BLOOD PRESSURE

OBJECTIVES

Students will learn basic concepts of acquiring systolic and diastolic blood pressures. Students will also learn about the various factors which influence blood pressure by working and becoming familiar with Vernier's blood pressure sensor. This lab also introduces the Noninvasive Blood Pressure Analyzer of the NI Biomedical Startup Kit.

MATERIALS

- NI Biomedical Startup Kit 3.0
- NI ELVIS II Series Benchtop Workstation
- NI ELVIS II Series Prototyping Board
- AC/DC power supply
- NI ELVISmx 4.0 or later CD
- High-speed USB 2.0 cable
- Computer
- Wires to build circuits
- Vernier Analog Proto Board Connector (Order Code BTA-ELV)
- Vernier Blood Pressure Sensor (Order Code BPS-BTA)

THEORY

This lab uses the oscillometric method as a way to non-invasively measure blood pressure. This method is based on the principle that blood pumped through the arteries by the heart causes the arterial walls to flex. First, a cuff is placed around the upper arm to occlude the brachial artery. When the cuff is inflated and then slowly deflated at a constant rate, an arterial pressure pulse forms, which passes through the arm and into the cuff itself. When the cuff reaches maximum inflation, the artery becomes highly occluded which stops pulsations of the blood. As the pressure in the cuff slowly decreases, blood pressure increases and the blood is forced through the artery in short pulses. As the pressure in the cuff continues to decrease, the pulses become increasingly significant until maximum amplitude is reached. The cuff pressure corresponding to this amplitude approximates the mean arterial pressure (MAP). At that point, the pulses will begin to decrease with any further decrease in cuff pressure.

These pressure pulses form an oscillating waveform and the peak-to-peak amplitudes of this waveform create a bell shaped "envelope" (Figure 1). The systolic blood pressure (SBP) is

calculated by determining the point along the envelope prior to the MAP using a known percentage of the maximum amplitude. Diastolic blood pressure is calculated using the same method but with the portion of the envelope following the MAP.

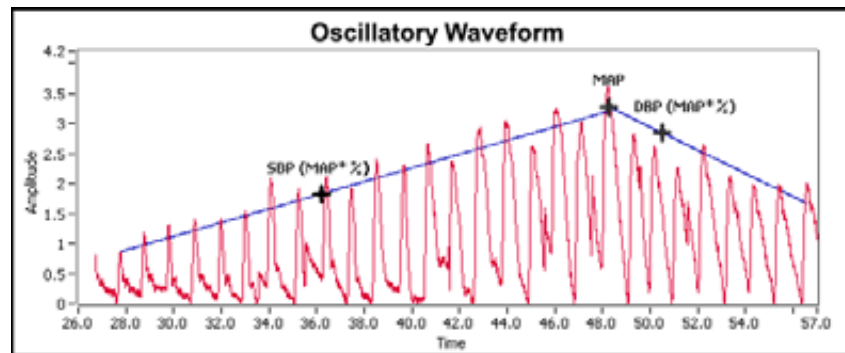(Summarized from the Blood Pressure Sensor User Guide; http://www.vernier.com)

Figure 1: Oscillatory Waveform of Blood Pressure Pulses

(www.vernier.com)

BUILDING THE EXPERIMENT ON ELVIS II SERIES

The Vernier sensor attaches to NI ELVIS II Series through the Analog Proto Board Connector. The following steps and Figure 2 below illustrate how to connect the Analog Proto Board Connector to the NI ELVIS II Series Prototyping Board.
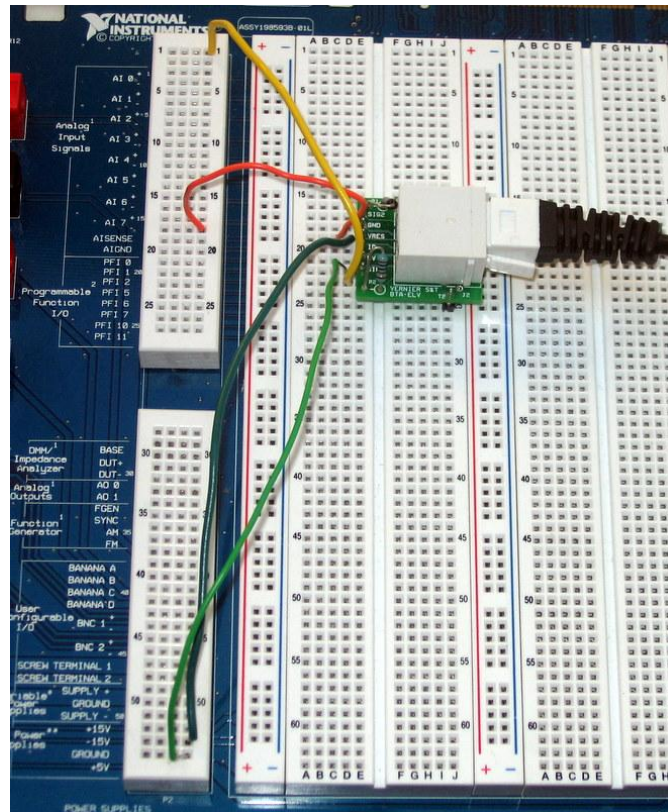
Figure 2: Connecting the Analog Proto Board Connector to NI ELVIS II Series

