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## #AS168 - Analysis of Intraventricular Pressure Wave Data (LVP Analysis)

The AcqKnowledge software has many features which allow the user to perform a wide variety of left ventricular pressure measurements. Some of these measurements can be performed as the data is collected (real-time), or after the data collection is over (post-acquisition). The measurements considered in this application note are:

- Ventricular Peak Systolic Pressure
- Ventricular Minimum Diastolic Pressure
- Ventricular End Diastolic Pressure
- Pressure value and  $dP/dt$  values at maximal ventricular contraction
- Pressure value and  $dP/dt/P$  values at maximal ventricular contraction
- Pressure value and  $dP/dt$  values at maximum ventricular relaxation

All of the measurements can be extracted from one ventricular pressure input signal, a common transducer is the MILLAR catheter tip pressure transducer. The left ventricular pressure data is commonly acquired by placing the MILLAR catheter in the left ventricle via the carotid artery. A common interface between the MILLAR catheter pressure transducer is the MILLAR TCB-600 Transducer Control Unit. This device allows the signal to be input to the MP100 Data Acquisition Unit, via a CBL105 Connection Cable to the UIM100A Universal Interface Module.

### Ventricular Systolic Pressure

Prior to acquisition, set up a **Calc** channel to Acquire and Plot, choose the **Rate** function. In the Set up window the source is the raw blood pressure analog channel. Choose Function: **Peak Maximum**, if your waveform tends to drift you can choose the Auto Threshold Detect, otherwise you may choose to select

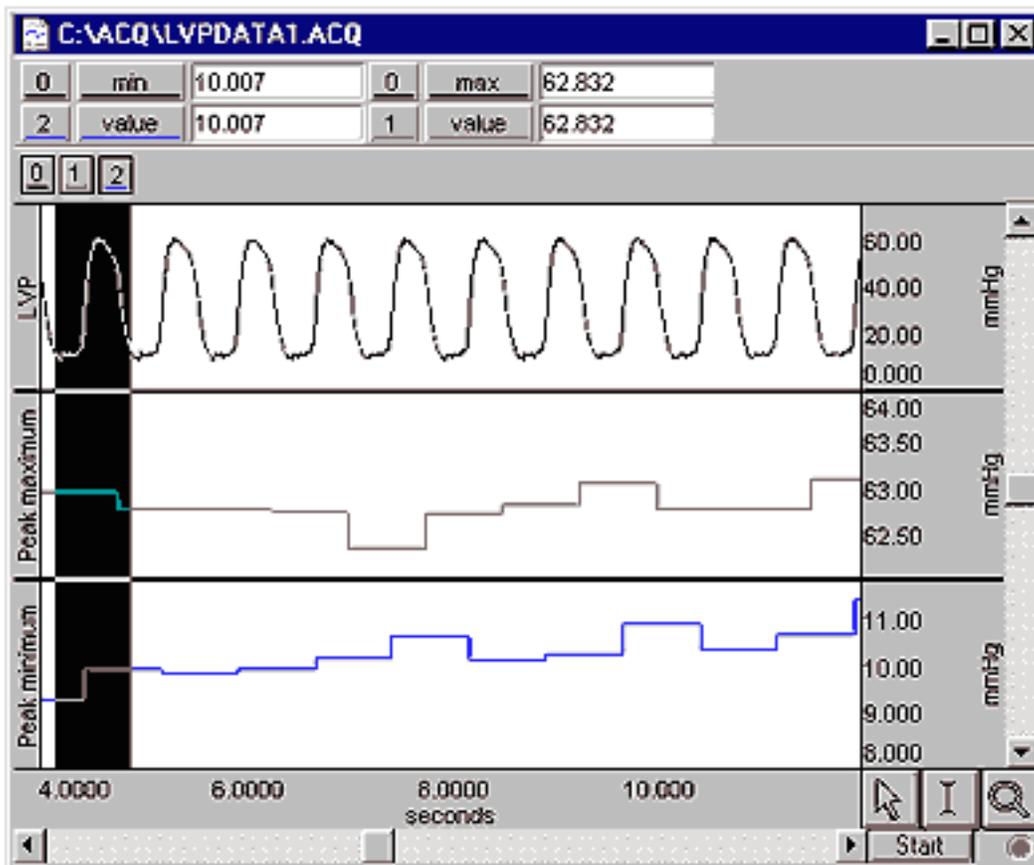
your own threshold level. If you decide to leave the default to Auto Threshold Detect then you will have to set your window parameters. The minimum should be about half the average BPM of your subject and the maximum about twice average BPM.

