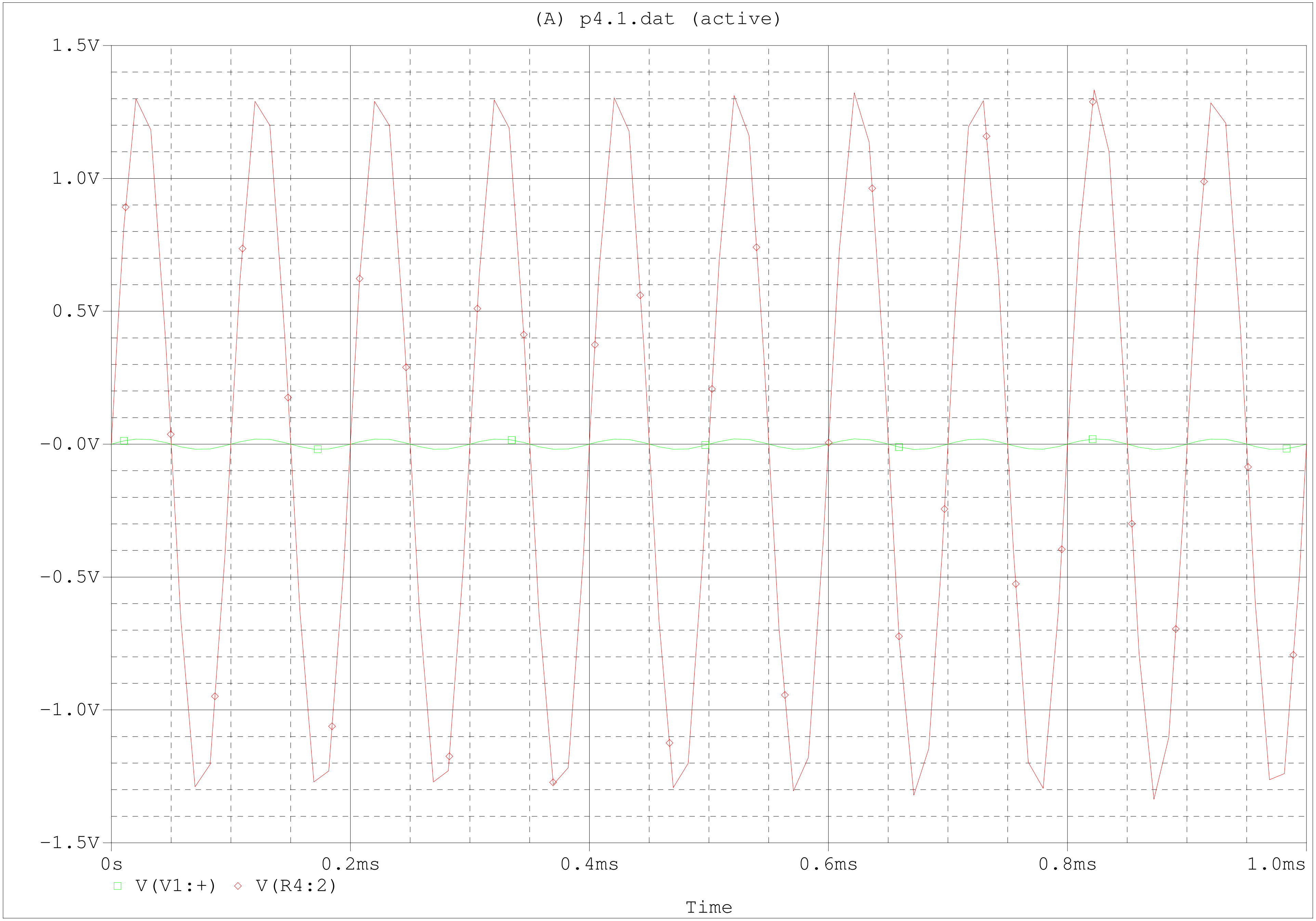
Date/Time run: 05/09/17 04:49:50 Temperature: 27.0