Connect the following pins to wire the connector:

1) AI0+ to SIG1 of the Analog Proto Board Connector
2) +5V DC power supply to 5V of the Analog Proto Board Connector
3) GROUND power supply to GND of the Analog Proto Board Connector
4) AIGND to GND of the Analog Proto Board Connector

RUNNING THE EXPERIMENT

To set up the experiment on NI ELVIS II Series:

1) Connect the USB cable from NI ELVIS II Series to your computer and plug the power supply into a power outlet.
2) Turn the prototyping board power switch located on the rear panel to the on position (see Figure 3).
3) Turn the prototyping power supply switch located on the benchtop workstation to the on position (see Figure 3).
   - A green power LED should now be lit, indicating that the full power supply is turned on.
   - A yellow USB ready LED should also be lit, indicating that the NI ELVIS II Series is properly connected to the USB host.

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4) Insert the blood pressure sensor into the Analog Proto Board Connector connected to AI 0+.

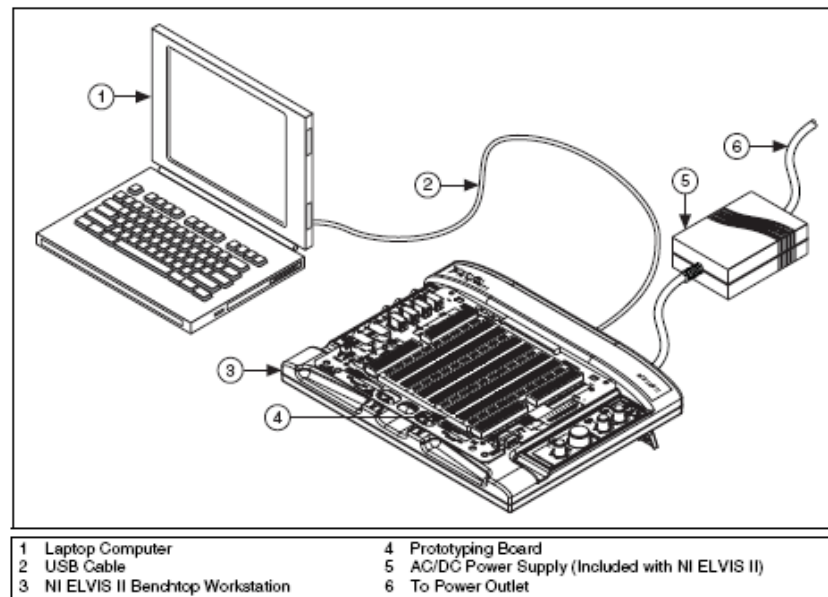| 1 | Laptop Computer | 4 | Prototyping Board |
| 2 | USB Cable | 5 | AC/DC Power Supply (Included with NI ELVIS II) |
| 3 | NI ELVIS II Benchtop Workstation | 6 | To Power Outlet |

Figure 3: NI ELVIS II Series Set-Up

To set up the experiment with the Biomedical Startup Kit:

1) If the Biomedical Applications palette is not installed on your computer:
   - Go to https://decibel.ni.com/content/docs/DOC-12646 and download Biomedical Startup Kit 3.0
2) Once Installed, go to Start>>All Programs>>National Instruments>>Biomedical Startup Kit and Click on Biomedical Workbench. A pop-up menu should show up on your screen.
3) Select Noninvasive Blood Pressure (NIBP) Analyzer from the Biosignal Tab. Two blank charts will be displayed in a separate window (Figure 4).
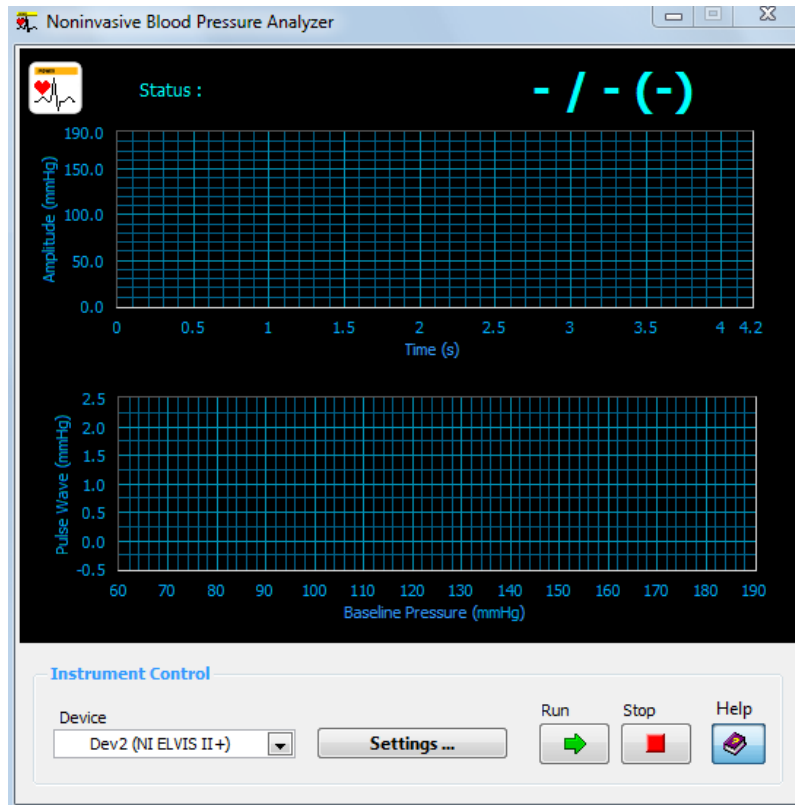
Figure 4: Noninvasive Blood Pressure Analyzer

1) In the Device dropdown menu, select the device corresponding to NI ELVIS II Series.
2) Click on "Settings" to view the Set NIBP Parameters window.
   - Select AI0 from the Pressure dropdown menu. This is the channel from which the program will acquire data.
   - Ensure that the "Vernier Sensor?" box is checked. This will tell the Analyzer to automatically use the correct calibration for the Vernier Blood Pressure Sensor.
   - The measurement process will stop automatically when the program detects a steady increase until the pressure is greater than "BP Range (High)" and then a gradual decrease until the pressure is less than "BP Range (Low)". Change the "BP Range (High)" setting to 150 mmHg. The pressure in the cuff must be greater than this value after inflation.
   - Look over the other settings. Leave these as their default values. The pump parameters are ignored when using a Vernier sensor because the cuff is inflated manually. Click "OK". Press the "Help" button on the NIBP Analyzer window to pull up a Help window that explains the details about each of these settings.

DATA COLLECTION

Part 1: Blood Pressure at Rest

Blood pressure readings may differ between measurements on the same individual due to the many factors that can cause a person's blood pressure to increase or decrease. Follow the steps and helpful tips below to take accurate measurements with the blood pressure sensor:

1) Attach the rubber hose from the cuff to the connection on the blood pressure sensor.
2) Wrap the cuff firmly around the volunteer's arm, approximately 2 cm above the elbow. The two rubber hoses should be positioned over the bicep muscle and not under the arm. The patch on the cuff that says "Artery" with an arrow pointing downward should be positioned directly over the brachial artery (See Figure 5).