Post acquisition, select the blood pressure waveform channel, by clicking on the waveform, then highlight the entire waveform, from **Edit** menu and choose **Select all**. Then click on **Transform** and **Find Rate**. Again, choose **Peak Maximum** as your function, and follow the same options as for on-line analysis. Be sure to check the box to **Find rate of entire wave**. Select OK.

### **Diastolic Pressure Calculation**

Prior to acquisition, set up a second **Calc** channel to Acquire and Plot, choose the **Rate** function. In the Set up window the source is the raw blood pressure analog channel. Choose Function: **Peak Minimum**, if your waveform tends to drift you can choose the Auto Threshold Detect, otherwise you may choose to select your own threshold level. If you decide to leave the default to Auto Threshold Detect then you will have to set your window parameters. The minimum should be about half the average BPM of your subject and the maximum about twice average BPM.

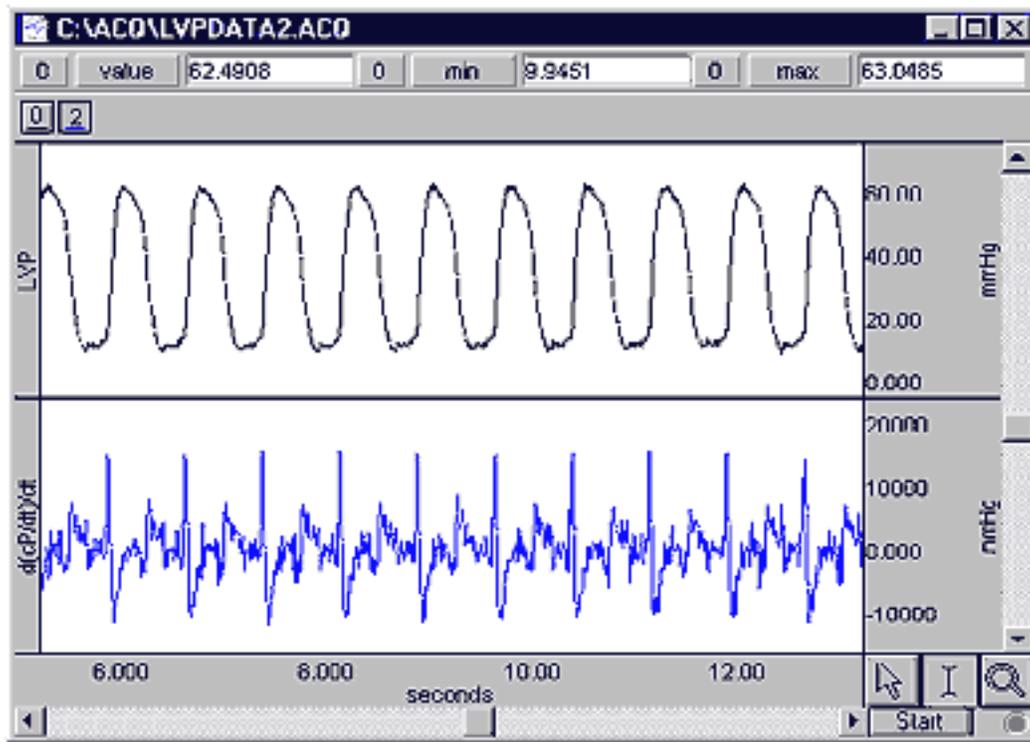
Post acquisition, select the blood pressure waveform channel, by clicking on the waveform, then highlight the entire waveform, from **Edit** menu and choose **Select all**. Then click on **Transform** and **Find Rate**. Again, choose **Peak Minimum** as your function, and follow the same options as for on-line analysis. Be sure to check the box to **Find rate of entire wave**. Select OK.



An alternative is to use the Peak Detect function and have the maximum and minimum values pasted directly to the journal. This feature will be described next with the analysis of Ventricular End Diastolic Pressure.

