Electronic Circuits Experiment (I) Final (Written)

Time: 19:00 ~ 20:40, 12/31/2009

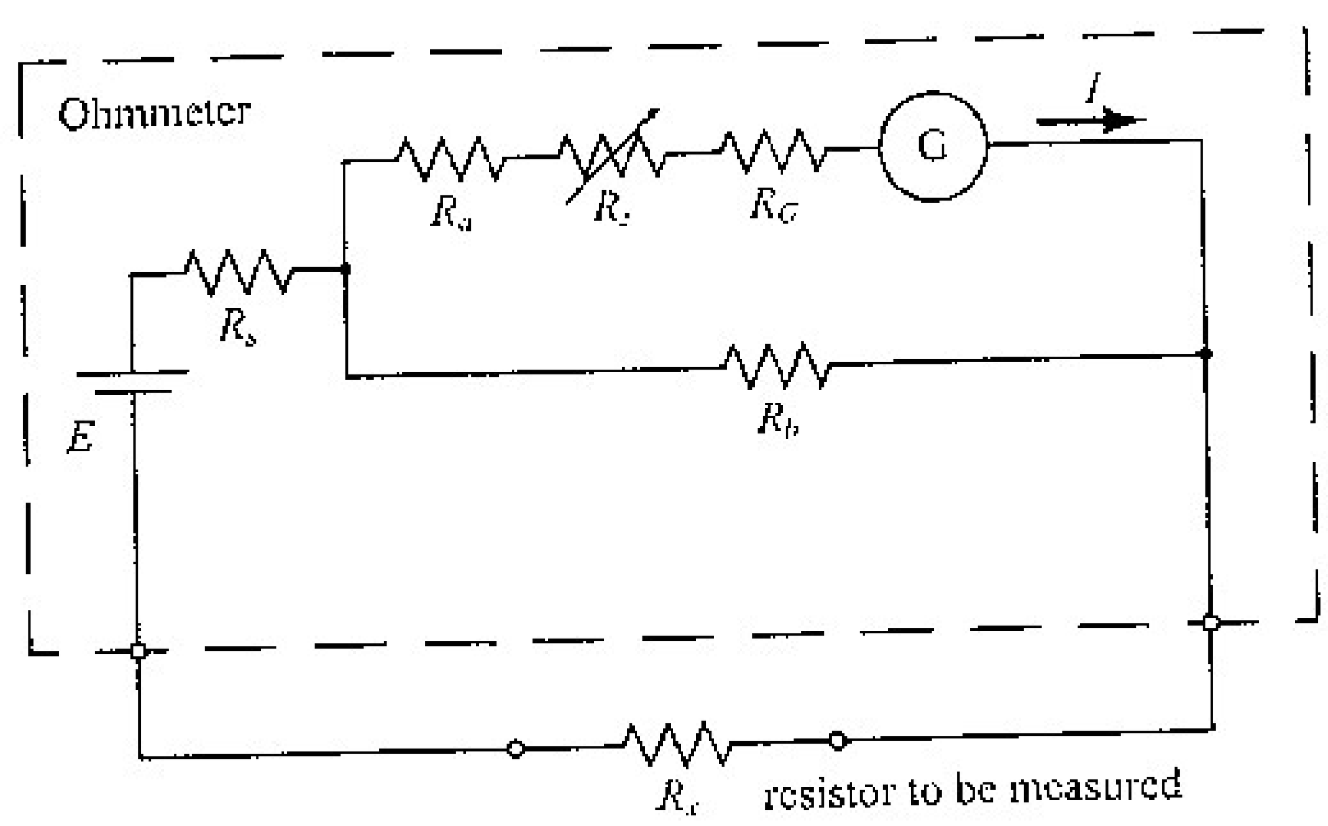
Answer the following questions either in English or in traditional Chinese. For each question involving calculation or derivation, you need to give **solutions** but not only simple answers. Simple answers without complete solutions result in no points even if your answer is correct.

