



**BIOPAC Systems, Inc.**

42 Aero Camino  
Santa Barbara, Ca 93117  
Ph (805)685-0066  
Fax (805)685-0067  
[www.biopac.com](http://www.biopac.com)  
[info@biopac.com](mailto:info@biopac.com)

---

## **Additional Hemodynamic Measurements**

AcqKnowledge has features which permit the user to perform a number of Hemodynamic measurements, in addition to basic measurements such as Systolic, Diastolic, Mean and Rate. These measurements can be performed as data is collected (in real-time), or after data collection is over (post-processing). A number of Hemodynamic measurements are cyclical in nature. "Cyclical" means that these measurements are performed on a beat-by-beat basis and are thus updated every time the raw blood pressure repeats a cycle. Following are the measurements considered in this application note.

- Cyclical Systolic Blood Pressure
- Cyclical Diastolic Blood Pressure
- Cyclical Diastolic to Systolic Delta Pressure
- Mean Blood Pressure
- Derivative of Raw Blood Pressure (dP/dt)
- Cyclical Maximum of dP/dt
- Cyclical Minimum of dP/dt
- Cyclic Rate (in BPM)

All eight of these parameters can be extracted from one arterial pressure input signal. This arterial pressure signal is typically obtained via a pressure transducer which is invasively attached to an artery. This pressure transducer (TSD104A or equivalent), is connected directly to the DA100B differential amplifier. In turn, the DA100B output is directed to the MP100 unit. The DA100B amplifier typically has its internal low pass filter set to ON (10 Hz cutoff).

For the purposes of this application, we will assume the raw BP signal is/was sampled at 50 samples/second. Also, its important to verify the pressure transducer calibration. To obtain these hemodynamic parameters in real-time,

set up five CALCULATION channels which have the raw BP signal as input.

### **For the Systolic Pressure Calculation:**

Calculation channel C0: Under RATE, set for PEAK MAXIMUM  
In this case, the Systolic Pressure will be calculated on a cycle by cycle basis.

### **For the Diastolic Pressure Calculation:**

Calculation channel C1: Under RATE, set for PEAK MINIMUM  
In this case, the Diastolic Pressure will be calculated on a cycle by cycle basis.

### **For Mean Pressure Calculation:**

Calculation channel C2: Under INTEGRATE select 250 points, rectify off.  
We choose 250 points, because we want the BP mean over a 5 second period.  
If the signal was sampled at 50 Hz, the 50 samples/sec; 5 sec = 250 samples. If you are using AcqKnowledge 3.5 or above this feature has been enhanced to allow you to get a more accurate integration. In the Integrate window choose Reset via Channel. The control channel is the Blood Pressure Analog input channel and the Low and High Thresholds are extreme values the the signal will pass through. Set the Reset Trigger option to Negative, this will perform the integration from the trough of one cycle to the next.

### **For the Blood Pressure Rate Calculation:**

Calculation channel C3: Under RATE, set for BPM  
In this case, the Rate will be calculated on a cycle by cycle basis.

### **For the Derivative of Blood Pressure Calculation:**

Calculation channel C4: Under DIFFERENCE, choose a 2 point difference.  
In this case, the derivative of the raw blood pressure signal will be calculated on a point to point basis. The units of this calculation are [mmHg/sec].

Three more parameters will also be generated, by using additional calculation channels which will extract data from previous calculation channels. These new parameters are:

### **For the Pk-Pk Pressure Calculation:**

Use two source channels: Systolic (C0) and Diastolic (C1)

Calculation channel C7: Under MATH, choose the function C0-C1.  
In this case, the Pk-Pk blood pressure (Systolic-Diastolic) will be calculated on a cycle by cycle basis.

