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#AS117 - Pulse Transit Time and Velocity Calculation

Pulse Transit Time (PTT) is the time it takes the pulse pressure waveform to propagate through a length of the arterial tree. The pulse pressure waveform results from the ejection of blood from the left ventricle and moves with a velocity much greater than the forward movement of the blood itself. The defining equation is:

$$v = K \cdot \sqrt{[V \cdot \Delta P / \Delta V]}$$

(from Bramwell & Hill, 1922)

where:

- v = Pulse Wave Velocity
- K = constant
- V = Initial Vessel Volume
- ΔP = Pressure Delta
- ΔV = Vessel Volume Delta

With increased vessel wall stiffness (decreased compliance), DELTA V decreases and pulse wave velocity increases. With increased blood pressure, the arterial walls are more strongly stretched and pulse wave velocity increases. Accordingly, for a fixed vessel distance, as the pulse transit time increases the blood pressure decreases.

In this application note, pulse transit time will be measured between the R-wave and the peak of the pressure wave at the finger, as measured by the pulse plethysmograph.

Equipment

- MP100 data acquisition system
- PPG100B pulse plethysmogram amplifier
- TSD100B pulse plethysmogram transducer
- ECG100B electrocardiogram amplifier
- Electrodes and leads

Hardware Setup

Select ECG100A for channel 1 and the PPG100A module for channel 2. Adjust the gain on each amplifier to obtain viable signal levels. The ECG100A should be set for NORM output, FILTER off and HIPASS on. The PPG100A should be set for AC coupling.

Connect the electrodes leads to the subject to obtain a Lead I or Lead II trace. Place the TSD100B plethysmograph transducer on the index finger.

Software Setup

Under Setup Channels, set the ECG100A amplifier for channel 1 and the PPG100A amplifier for channel 2. Also, set up the following calculation channels:

Calculation C0: Peak Time for channel 1...Under the **RATE** option
Calculation C1: Peak Time for channel 2...Under the **RATE** option
Calculation C2: Peak Time Delta (C1-C0)...Under the **MATH** option
Calculation C3: Pulse Transit Time (Maximum of C2)...Under the **RATE** option

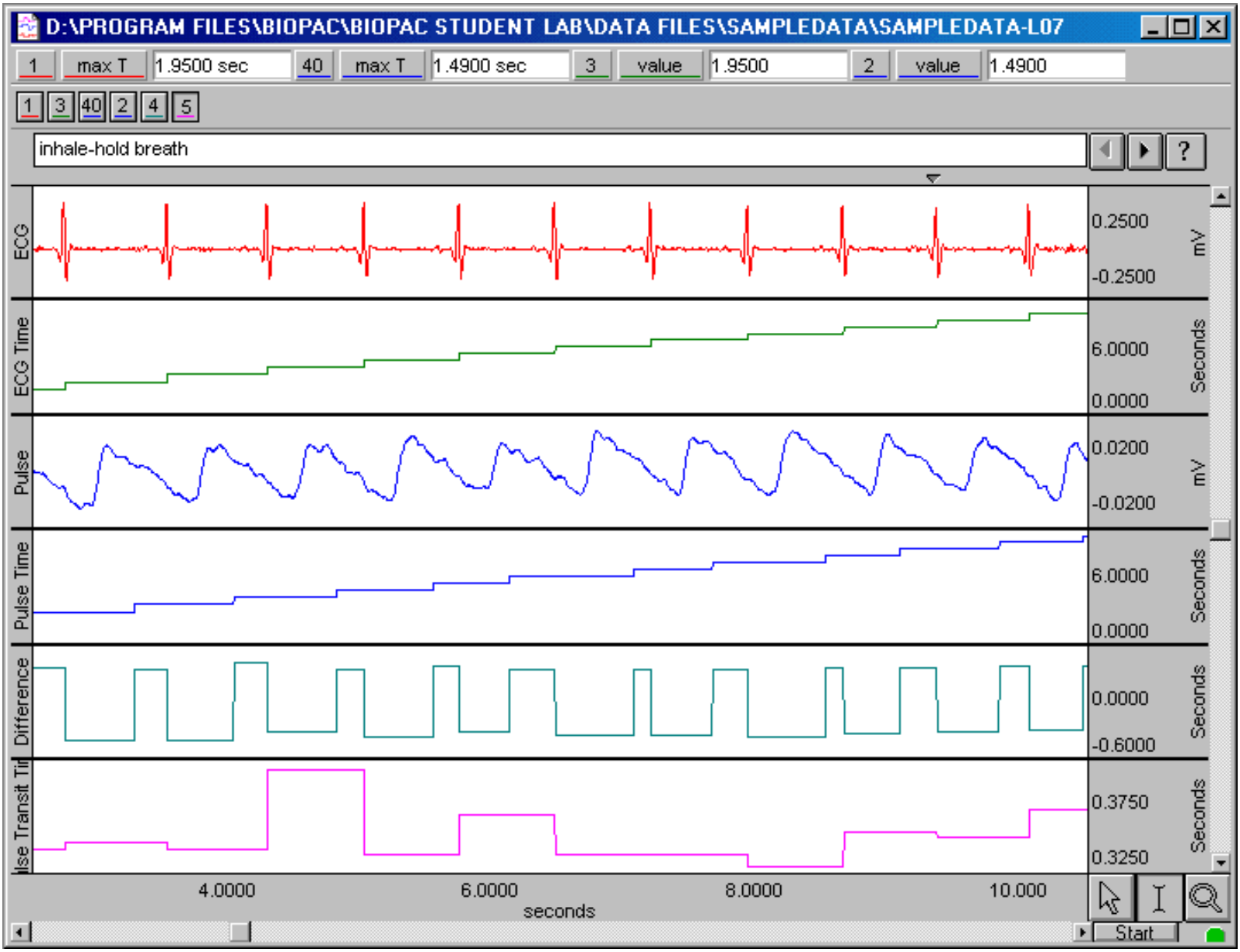
Under Setup Acquisition set storage to Memory of Disk, sample rate to 1000 samples per second, acquisition length to 60 seconds. A sample rate of 1000 Hz will provide 1/1000 Hz (1ms) resolution for the PTT measurement.

Procedure

To begin recording, press the START button. You should see data similar to the following graph. If your computer isn't sufficiently fast, you may need to record to MEMORY as opposed to DISK. Also, to help increase speed, you can turn off plotting of the intermediate calculation channels (C0, C1 and C2).

After the data is recorded, you may wish to resample the pulse transit time waveform to a 1Hz interval. This procedure will cut your data storage requirements by more than a factor of 1000. It's important to initially sample at 1000Hz, because the timing resolution is important for proper PTT calculation, but after the data is collected, you can resample at a much lower rate because the PTT variations will typically occur slowly.

In the following graph, the PTT (bottom wave) shows a stepped waveform where the increases correspond to decreases in blood pressure resulting from decreases arterial vessel wall stiffness. In this manner the PTT can be used to indicate fast changes in real-time blood pressure. The correlation of the PTT to actual blood pressure values is difficult, because of the many variables, but it's possible to determine a simple monotonic relationship between PTT and blood pressure.



PULSE TRANSIT TIME MEASUREMENT

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