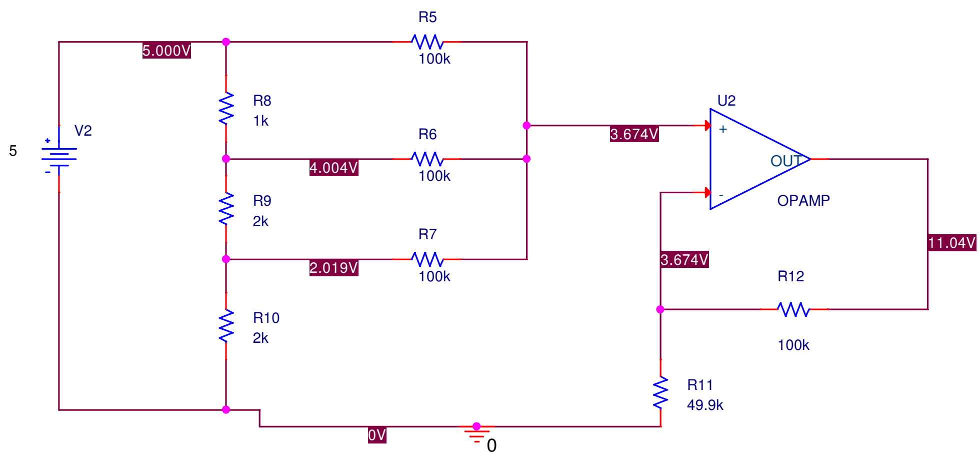
XiKUN Zou 1000hz

** Profile: "SCHEMATIC1-p4.1" [C:\PExcercise\plab4-PSpiceFiles\SCHEMATIC1\p4.1.sim]

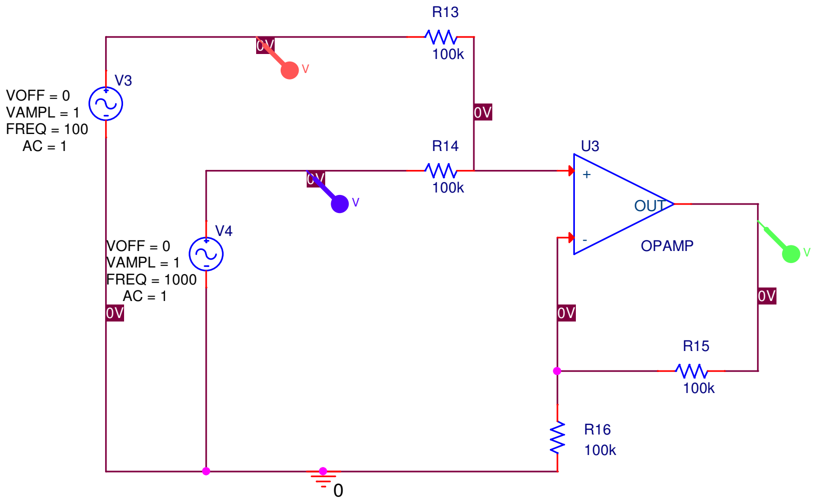
Date/Time run: 05/09/17 05:32:53 Temperature: 27.0



Date: May 09, 2017 Page 1 Time: 05:32:57



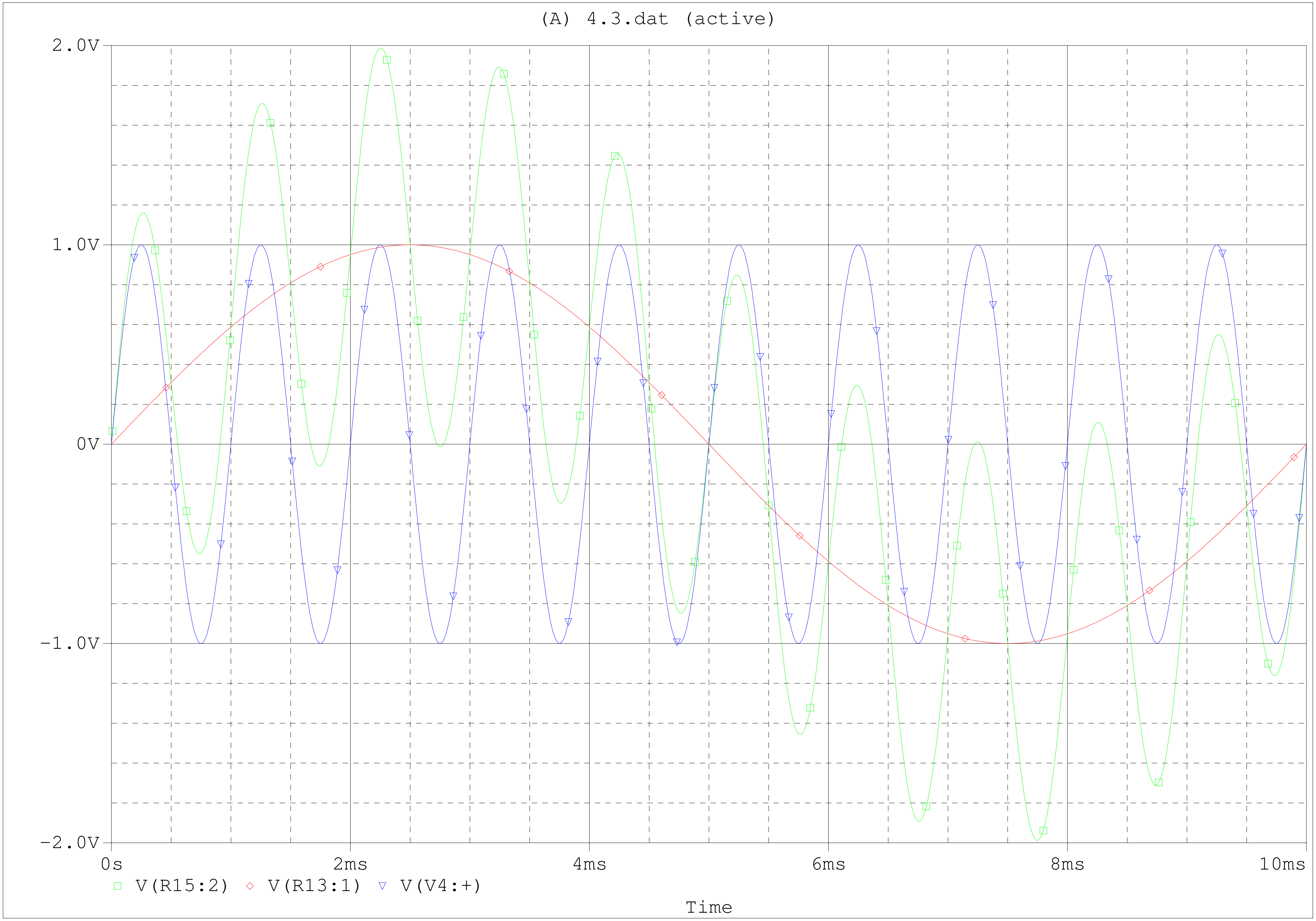
Title	Xi Kun Zou	
Size A	Document Number <Doc>	Rev <RevCod
Date: Tuesday, May 09, 2017	Sheet 1 of 1	