3) The volunteer should remain seated for the duration of the experiment. To ensure accuracy, the volunteer should also remain quiet and still throughout the experiment.
4) Click on the green "Run" arrow on the NIBP Analyzer to begin collecting data.
5) Quickly and repeatedly squeeze the bulb to inflate the cuff on the volunteer's arm until a pressure between 150 and 170 mmHg is reached. When the cuff inflates to this pressure, set the bulb pump down onto a table. The built-in pressure release valve will start to slowly deflate the cuff**.
6) When the pressure drops to 50 mmHg, press the "Stop" button to stop data collection.
7) Press down on the pressure release valve (right above the bulb pump) to release any air left in the cuff.
8) The NIBP Analyzer window displays the real-time blood pressure plot in the top waveform graph. After the measurement process stops, the pulse wave amplitude profile is displayed in the bottom waveform graph. The estimated blood pressure (systolic/diabolic) is displayed in the top right corner. An example of the results of a blood pressure measurement is shown in Figure 6.
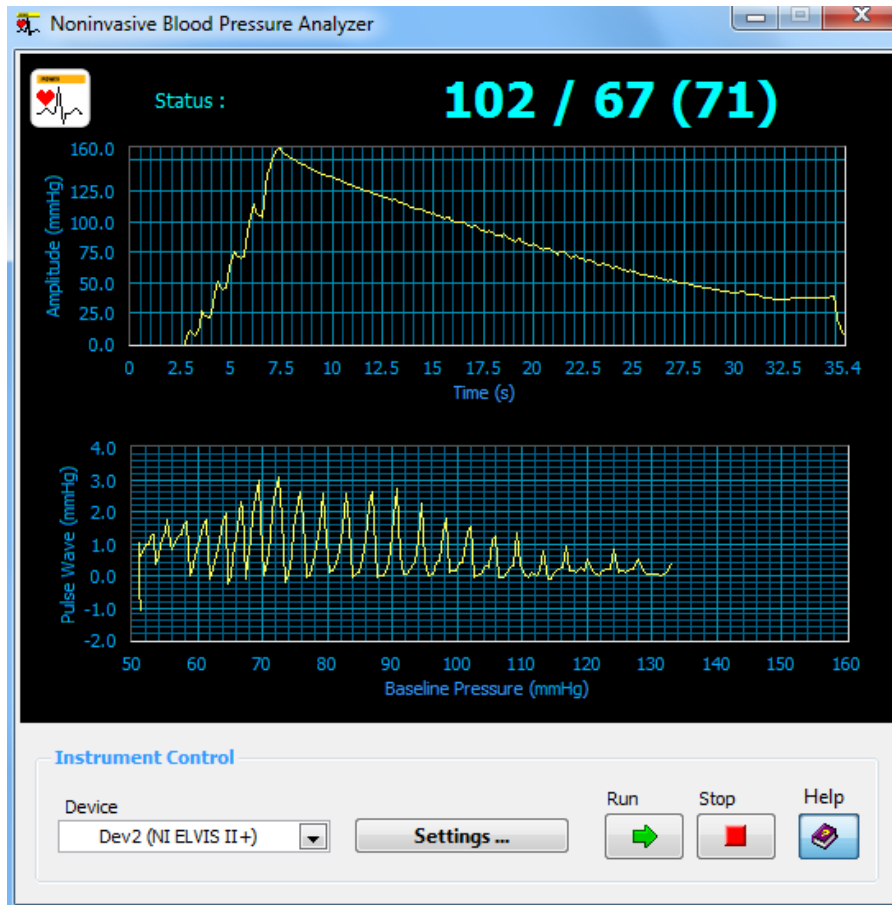
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Figure 6: Example Results of Blood Pressure Measurement

9) Record the systolic and diabolic blood pressures in Table 1.
10) Repeat steps 1-9 for each student.

** The pressure release valve is set to release at a rate of 3.0 mmHg/second on an arm with a circumference of 32 cm. If it seems to be taking too long for the cuff to deflate to 50 mmHg, adjust the exhaust rate of the pressure valve according to the following directions:

- Place a screwdriver into the metal slot on the top of the release valve.
- Turn the screwdriver clockwise to increase the rate of the exhaust or counterclockwise to decrease the rate of the exhaust.
- Note: For a larger arm circumference, the release valve will exhaust at a slower rate.

Part 2: The Effect of Physical Activity on Blood Pressure

1) Now, instruct the volunteer to run in place for 3 minutes.
2) Follow steps 1-8 from Part 1.
3) Record the systolic and diabolic blood pressures in Table 2.
4) Repeat steps 1-3 for each student.

DATA ANALYSIS

Part 1: Blood Pressure at Rest

Table 1: Resting Blood Pressure

Student Name	Systolic Blood Pressure	Diastolic Blood Pressure

Part 2: The Effect of Physical Activity on Blood Pressure

Table 2: Blood Pressure After Physical Activity

Student Name	Systolic Blood Pressure	Diastolic Blood Pressure

1) Did the pulse waves displayed on the NIBP Analyzer window create a bell-shaped "envelope" similar to the graph in Figure 1?
2) Compare the data recorded from each student. Do you notice a difference based on body size? What about fitness level?
3) Based on what you know about the heart, how do you think age would affect blood pressure?
4) List various factors and/or diseases that could affect blood pressure. How would each of these affect the blood pressure measured by the blood pressure sensor?
5) Compare the data in Table 2 with that from Table 1. Did physical activity affect the systolic and diastolic blood pressure? Why or why not?
6) Were the trends noted in the question above consistent for each member in your group?

REFERENCES

Blood Pressure Sensor User Guide. Vernier Software & Technology. Rev. 2/16/10. Accessed 7/22/11. www.vernier.com.

NI Educational Laboratory Virtual Instrumentation Suite II Series (NI ELVIS II Series) User Manual. National Instruments. Austin, TX: National Instruments Corporation. 1/09. www.ni.com.

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