Warning: If you are wrong in some sub-problem only because you are wrong in the related former sub-problem, you still get no points in the latter sub-problem. Therefore, answer every sub-problem very carefully.

Begin of Problem Set

1. **[4]** What is your seat ID? (Hint: An English letter with an Arabic numeral, such as C17 or D9.)

2. A design of the ohmmeter is shown as the right figure, where G is an ideal galvanometer (that is, the internal resistance of the galvanometer is 0) with the maximum affordable current $I_{\max}$, and R_x is the resistor to be measured.



For the convenience, let's define $R_A = R_a + R_z + R_G$.

NOTE: You cannot leave the variables which are not in the domain of the functions in the following sub-problems.

(a) **[4]** The current of the galvanometer is designed to be $I = I_{\max}$ when the ohmmeter is shorted (that is, $R_x = 0$). Find and simplify the *explicit* function $R_s = f(E, I_{\max}, R_A, R_b)$.

(b) **[4]** The current of the galvanometer is $I = 0.25 I_{\max}$ when we use the ohmmeter designed in (a) measuring some resistor R_{x_1}. Find and simplify the *explicit* function $R_{x_1} = g_1(R_A, R_b, R_s)$.

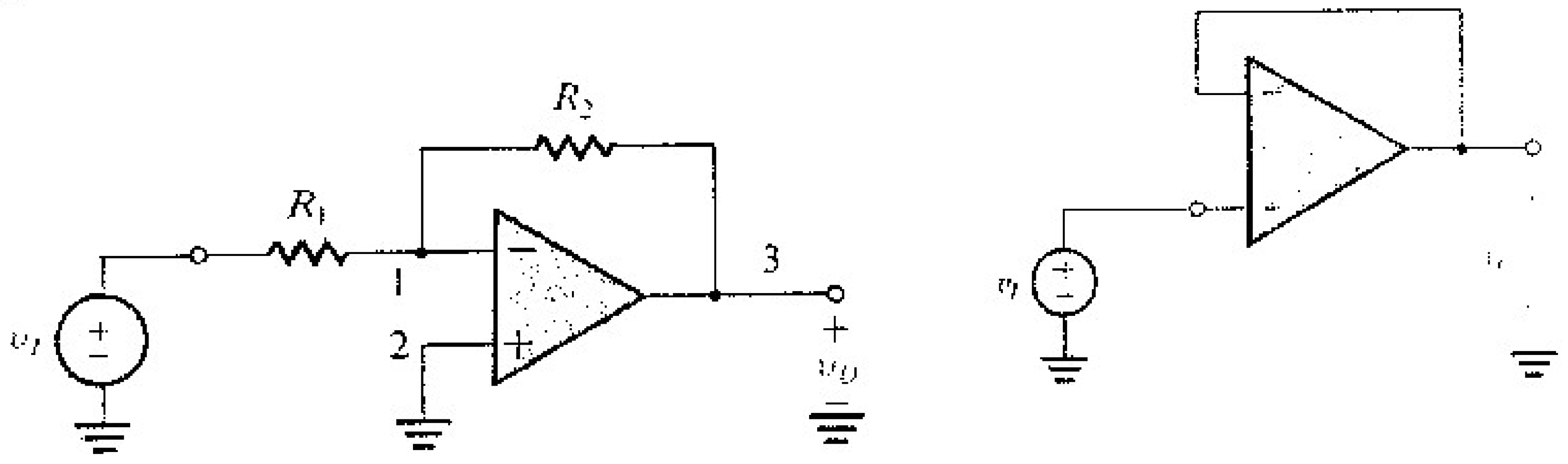
(c) **[4]** The current of the galvanometer is $I = 0.75 I_{\max}$ when we use the ohmmeter designed in (a) measuring some resistor R_{x_2}. Find and simplify the *explicit* function $R_{x_2} = g_2(R_A, R_b, R_s)$.

