Lab #2: Introduction to iWorx

<u>**Materials Required**</u>: Oscilloscope; AF Signal Generator; iWorx ETH-256 Bioamplifier with NI USB-6009 Interface; BNC Tee, F-M-F; Two 1 m BNC-BNC Coaxial Cables; LabScribe Software.

Introduction:

In the past (and we do mean the distant past!), electro-mechanical instrumentation was king in the medical field. Hospitals and laboratories were home to dozens of devices such as paper plotters, analog computers, and mechanical waveform storage systems -- such as the kymograph, which plots waveforms with a mechanical stylus onto a rotating drum coated with carbon black.

Modern instrumentation is computer based. Computer-based instrumentation uses one or more analog-to-digital converters to convert the input signals into a sequence of binary numbers. Usually the computer is embedded into the product, but personal computers (PC) can also be used.

In our laboratory we will use three components in a PC-based system to acquire biomedical data. These components are:

- The iWorx ETH-256 Bioamplifier. This is a precision programmable amplifier that provides necessary voltage gain and bandpass filtering for acquiring biomedical signals. (It does *not* provide safety isolation; a separate pod is attached to provide this feature.)

- The National Instruments NI-6009 Data Acquisition Unit (DAQ). This unit converts the amplified analog signals from the ETH-256 bioamplifier into digital. The digital data is passed to a PC through the Universal Serial Bus (USB) interface.

- LabScribe Software. This package uses the API (Application Programming Interface) of the NI-6009 to acquire, display, manipulate, and store the incoming data. LabScribe can perform a wide variety of operations on signals, from basic math (addition, subtraction, and so on) to calculus (integration, differentiation). It is also "units savvy." It can be programmed to display data in the correct dimensional units to make it easier to interpret results.

In this experiment you'll acquire some "known" signals from an audio signal generator into iWorx and process them. This will be valuable hands-on experience, because you'll be relying on iWorx for the remainder of the semester. (Of course, if you ever get into a pinch, we can pull out an analog scope for you to use; but we hope that you get confident enough with the iWorx package to have a good feel for what your signals are really doing.)

Lab Procedure:

1. Read the online documentation for LabScribe. (This documentation is located at http://faculty.kc.devry.edu/twheeler/bmet311/lsmanual.pdf)

2. Log in to the desktop computer. Give the computer a minute or so to stabilize after logging in.

3. Apply power to the ETH-256, then connect the USB cable from the NI-6009 DAQ unit to one of the USB connections on the front of the computer. One of the following will take place:

   - If this particular DAQ has been used with the computer before, nothing will happen on screen. The green LED on the DAQ will flash rapidly to indicate that the DAQ and PC are communicating with each other. If this is so, you are ready to start iWorx (proceed to Step 4).

   - If the computer hasn't seen this DAQ's serial number before, it will pop up the following window:
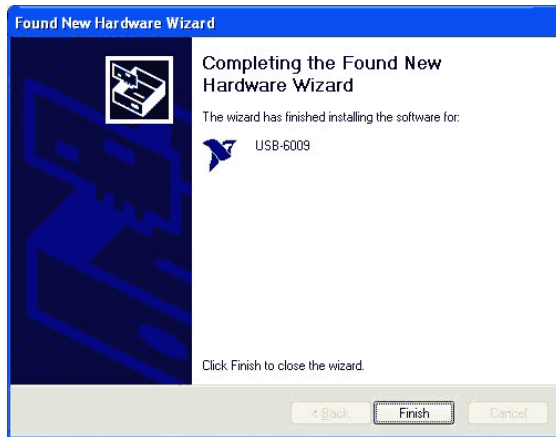

   → Choose "No, not this time" and click NEXT. You'll then see:
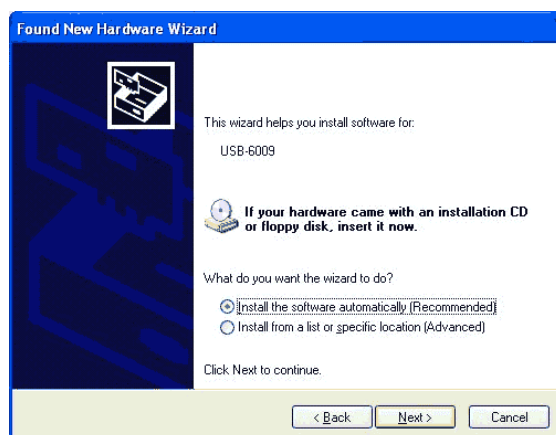
   → Choose "Install the software automatically (Recommended)" and click NEXT.