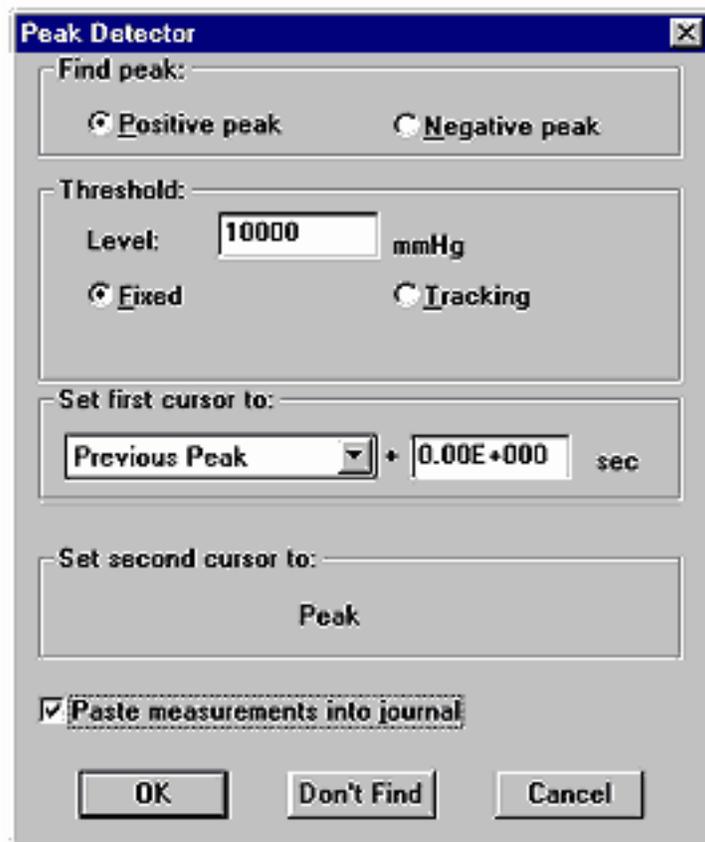
## Ventricular End Diastolic Pressure

For the purposes of this application note, we will describe LVEDP as the minimum value just before the rapid increase in pressure representing systole. Mathematically this is given by the maximum of the second derivative. To automate the process of finding this value, plot the second derivative by duplicating the waveform. Be sure the LVP waveform is selected, then from the **Edit** menu choose **Select All** and then again from the **Edit** menu select **Duplicate Waveform**. Next, with the duplicated LVP waveform selected choose **Derivative** from the **Transform** menu, twice. You should now have two waveforms: the original raw LVP signal and the second derivative. For future reference, you may want to change the waveform labels by double-clicking on the box with the waveform name, located to the left of the waveform, and typing in the new name. Your screen will look similar to the following:



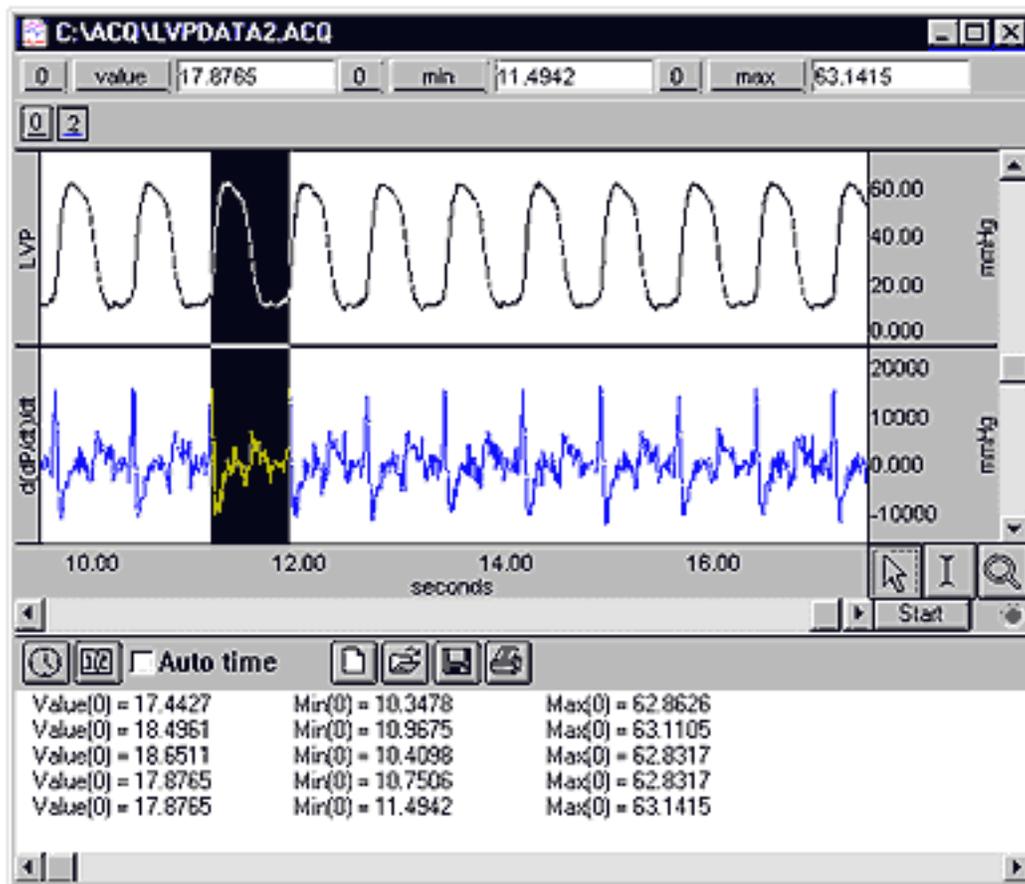
You may need to autoscale your data in order to see the waveforms on the screen. Since you are only concerned with the maximum peaks and not the values of the second derivative, smoothing the waveform will help the maximum peaks to be more pronounced from the rest of the data. Do this by selecting the second derivative waveform, then select **Smoothing..** from the **Transform** menu. Type in the number of samples, to smooth, a small number such as 3 works fine for our purposes. Be sure to check the box labeled Transform entire waveform.

