Analytical Chemistry Cumulative Exam: Electronics and Data Acquisition

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May 2016

Answer each question in a complete and concise manner. Try to answer all questions: you will receive credit for partially correct answers.
Total 100 points. The pass line is ~70 points.
Clearly identify all your answers in the exam booklet by question number.

1) **(5pt)** Draw the electronic symbol for the following electrical components:
   a) Capacitor; b) Resistor; c) Op-Amp; d) LED*; e) 8-pin IC.
2) **(10pt)** What is the function of the transducer and the sensor? Give example of a sensor.
3) **(20pt)** a) Describe application where you must use an oscilloscope rather than a DMM** and explain why the oscilloscope is necessary.
   b) Draw a diagram of how you attach a DMM to measure the current and voltage across the light bulb running off 10 V DC power supply;
   c) You discover that your bulb in previous circuit has stopped working. What is your step to troubleshoot the problem (or problems)?
4) **(10pt)** Integrated circuits contain a maze of interconnected, microscopic elements called transistors. What is the function of these transistors? Is transistor an active or passive circuit element? Why?
5) **(10pt)** What is the difference between an Operational and Lock-in amplifier? Describe application where you use them.
6) **(20pt)** A signal of interest has a maximum frequency of 100 KHz, but there is a significant "white noise" and simulated noise at 5 MHz present.
   a) Describe two significantly different ways (analog and digital) to remove noise from an electrical signal without strongly affecting the 100 kHz signal;
   b) What is the theoretical minimum sampling rate needed to accurately digitize the signal of interest?
   c) What will be the highest accuracy (or step size, in volts) for signal of interest attainable with a 16-bit DAC that has an output range of 0 to +10 V DC.
   (*Show your work in determining this value*).
7) **(5pt)** You have a commercial instrument that creates binary data files. When you look at the data file with an editor program, you see a bunch of nonsensical numbers and characters instead of your data. Why?

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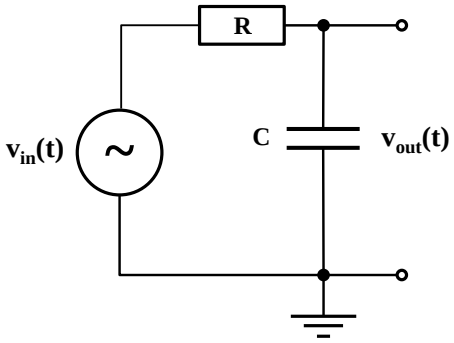
* Light Emitted Diode

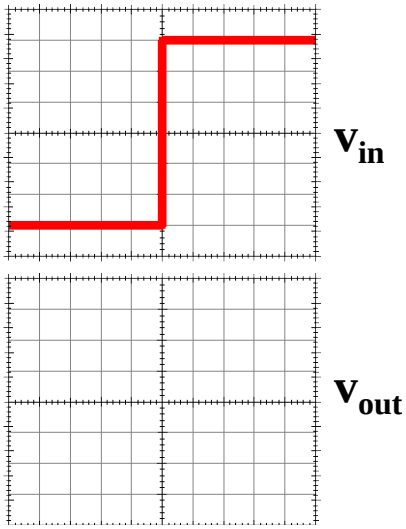
** **D**igital **M**ulti**M**eter

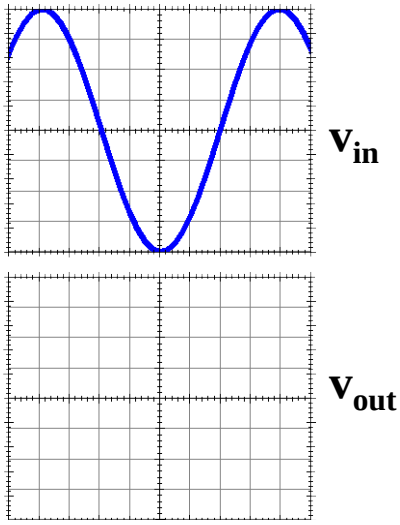
8) **(20pt)** Consider that you plan to use the circuit shown on the right as frequency filter.



a) What kind of a filter do you think this is?

b) Sketch the output voltage for this circuit with step waveform input (time scale in a.u.) *(shown on the right)*





c) Sketch the output voltage (vertical sensitivity in a.u.) for same circuit with sine waveform input *(shown on the left).* Assume that $Z_R=Z_C$

9) **(bonus 15pt)** Assume for same circuit *(see question 8)* that the oscilloscope screen vertical sensitivity is set to 1 Volt per division, the timebase control is set to 2 ms per division and $Z_R=Z_C=100\ \Omega$

a) calculate the frequency of AC current and RMS values for sine wave form *(input and output).*

b) What is f_{3dB} value for this filter?

c) Describe how <u>in general</u> you can obtain f_{3dB} value by using oscilloscope.