Step 3 (Continued):

- You should see the following to confirm successful installation of the DAQ:

If you don't get this screen, ask the instructor for help.

4. Connect the signal generator, oscilloscope channel 1, and ETH-256 channel 1 together using two coaxial cables and the BNC tee.

   This setup provides the scope and ETH-256 with exactly the same signal.

5. Adjust the signal generator to produce a 5 Vpp 20 Hz sine wave signal. Verify this with the oscilloscope.

6. Start iWorx. It may prompt you for a safe directory in which to write data. Choose the local drive, which is probably D. (You should verify this with Explorer first.)

7. Configure iWorx to properly acquire the signal. In particular, you'll need to:

   → Make sure the sample rate is at least 10X the frequency of the signal you're acquiring, at least 200 Hz in this case. *This setting is under Edit→Preferences.*

   → Set the ETH-256 channel 1 filtering to: HPF: DC   LPF: 2 kHz   GAIN: x1

   Your front panel should look like this:
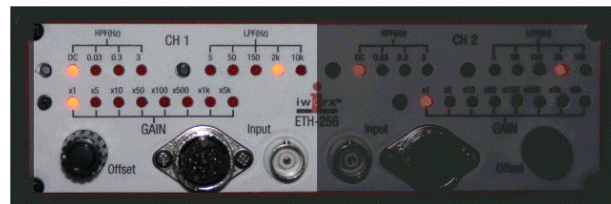
   → Make sure the scale setting of Channel 1 on screen is from (-5V) to (+5V).

   → Press the START button (near upper right) to begin acquiring the data. You only need to acquire a few seconds of data; press STOP when you're done.

8. You will almost always need to adjust the DC OFFSET for each channel when you're acquiring data.

→ If the signal trace is not centered around 0 volts, adjust the "Offset" knob for Channel 1 on the ETH-256 front panel. This control is a multi-turn potentiometer, so it may take several rotations to get it right.

→ It's usually BEST to adjust DC OFFSET with the input signal zeroed. However, there must be SOMETHING connected to the input jack of the bioamplifier for this to be a valid adjustment. If you can't seem to get a channel to zero, make sure it's correctly connected!

→ For some sensors, the center or average value of the trace will NOT be zero volts!

→ You can only see the effect of the DC OFFSET adjustment while you are actively acquiring data (iWorx is in RUN mode). It does not affect previously-captured data.

9. Save the image of your captured data to the clipboard by pressing the ALT - PrintScrn keys. Your data be on the clipboard -- you can then paste this picture into an Office document (such as a lab report!)

TIP: You might find it helpful to keep OpenOffice or Word open during the lab procedure so that you can store the screen captures. You can also save waveform data as a MATLAB sequence, if you want to manipulate the data in MATLAB.

10. Let's try doing some computations on input data. In particular, we'll capture a waveform and calculate it's derivative and integral.

Change the input signal to a 4 Vpp square wave, and capture two seconds of data. Leave the sample rate at 200 Hz.

TIP: You MUST start a new document ⬜ in iWorx so that the old data will be erased. Otherwise, iWorx will append the new data capture onto the existing data set. Also, you MUST start a new document whenever you change a setting such as sample rate, or the setting change will be ignored.

11. Set the preferences so that three channels are displayed on screen. (This is located under CHANNELS in the Preferences dialog of iWorx, located at Edit→Preferences.)

12. Capture two seconds of data, as before.

13. Right-click within the Channel 2 area and choose "Derivative→First" from the pop-up menu.

Raw Data
Periodic ▶
Integral ▶
✔ Derivative ▶
Channel Math...
Filter...
Power...
Spirometry ▶
EEG ▶
Set Raw Ch (1) ▶

The bottom option on this menu shows you that the raw data will come from Channel 1.

By choosing "Title..." from the pop-up menu, you can set the text for this channel. Set the text to read "First Derivative."

14. Calculate the integral on Channel 3. You'll have to do this in two steps:

   a) Right-click within the Channel 3 area and choose "Set RawCh()" to 1. This
      tells iWorx which data to use for the calculation.

      NORMALLY, THE DEFAULT "INPUT" FOR MATH OPERATIONS IS THE
      CHANNEL IMMEDIATELY ABOVE!

   b) Right-click within the Channel 3 area again and choose "Integral→Regular."

   c) Label Channel 3 appropriately using the "Title..." option.

15. Do another screen dump to the clipboard to save this data (use the ALT - PrintScrn
    sequence).

16. Do the first derivative and integral look "correct" for the square wave data? Comment on
    this in your report.

17. You might have noticed that the square wave doesn't look very square. Try increasing the
    sample rate to 5 kHz (don't forget to create a new document for this to take effect), and
    capture two seconds of 20 Hz data again.