Next, we want to record the original LVP value when the second derivative is at a maximum value. We can use the Peak detect function for this purpose. Scroll through the second derivative data, find a threshold value that all the maximum peaks pass through, but greater than the intermediary peaks of the rest of the data. Record this value, as this is your fixed threshold value. Select **Find peak** from the **Transform** menu. Check the **Fixed** Threshold button and enter the Fixed Threshold value. Set first cursor to Previous Peak and check the box to Paste measurements to journal. Click on **Don't Find**, for now.



Set up your measurement boxes to give the **Value** of the original LVP waveform, channel 0, for our data. This will be the LVEDP value. You will want to set the rest of the boxes to None, unless you are pasting other values to the journal. (This function is described in the following paragraph.) Then with the I-bar selected drop the cursor at the beginning of the data. When you choose **Find next peak** or **Find all peaks** the program will automatically paste the LVEDP values to the journal. (To open a journal, select Show from the Display menu and choose Journal, or you can click on the icon that looks like a piece of paper.)

As a note, you can use this same procedure to paste the maximum systolic pressure and minimum diastolic pressure by setting the Measurement boxes to **max** and **min** respectively and setting the wave channel to 0 for the LVP wave.



## Maximum and Minimum dP/dt Values

To perform this calculation online, Select **Setup Channels** from the **MP100** menu and Select **Calc**, check the **Acquire** and **Plot** boxes, then chose **Difference** function. Click on the **Setup** box. The **Source Channel** is the original LVP waveform. The number of samples is 1. On the next channel, click the **Acquire** and **Plot** boxes. Choose **Rate** as the function. Click on **Setup**. In the **Rate Detector Setup** window select the result of the difference calculation, then Select **Peak Maximum** or **Peak Minimum**. Choose **Auto threshold detect**, and set the **Noise Rejection** to 5%. Adjust the **Peak Interval Window** so that the minimum is about half the average BPM of your subject and the maximum is twice average BPM.

The same effect can be achieved post-acquisition. First, duplicate the LVP waveform, select **Duplicate Waveform** from the **Edit** menu. Take the derivative of the second waveform by selecting **Derivative** from the **Transform** menu. To get the maximum and minimum waveform, from the **Transform** menu, select **Find Rate**, set the function to **Peak Maximum** or **Peak minimum**. Check **Auto Threshold Detect** with the **Noise Rejection** at 5% of peak. Set the window to a minimum of half the average BPM, and a maximum of twice the average BPM. The **Rate** function will take a few

seconds to stabilize, therefore the first 3-4 seconds of data should be ignored.

If you are just interested in the maximum and minimum values being pasted to the journal, you can use the Peak Detect function described previously in the LVEDP section, or in the following section. Simply choose **max** and **min** for the Measurement boxes, and choose the first derivative waveform as the channel.