(d) **[4]** The battery is exhausted such that the voltage it supplies becomes $0.9E$ in the ohmmeter design in (a). In this case, R_z is tuned to $R_{z,\text{new}}$ making the current of the galvanometer be still $I = I_{\max}$ when the ohmmeter is shorted. Defining $R_{A,\text{new}} = R_a + R_{z,\text{new}} + R_G$, find and simplify the *explicit* function $R_{A,new} = h(R_A, R_b, R_s)$.

(e) **[4]** The current of the galvanometer is $I = 0.25 I_{\max}$ when we use the ohmmeter designed in (d) measuring resistor $R_{x_1,\text{new}}$. Find and simplify the *explicit* function $R_{x_1,\text{new}} = g_{1,\text{new}}(R_A, R_b, R_s)$.

(f) **[4]** The current of the galvanometer is $I = 0.75 I_{\max}$ when we use the ohmmeter designed in (d) measuring resistor $R_{x_2,\text{new}}$. Find and simplify the *explicit* function $R_{x_2,\text{new}} = g_{2,\text{new}}(R_A, R_b, R_s)$.

3. A non-ideal operational amplifier with the open loop gain $\dfrac{10^6}{1+\frac{j\omega}{10}}$, infinite input resistance, and no output resistance is used to design an inverting configuration (left; $R_1 = R_2 = R$) and a voltage follower (right) shown in the following figure.



(a) **[4]** Find the transfer function of the inverting configuration.

(b) **[4]** Find the transfer function of the voltage follower.

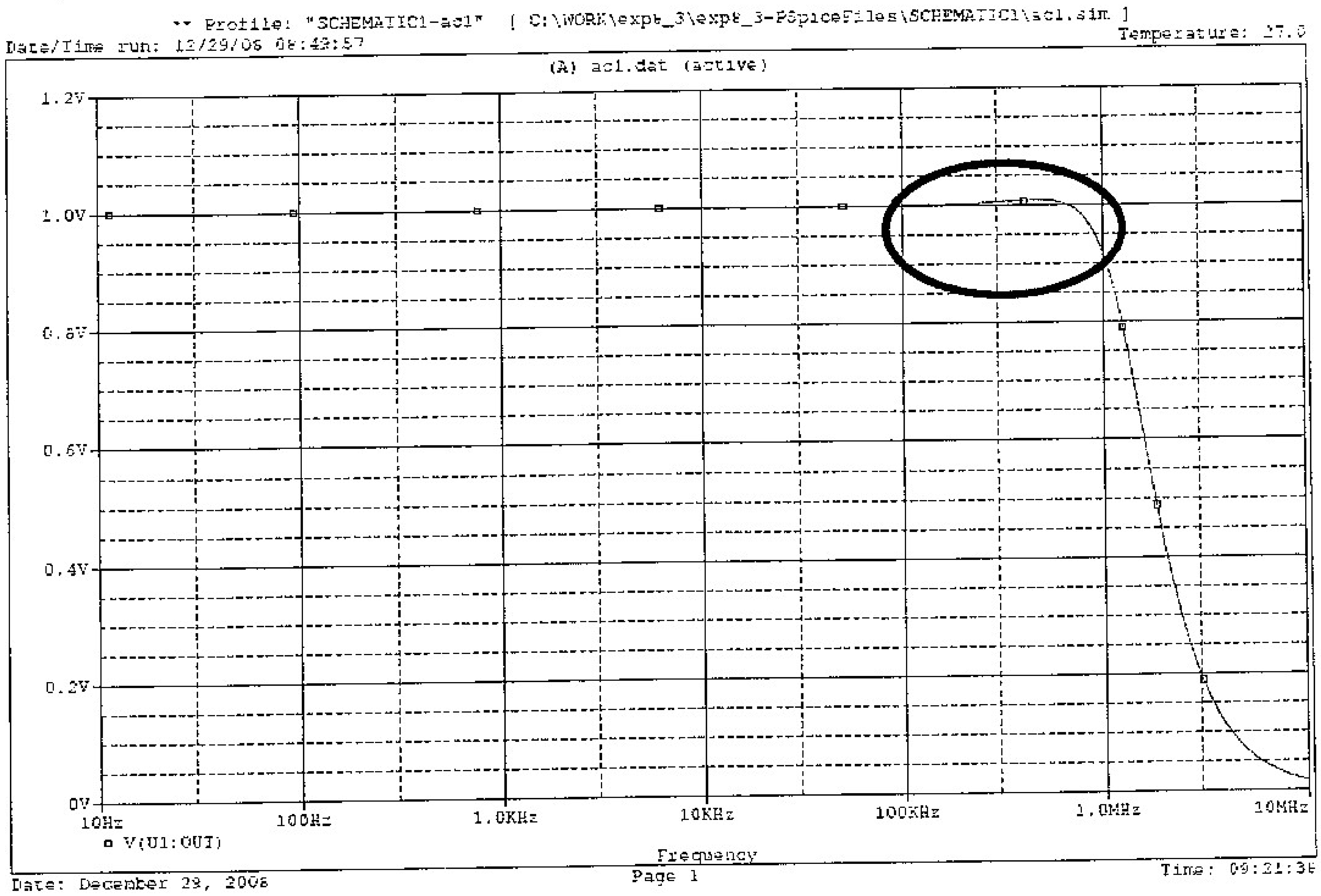
(c) **[4]** Which one is with the wider bandwidth when using such an OP-AMP? The inverting configuration with $R_1 = R_2 = R$? Or the voltage follower?