Title	Xi Kun Zou	
Size A	Document Number <Doc>	Rev <RevCod
Date: Tuesday, May 09, 2017	Sheet 1 of 1	

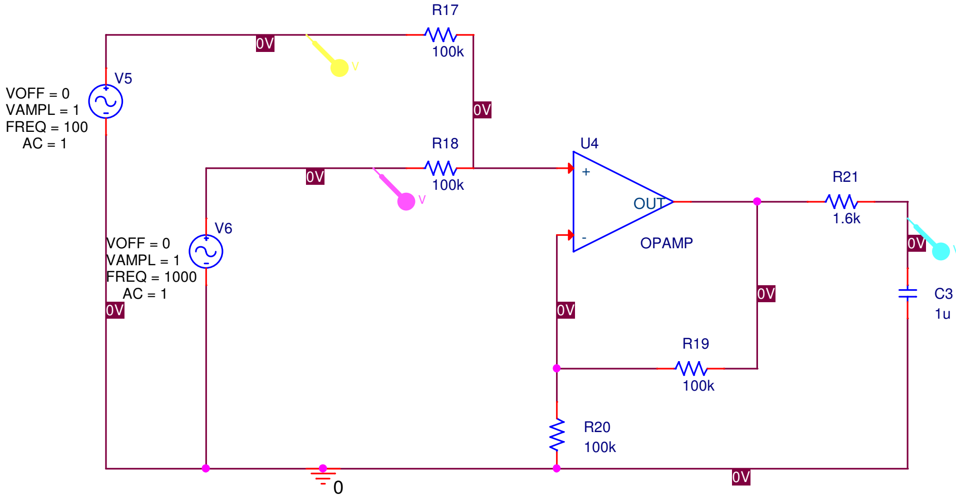
X iK un Z ou

** Profile: "SCHEMATIC1-4.3" [C:\PExcercise\plab4-PSpiceFiles\SCHEMATIC1\4.3.sim]
Date/Time run: 05/09/17 06:26:14 Temperature: 27.0