   → Recalculate the 1st derivative and integral, as before. (You might make sure everyone
      in your group is comfortable with doing this operation.)

   → Comment in your report: Did increasing the sample rate improve the quality of the
      data capture? What characteristic(s) of the captured waveform tell you about the
      "quality?"

18. You're almost done! Let's try just one more operation with iWorx. We're going to capture
    data from a force sensor, and have iWorx display this data in correctly-scaled units.

   → Connect the Hand Dynamometer (the rubber bulb) to Channel 2 of the ETH-256.

   → Set the ETH-256 Channel 2 filtering to: HPF: DC   LPF: 5 Hz   GAIN: x1

   → Look up the specs for this sensor. They're on page 101 of the document "hk256ni.pdf."
      We'll use this information to setup iWorx to correctly acquire and display the signal.

      Sensitivity: _____ mV/kg (Note: These aren't force units, but ignore this detail.)

      Possible DC Offset: _____ mV

      Maximum Value Expected: 150 kg (Full-Range output. PLEASE DO NOT APPLY
                                      MORE FORCE THAN THIS TO THE SENSOR.)

19. Create a new document in iWorx. (You can leave Channel 1 connected to the signal generator; no need to change it.)

From your data in Step 18, you've probably figured out that the maximum DC input voltage will be about (150 kg) (3 mV/kg) or about 450 mV. We'll set the input to read the range (-0.5 V, +0.5 V) to cover this range, and set iWorx to properly report the converted units from the sensor.

→ Right-click in the Channel 2 area and set its function back to "Raw Data."

→ From the Edit menu, choose "Preferences." You'll see the following dialog:

Text description of the display units

Minimum and maximum for GRAPH SCALE

Raw input min and max values, and their corresponding "Calibrated unit" display. (0 V = 0 kg, 0.45 V = 150 kg)

In this dialog, the Channel 2 information is important. Notice how we're really supplying a conversion factor to iWorx. We're telling the program that 0 volts at the input is 0 kg, and 450 mV at the input is 150 kg (remember, about 3 mV/kg). We're also telling it to tag the displayed values as "kg" units. Finally, we're instructing iWorx to scale the graph Y-axis to -150 and +150 kg.

NOTE: The settings for Channel 1 in the above figure should be ignored!

20. Now click the START button. Do not squeeze the bulb yet. Set the DC OFFSET control so that the graph is zeroed.

→ Now squeeze the bulb. The graph will indicate the force, but it will be *negative* due to the inversion in the ETH-256 bioamplifier. To fix this, right-click on Channel 2 and choose *Invert*.

21. So what are the relative strengths of your little finger and index finger? Now that we have the sensor calibrated, we can easily answer this question.

PLEASE DO NOT EXCEED 150 kg FORCE DURING THIS MEASUREMENT, AS THE SENSOR CAN BE EASILY DAMAGED.

→ Record the maximum force you can produce by holding the bulb between your thumb and little finger.

→ Repeat the measurement between your index finger and thumb.

→ Collect this data for each member of your group:

    a) Which finger was stronger, and was this true for all members of the group?
    b) What is the average value of force available through the little finger for the group?
    c) Squeeze the bulb again between the thumb and little finger, and measure how long it takes for the force to drop to 70% of its initial (full tetany) value. What biological effect is taking place causing the force to fall?

Lab Report #2 Checklist

The lab reports in BMET-311 are formal, and for this experiment the following content (as a minimum) should be present:

- Cover page, with the experiment title, and names and *roles* of the team members. Don't forget to rotate roles for each experiment. (Refer to the course syllabus for more details).

- Introduction and Discussion of Theory: Present the theory behind this experiment; why is it important, what theories and ideas are being explored/tested, and so forth.

- Procedure and Data: This report has the following recorded data, which should be discussed in the procedure:

    Step 9 - Signal, derivative, and integral @ 200 samples/sec
    Step 17 - Signal, derivative, and integral @ 5000 samples/sec
    Step 21 - Hand Dynamometer data

    Don't forget to explain each major step your group performed, and WHY. *Your report must answer all questions posed during the experimental instructions.*

- Conclusion: What can be concluded from the data you collected in the experiment? Please note that this is different than a summary (although it is okay to recapitulate or summarize what you did in the experiment as you reach conclusions).

NOTE: This will be the last "checklist" you'll see for BMET-311 lab reports. You'll (almost) be on your own from now on!