4. A non-ideal operational amplifier with the open loop gain $\dfrac{10^6}{(1+\frac{j\omega}{10})(1+\frac{j\omega}{10^7})}$, infinite input resistance, and no output resistance is used to design a voltage follower.

(a) **[4]** Find the transfer function of the voltage follower.

(b) **[4]** Why does the PSpice simulation result of the voltage follower show the resonance when the frequency is about 500kHz?

(Hint: You will be glad to use the result you derived in (a).)



NOTE: There are problems in the back.

5. Answer the following questions about the function generator and the oscilloscope.

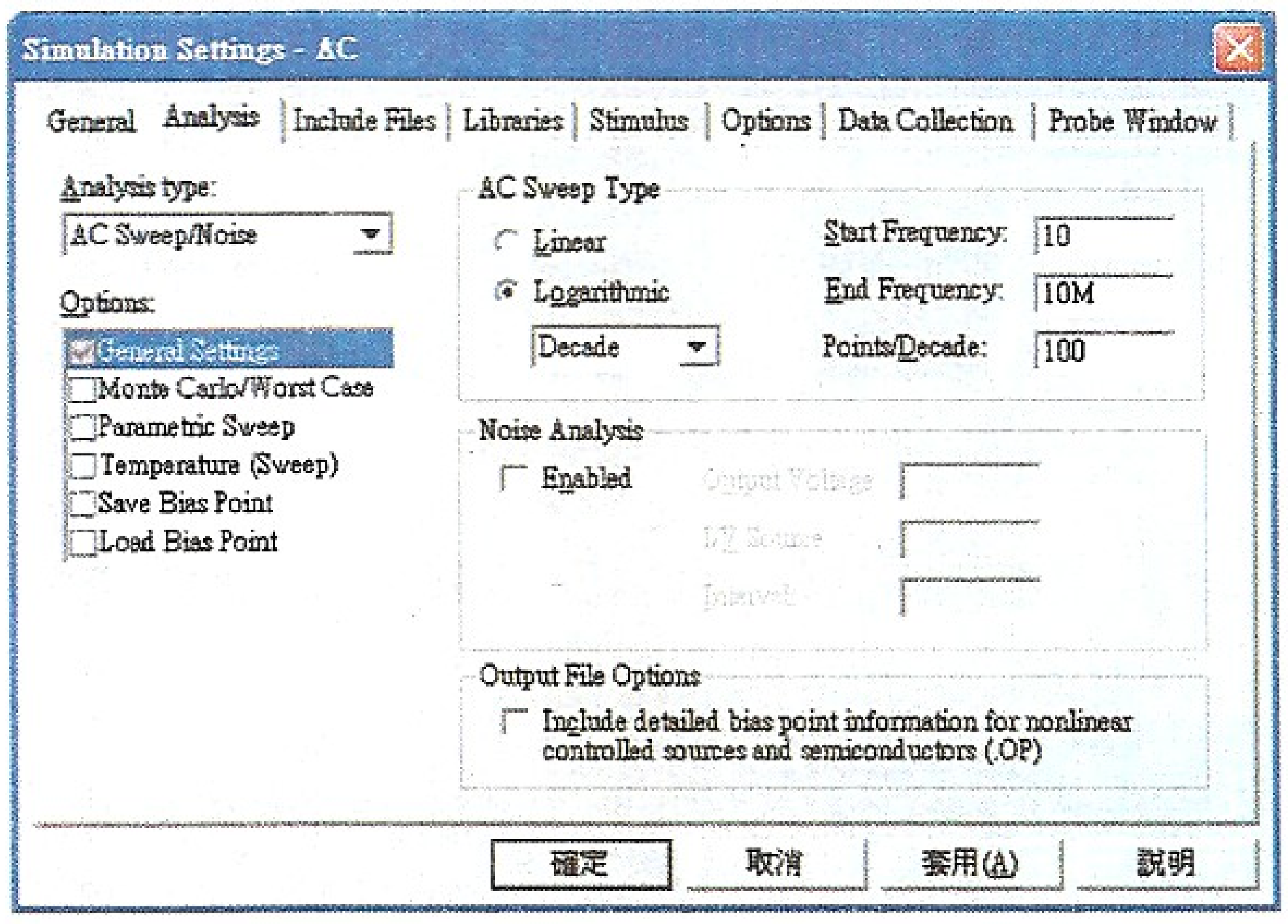
   (a) **[4]** Sketch the cable used to connect the function generator.