Date: May 09, 2017 Page 1 Time: 06:26:55

Low Pass Filter



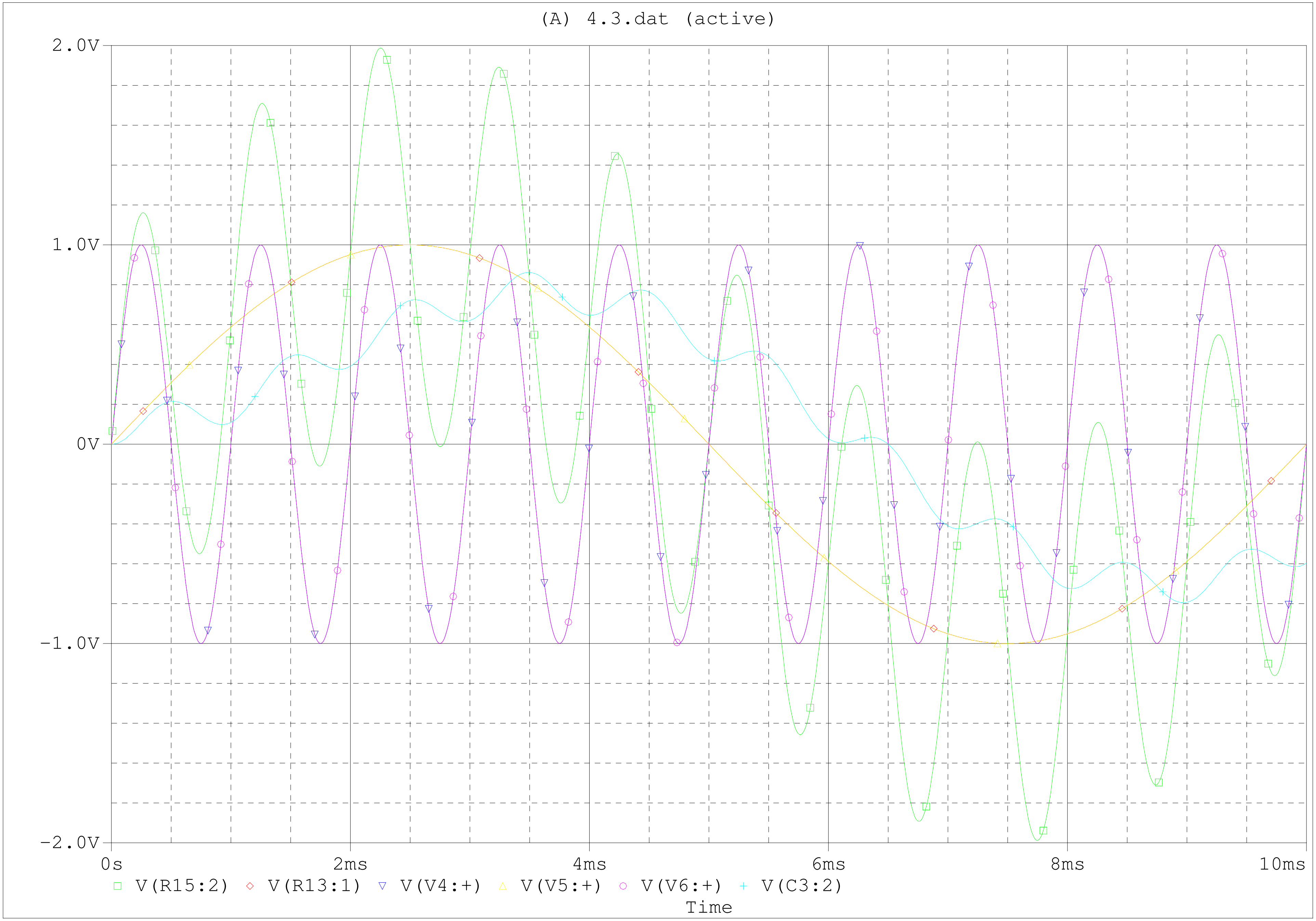
Title
Xi Kun Zou

Size A | Document Number <Doc> | Rev <RevCod

Date: Tuesday, May 09, 2017 Sheet 1 of 1

X iK un Z ou

** Profile: "SCHEMATIC1-4.3" [C:\PExcercise\plab4-PSpiceFiles\SCHEMATIC1\4.3.sim]
Date/Time run: 05/09/17 08:13:18 Temperature: 27.0

