Homework Assignment #3 (ME-190, Fall 2016)

Due date: Thursday, Sept. 29, 2016, 2:00 pm.

Objective: Develop an analog RC filter and a digital filter for noise reduction of analog measurements

Exercise 1- Create an analog RC filter with the resistor value of **10 kΩ** and capacitor value of **1 μf** on a breadboard.

Step 1: Connect the capacitor end to the ground, and the resistor end to your analog sensor data pin.

Step 2: Take another wire from the resistor end on the breadboard and connect it to one of the Arduino's analog pins. This should connect the analog sensor's data pin to the Arduino's analog input pin.

Step 3: Take a wire from the capacitor/resistor junction point and connect it to another Arduino's analog pin. This will be the capacitor's voltage, which is considered as the filter voltage.

Step 4: In the Arduino code's void loop, read the Sensor output voltage and Capacitor voltage, and send them out to a text editor using "serial.print" function. Also send time to the text editor using "millis()" and serial.print functions. You should use "serial.print" and "serial.println" and manage to get three columns in your text editor (e.g. serial printer) separated by tabs.

Time (ms) Sensor Voltage(V) Capacitor voltage(V)

Do not print any other information except for the numbers.

Example:

12 2.31 2.30
24 2.35 2.32
36 2.40 2.36
. . .
. . .
. . .

Step 5: Try to change the analog sensor's response by externally modifying the conditions. For example, if you are using a light sensor, try to change the light intensity randomly by waving your hands in front of the sensor. If you are using a temperature sensor, try to increase or decrease the temperature by moving a hot or cold object close to it.

Step 6: After running the test for 10-20 s, stop collecting the data.

Step 7: Copy and paste the data in Excel or Matlab:

MyData = [“Paste here”];

Step 8: Plot the actual sensor voltage and the filtered sensor voltage (Capacitor voltage) vs. time in Matlab. If you copied data into Excel, read it from Matlab and plot it in Matlab. Do not plot in Excel!

Step 9: Include labels and legends in your plot.

Your submitted report must include:

- A picture of your setup
- Arduino code
- A had drawn schematic diagram of the circuit with appropriate labels
- Plot of the sensor and capacitor voltage on the same figure
- A zoomed-in plot showing the filter has removed high-frequency noise from your data
- The same plots for the capacitor value of 2200 µf (The big capacitor.
- A brief summary of your conclusions about the RC filter

Exercise 2- Repeat the work in the previous exercise for the case of a digital filter instead of the RC filter. A digital filter’s update equation is given by:

$$v_k^{filt} = \alpha v_{k-1}^{filt} + (1-\alpha) v_k^{Sensor}$$

which can be implemented in the Arduino code’s void loop. In this case, v^{sensor} is the raw sensor voltage. There is no need for the RC filter in this exercise.

Try different values of α (between 0 and 1) and present your results. Which value of α would provide a good trade-off between noise reduction and signal accuracy?

Your submitted report for this part must include:

- Arduino code
- Plots of the raw and filtered sensor voltages on the same figures for 3-5 different values of α. Use separate figures for each value of α.
- Your designed filter plot (with α which gives the best trade-off in your view)
- A zoomed-in plot showing the filter has removed high-frequency noise from your data (For your selected value of α only).
- A brief summary of your conclusions about the digital filter