   (b) **[4]** Sketch the probe used to connect the oscilloscope.

   (c) **[4]** What is the X1-X10 switch of the probe used for?

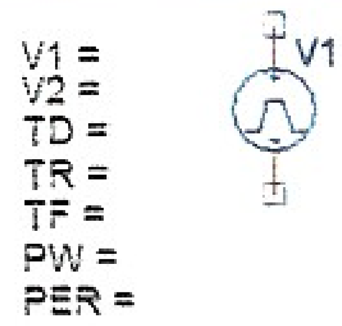
   (d) **[4]** In the experiment of the Wien Bridge, what happens if we connect the input to the channel 1, and the output to the channel 2? (Hint: can we observe the circuit correctly? Why or why not?)

6. Answer the following questions about the usage of OrCAD 16.2 Demo version.



   (a) **[4]** John applies the AC Sweep window as the right figure, and he complains that PSpice doesn't work. What's wrong?

   (b) **[4]** Give the values of V1, V2, TD, TR, TF, PW, and PER to setup a square wave with the low voltage –5V and the high voltage 5V by the element VPULSE shown in the right figure.



   (c) **[4]** Give the values of V1, V2, TD, TR, TF, PW, and PER to setup a triangular wave with the least voltage –5V and the highest voltage 5V by the element VPULSE shown in the right figure.

7. Answer the following questions about the labeling of the passive elements.

   (a) **[4]** Why are the capacitors with 20% error sold in the market with significant digits 10, 15, 22, 33, 47, 68 only?

   (b) Write down the color codes of the 5%-error carbon-film resistors.