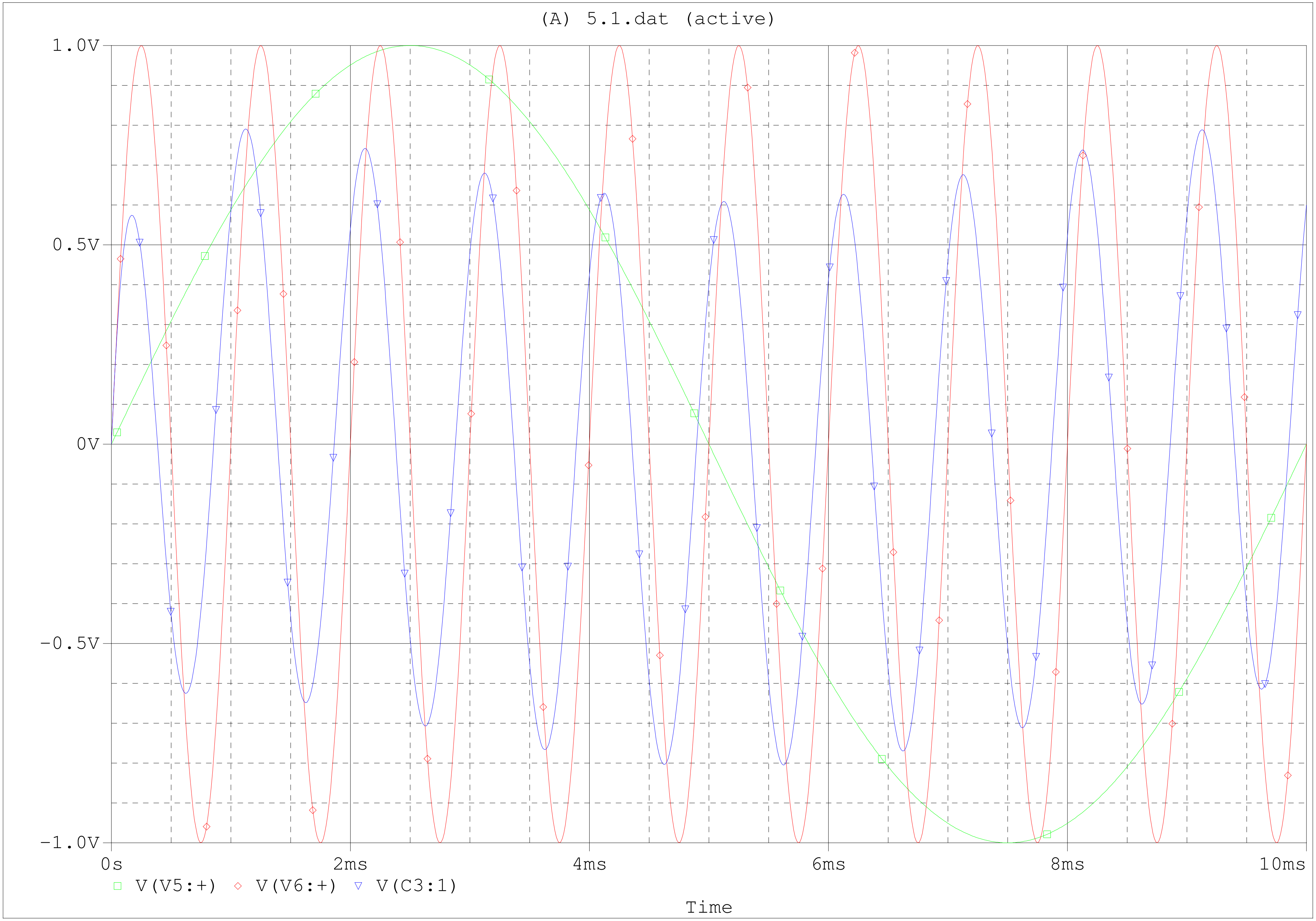


Date: May 09, 2017 Page 1 Time: 08:13:53

X iK un Z ou

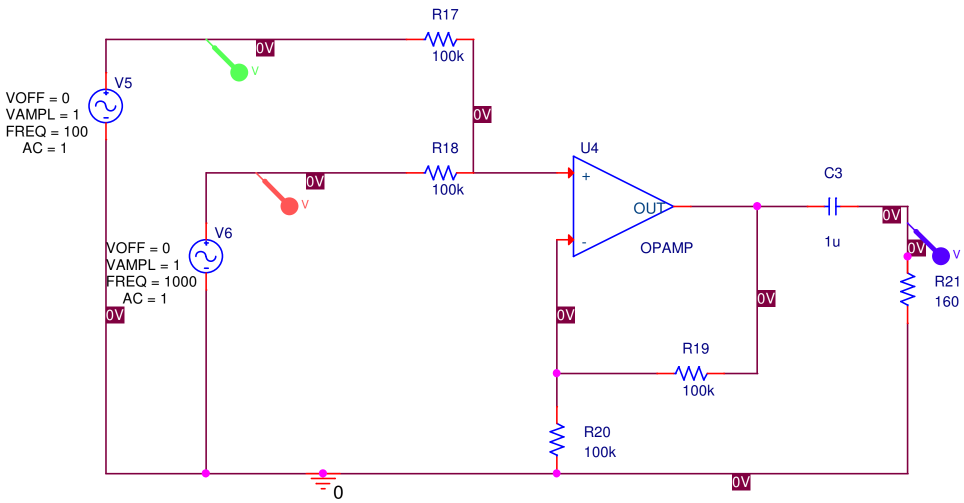
** Profile: "SCHEMATIC1-5.1" [C:\PExcercise\plab4-PSpiceFiles\SCHEMATIC1\5.1.sim]

Date/Time run: 05/09/17 08:20:20 Temperature: 27.0



Date: May 09, 2017 Page 1 Time: 08:20:26

High-pass filter



Title	Xi Kun Zou	
Size A	Document Number <Doc>	Rev <RevCod
Date: Tuesday, May 09, 2017	Sheet 1 of 1	

ECE 212 Spring 2017	M / Th / F	Names: Xi Kun Zou
Circuit Analysis II	Group A / B	

Lab 4: Analysis of the Stereo Amplifier

Objectives

In this lab exercise you will use the power supply to power the stereo amplifier built in the previous lab. You will then analyze the frequency response of the stereo amplifier. The idea of filtering signals will be presented in an auditory manner in order to give another means of observing the output of a circuit. You will also determine the resistance and inductive reactance (imaginary part of impedance, which is positive) of a typical speaker.