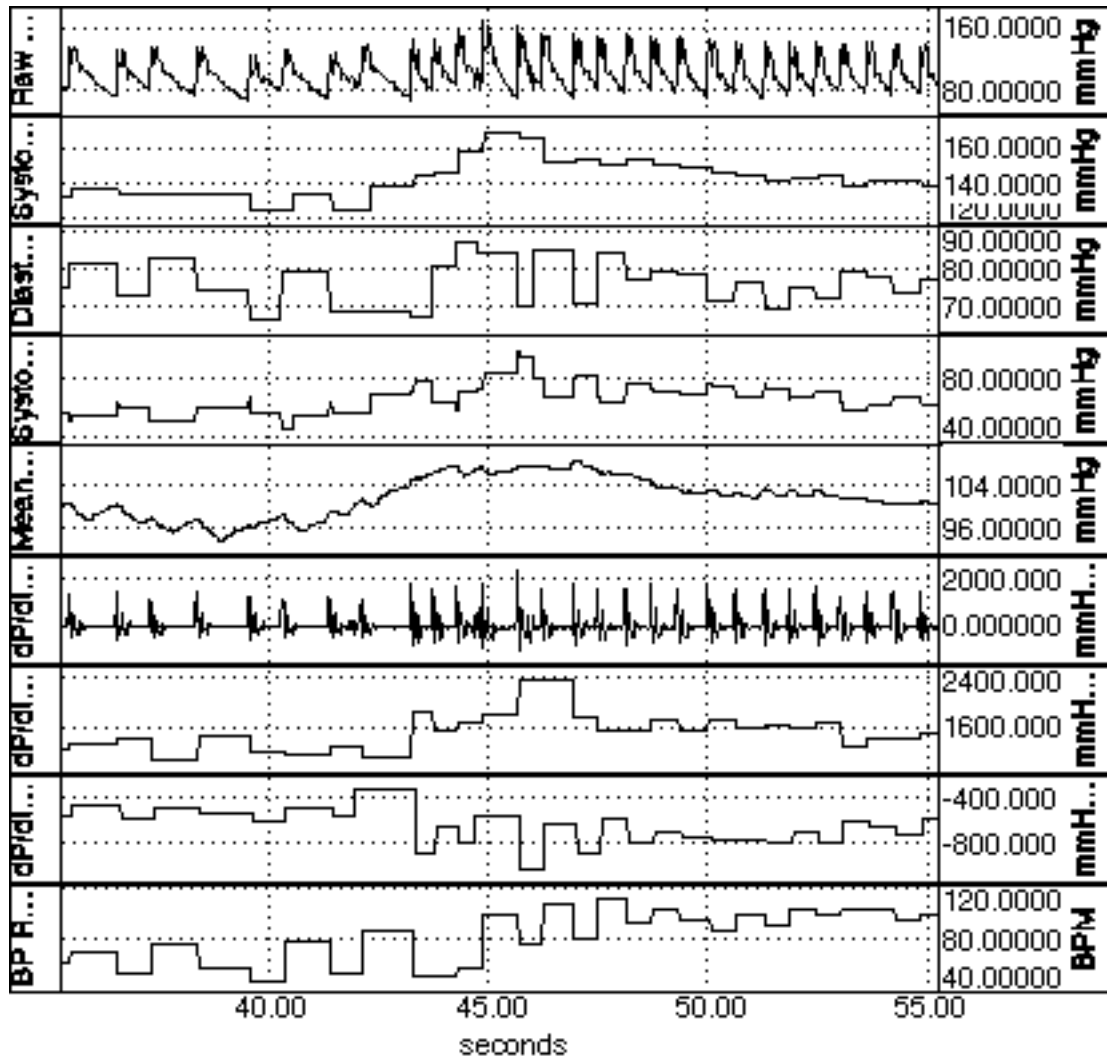
**For the dP/dt Maximum Calculation:**

Use source channel: Derivative of the blood pressure channel (C4)  
Calculation channel C5: Under RATE, set for PEAK MAXIMUM  
In this case, the dP/dt maximum will be calculated on a cycle by cycle basis.