      (1) **[4]** 4.7MΩ

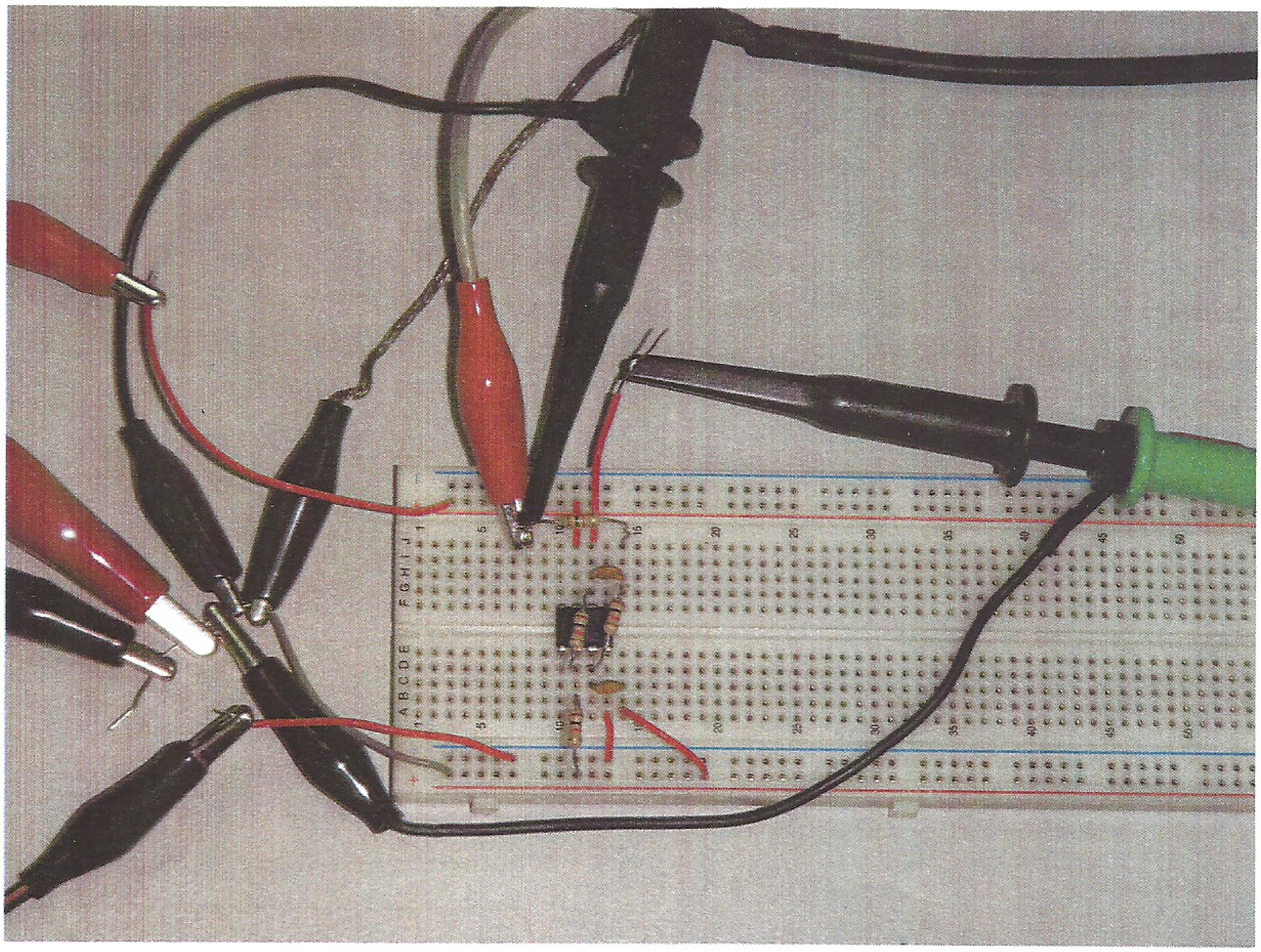
      (2) **[4]** 3.9Ω

8. Mary designed and then connected a filter involving IC μA741 on the breadboard shown in the following picture. It is confirmed that her circuit works correctly. All of the resistors are 1kΩ, and all of the capacitors are 0.1μF. The black probe is connected to the input v_i and the green probe is connected to the output v_o.

   (a) **[4]** Draw the circuit of this filter.

   (b) **[4]** What is the transfer function of the filter?

   (c) **[4]** What type is the filter? A low-pass, high-pass, or a band-pass filter?



End of Problem Set

NOTE: All the score records of the reports and the finals will be announced before January 8 on the website. Remember to check if your records are correct.