Pre-Lab Instructions

Calculations

1. The simplified schematic for one channel of the stereo amplifier constructed in the previous lab is shown in Figure 1.

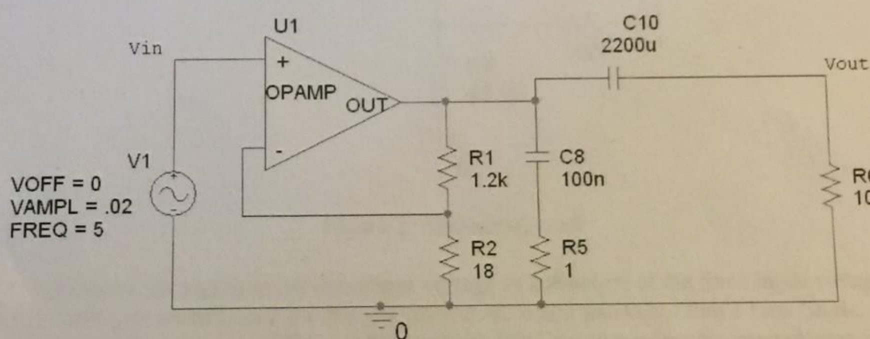


Figure 1: Simplified Schematic for One Channel of the Stereo Amplifier

(a) In PSpice, simulate the circuit and measure the frequency response (gain and phase) for the different values of the frequency f (i.e., $v_i(t) = \cos(2\pi ft)$).

$\varphi = T_{p\text{-}p} \cdot f \cdot 3$

Frequency	|Vout/Vin|	Phase Shift (degrees)
5Hz	572.303/16.98 = 33.7	135.29°
10Hz	790.738/19.253 = 41.07	0°
100Hz	1.2506/19.552 = 63.96	0°
1,000Hz	1342.7/19.991m = 67.165	0°
10,000Hz	1.3/19.223m = 67.63	0°

(b) Print the waveforms for the case of $f = 5$Hz and $f = 1{,}000$Hz. Also print out the schematic for any one frequency value. **(NOTE: your name must appear in the filename of all circuit and waveform printouts!)**

2. A summer-circuit is shown in Figure 2 below:

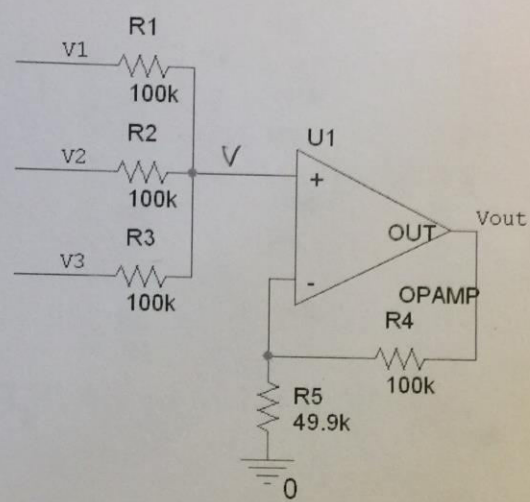


Figure 2: Summer-Circuit

(a) Derive the equation for the output voltage as a function of the three input voltages. The only tools you should need for this calculation are nodal analysis, Ohm's Law (in the form of a voltage divider made up of R4 and R5), and the ideal op-amp rules: No current goes into the + or – terminal, and the voltage difference between those two terminals is zero. Also, comment on why you think this circuit is known as a "summer."

$$\frac{V-V_1}{R_1} + \frac{V-V_2}{R_2} + \frac{V-V_3}{R_3} = 0 \qquad V\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right) = \frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}$$

Since $R_1 = R_2 = R_3$

$$V = V_{out}\,\frac{R5}{R4+R5} \qquad V = \frac{V_1+V_2+V_3}{3}$$

$$V_{out} = \frac{(V_1+V_2+V_3)(149.9k)}{3 \cdot 49.9k}$$

Vout = $V_1+V_2+V_3$ approxiatel

Since the Circuit gives the addition of the [illegible] applied signal at the output So its called Summer

3. (a) In PSpice, simulate the summer-circuit shown in Figure 3 (using a bias point analysis, as opposed to a time domain analysis), and print the circuit with the bias voltages displayed on every node (simply click the "Enable Bias Voltage Display" button in the toolbar after performing the bias analysis). N.B., you should not print a waveform for this part, just the schematic with the bias voltages displayed.