### Maximum dP/dt divided by Pressure

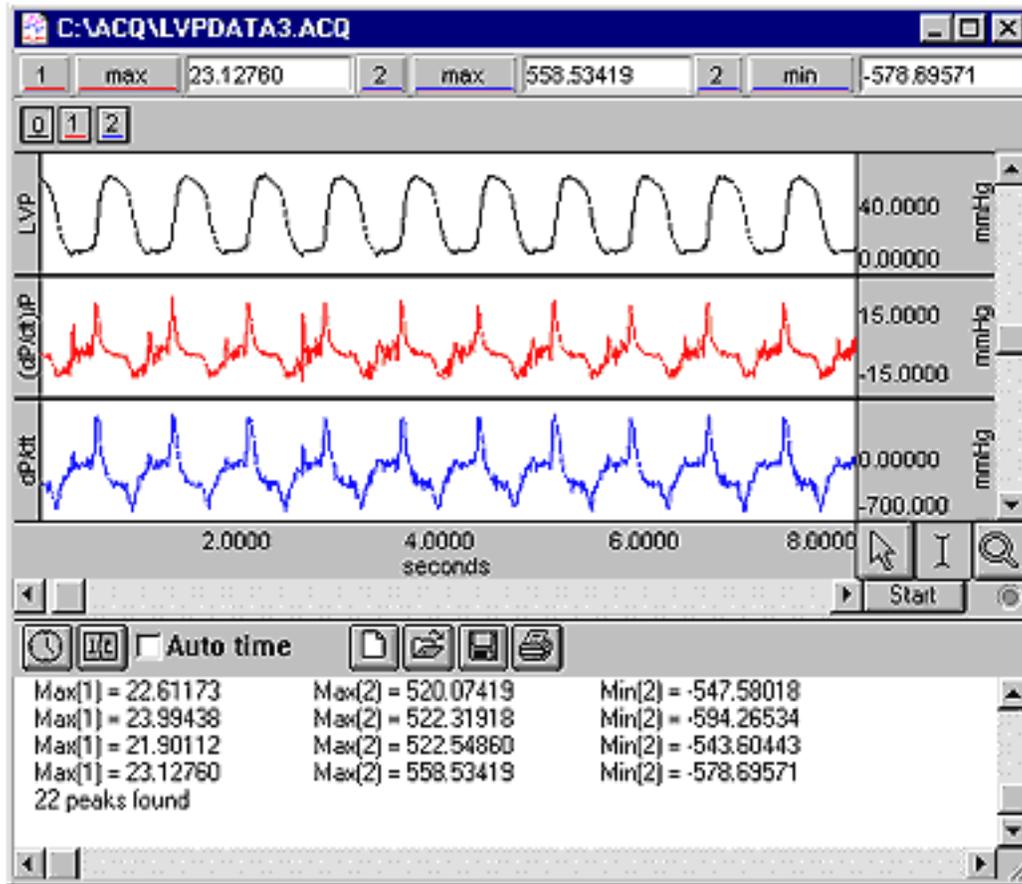
This value can not be found online because the Rate transformation delays the waveform so the max dP/dt is a beat behind the original waveform data. For post acquisition analysis, you will need the derivative waveform. If this has not already been plotted, you will need to do this now. First, duplicate the LVP wave form by selecting **Duplicate waveform** from the **Edit** menu. Take the derivative of this second waveform by selecting **Derivative** from the **Transform** menu.

Next, select **Expression** from the **Transform menu**, in the Expression window divide the derivative channel by the original channel, select Destination NEW, and be sure to check Transform entire waveform. You should now have three waveforms as seen below. Next, you can either set up the Rate function to give a graphical representation of the maximum values of the expression or you can setup the Peak Detect function to automatically paste the maximum values to the Journal as you did with LVEDP.

To graph the Maximum waveform select the (dP/dt)/P waveform and choose **Find Rate** from the **Transform** menu. Set the function to **Peak Maximum**. Check Auto Threshold Detect with the Noise Rejection at 10% of peak. Set the window to a minimum of half the average BPM, and a maximum of twice the average BPM. The Rate function takes a few seconds to stabilize, therefore the first 3-4 seconds of data should be ignored.

Alternatively, use the Peak Detect function to automatically paste these values to the journal. Determine which waveform you want to define your cycle, for this application we chose systole to systole of the original pressure waveform. Choose **Find peak** from the **Transform** menu, choose to find the Positive peaks. Type in a Threshold level of approximately 10% your max LVP. Set the first cursor to Previous Peak and second cursor to Peak. Then check the box Paste measurements to journal. Click **Don't Find**. Then with the I-bar selected drop the cursor at the beginning of the data. Select **Find all peaks** to paste all the measurements to the journal at once or to watch peak by peak choose **Find**

next peak.



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