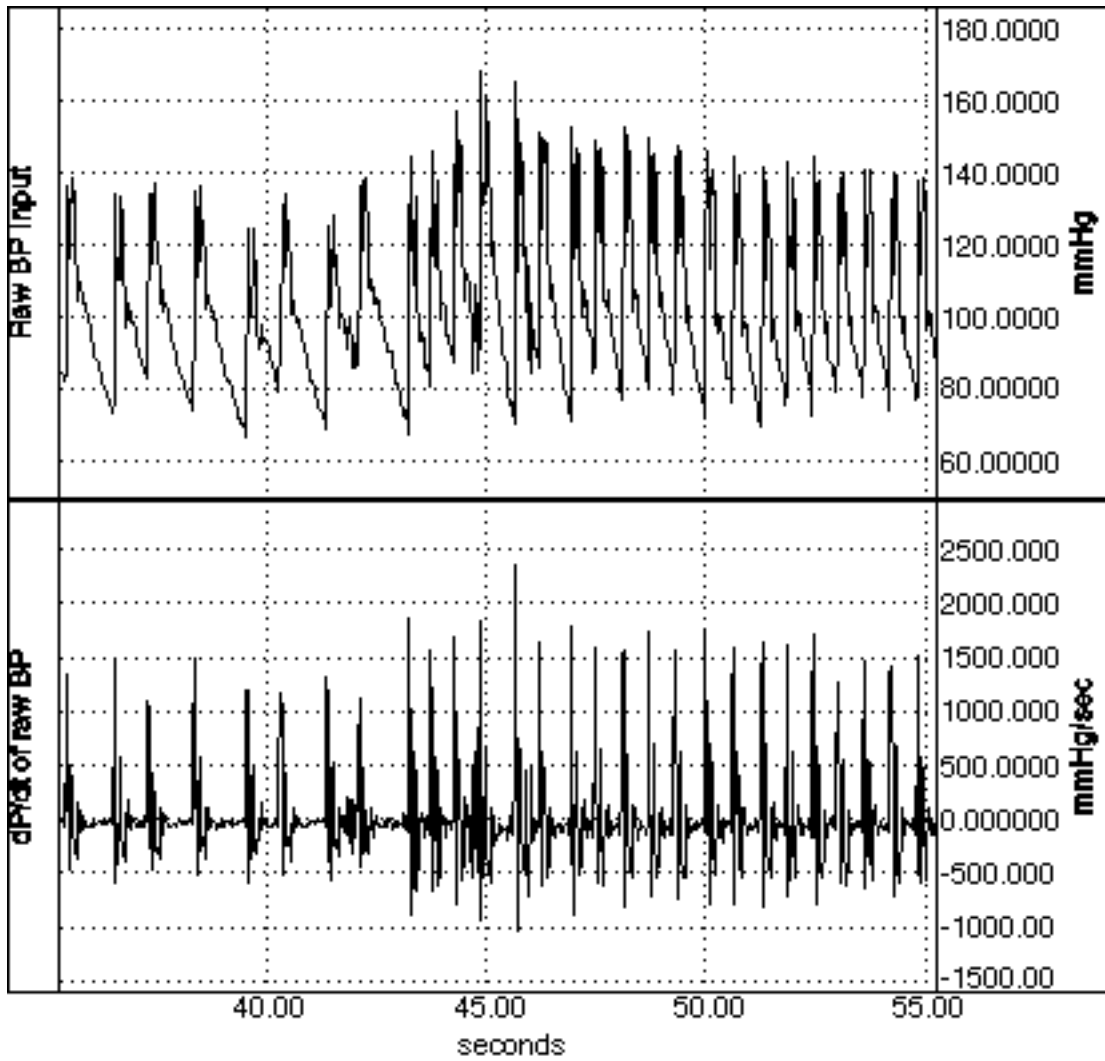
**For the dP/dt Minimum Calculation:**

Use source channel: Derivative of the blood pressure channel (C4)  
Calculation channel C6: Under RATE, set for PEAK MINIMUM  
In this case, the dP/dt minimum will be calculated on a cycle by cycle basis.