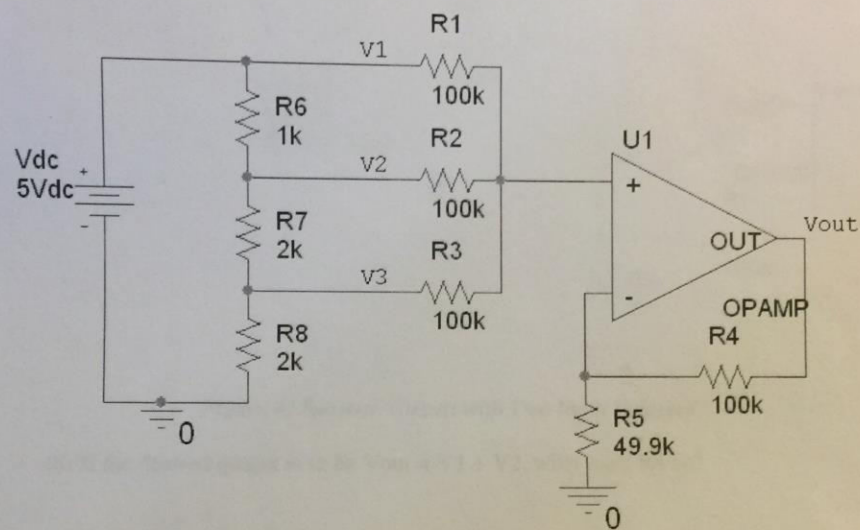


Figure 3: Summer-Circuit with Input Voltages Defined

(b) The voltage source Vdc and resistors 6 through 8 are nothing more than a voltage divider (since an op-amp has a very high input impedance, and thus draws very little current through resistors 1, 2, and 3). Derive the DC values of voltages 1, 2, and 3, and using the equation for the output of this summer-circuit previously obtained, check to see that the bias voltage calculated in PSpice is correct.

V1 5V

bias Voltages are Correct

V2 4V

V3 2V

Vout 11V

4. A summer-circuit with only two inputs is shown in Figure 4:

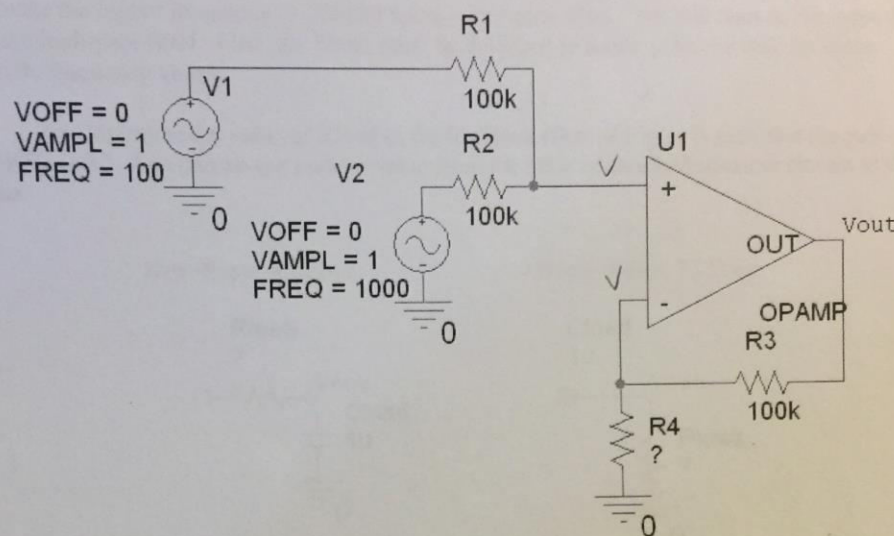


Figure 4: Summer-Circuit with Two Input Voltages

(a) If the desired output is to be Vout = V1 + V2, what must R4 be?

$$V = \frac{(V_1+V_2)}{2}$$

$$V_{out}\frac{R4}{R4+100k} = \frac{V_{out}}{2}$$

$$V = \frac{V_{out}}{2}$$

$$\frac{R_4}{R_4+100k} = \frac{1}{2}$$

R4 100k

(b) Once you have chosen the value of R4, perform an AC (PSpice) analysis of the circuit, and print out a waveform showing both the inputs and the output.

5. We will now attempt to filter the output to isolate the lower frequency (100Hz) and attenuate the higher frequency (1,000Hz) using a low-pass filter. We will then do the opposite using a high-pass filter. First, the filters must be designed to accomplish the task for these specific frequency values.

(a) Determine the value of Rload in the low-pass filter of Figure 5 such that the gain at 1,000Hz is 0.1, then choose the resistor value from the table of standard resistors closest to this value.

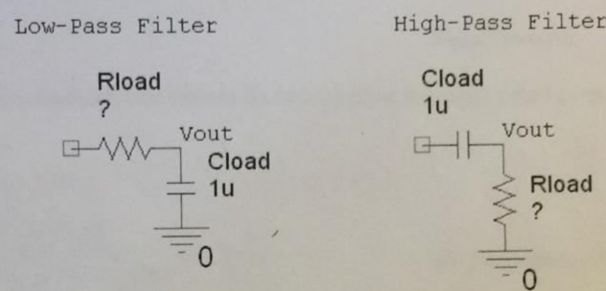


Figure 5: Filters Used to Filter the Output of the Summer-Circuit

$$1000 = \frac{1}{2\pi RC}$$

$$0.1 = \frac{159.1}{\sqrt{R^2 + 159.1^2}}$$

Rload (low-pass) 1583.57Ω

Rload (chosen) 1.6K

(b) For the resistor value chosen above, calculate the gain of the low-pass filter at 100Hz and 1,000Hz.

For 100 Hz

$$G = \frac{1591.549}{\sqrt{1600^2 + 1591.549^2}}$$

For 1000Hz

Av (low-pass, 100Hz) 0.705

Av (low-pass, 1,000Hz) 0.1

(c) Determine the value of Rload in the high-pass filter of Figure 5 such that the gain at 100Hz is 0.1, then choose the resistor value from the table of standard resistors closest to this value.

1591.549

$$0.1 = \frac{R}{\sqrt{R^2 + 1591.549^2}}$$

Rload (high-pass) 159.956 Ω

Rload (chosen) 160 Ω

(d) For the resistor value chosen above, calculate the gain of the low-pass filter at 100Hz and 1,000Hz.

For 100 Hz

For 1000 Hz

$$G = \frac{1591.549}{\sqrt{160^2 + 1591.549^2}}$$

$= 1$

Av (high-pass, 100Hz) 1

Av (high-pass, 1,000Hz) 0.705

(e) With these resistor values chosen, add each filter to the output (one at a time) to the output of the circuit shown in Figure 4. Print out both the schematic and the resulting waveform, showing the inputs and the filtered output, for both the low-pass filter and the high-pass filter. For an example of how to attach the filters, see how the low-pass filter is attached in Figure 6:

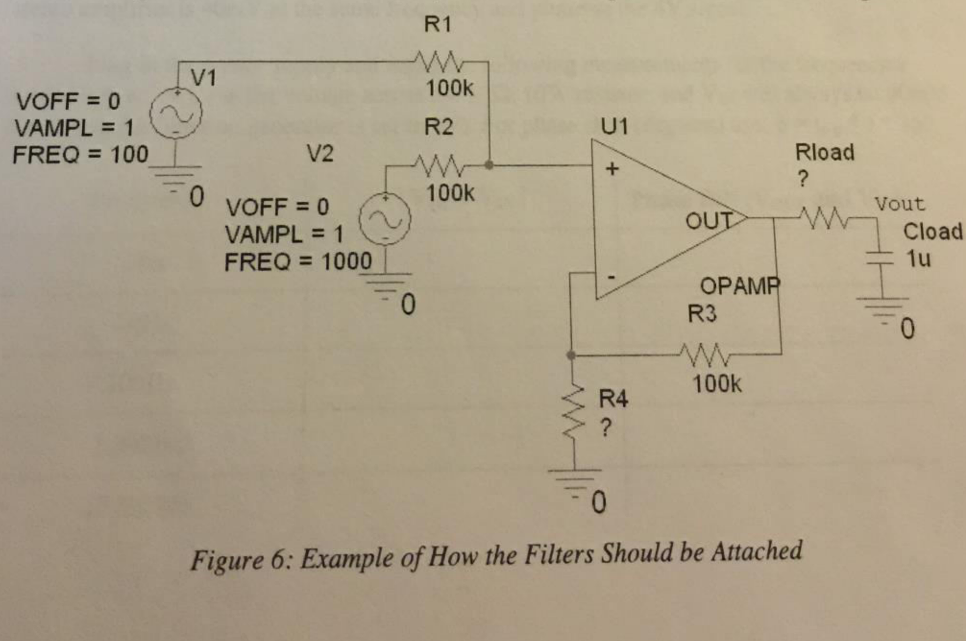


Figure 6: Example of How the Filters Should be Attached