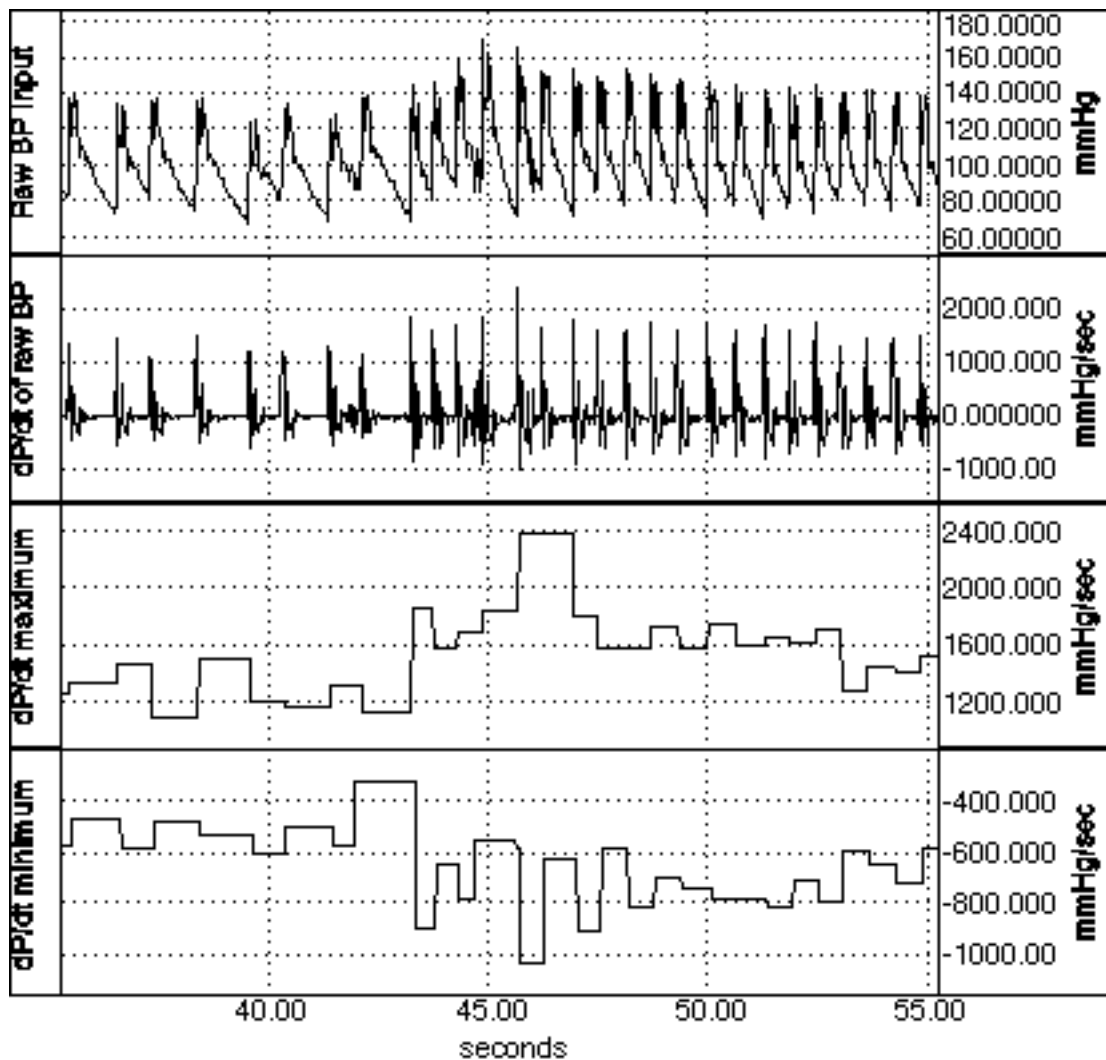
When starting to collect data, you will see the following graph:



**Eight Hemodynamic Measurements Displayed in Real-Time**



**Raw Blood Pressure and Derivative (dP/dt) Displayed in Real-Time**



## Calculated Maximum and Minimum dP/dt from dP/dt Waveform

When calculating these parameters after the data is collected, the procedure is very similar, but you just employ various tools under the TRANSFORM menu. Simply use the RATE function under the TRANSFORM menu, to calculate the Systolic and Diastolic Blood Pressure and Rate. When calculating the Blood Pressure Mean over a 5 second period, use the SMOOTHING function, under the TRANSFORM menu.

To calculate the derivative of the raw blood pressure (dP/dt), just perform a 2 point difference on a duplicate of the original blood pressure waveform. Then use the RATE function under the TRANSFORM menu, to calculate the dP/dt maximum and dP/dt minimum.

Usually, the default parameters for the RATE function work quite well to calculate the desired hemodynamic parameter. If you experience difficulty in getting accurate results, its probably because the default parameters for the

RATE function need changing. To insure you have the right settings in the RATE window, its usually a good idea to inspect the waveform visually prior to processing.

Try to establish if the BPM Min/Max settings are correct. These Min/Max settings tell the RATE function what range the actual signal BPM falls into. The closer these values are to the true BPM range, the better the RATE detector will work. Naturally, if you estimate a little high or low, thats OK, just dont estimate too high or low.

Generally, keep REMOVE BASELINE and AUTO THRESHOLD DETECT clicked ON. These settings help the RATE function track a signal with a moving baseline. A NOISE REJECTION of about 5% works well for your typical raw BP signal.

In the raw BP signal has a lot of noise, then it may be a good idea to filter it. When filtering in real-time, use a Calculation channel. You can select the FILTER option and use a LOWPASS filter. Set the filter cutoff somewhere in the range of 5 to 10 Hz. When calculating your Hemodynamic parameters, just use the output from this LOWPASS filter Calculation channel, to feed into the inputs of your Hemodynamic parameter channels.

When post-processing, and you need a simple smoothing filter, just pick SMOOTHING under the TRANSFORM menu and set the number of points to five (5). Be sure to duplicate the original raw BP channel before smoothing, because the SMOOTHING function will overwrite the data. Now, just use the smoothed data as input to the RATE function under the TRANSFORM menu.

Finally, to calculate the Pk-Pk pressure (Systolic-Diastolic), use WAVEFORM MATH under the TRANSFORM menu to subtract the Diastolic channel from the Systolic channel, and place the result in a new channel.

---

[Return To Application Note Menu](#)