

Scisense PV Technical Note

How to Analyze PV Loop Data (Admittance) in LabChart Software

The following document outlines the essential and suggested steps for analyzing PV loop data in LabChart software when used in conjunction with the ADV500 PV System. Every experiment is different and may require different settings or the use of different software features. Please contact ADInstruments directly for additional information about all the available features or any software functionality issues

For the purpose of this exercise, a sample file recorded from a healthy mouse using the ADV500 PV system will be used. Only raw data was recorded at the time of the experiment, therefore, this example does not show hemodynamic measurements as calculated channels over time. Remember, that these channels can be created during analysis if required to show trends over the course of the experiment.

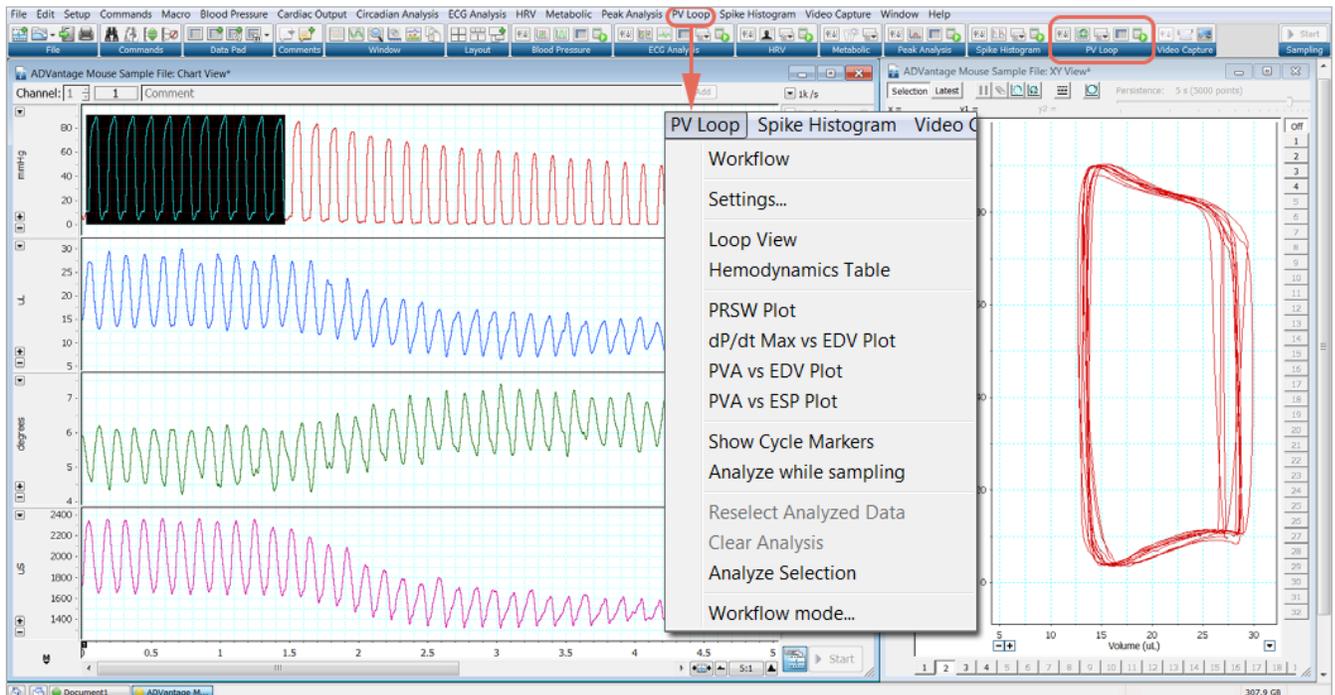
GETTING STARTED

Open up LabChart Software. Upon start-up a dialog box will appear and run through a diagnostic to confirm connection to PowerLab hardware.



- Settings
- Loop View Window
- PV Loop Plots
- Hemodynamics TableWindow
- Analyze Data

Close up view of PV Loop Hotkey menu



Main window showing mouse left ventricle PV loop data. PV Loop menu is circled and the expanded view shown. PV Loop hotkeys are circled and the expanded view is shown above.



Analyzing PV Loop Data in LabChart Cont.

Connection to the PowerLab is not essential for data analysis: therefore, if no hardware is connected simply click OK to proceed.

The Welcome Centre will appear. Select the data file of interest from the "Recent Files" column, or click the OPEN icon to search for the file of interest.

After selecting the file it will open in the LabChart Main Window.

PV Loop Menu & Functions

This menu and its sub-menus include all setting, preferences, or functions that one will need to address in order to ensure correct PV data calculation.

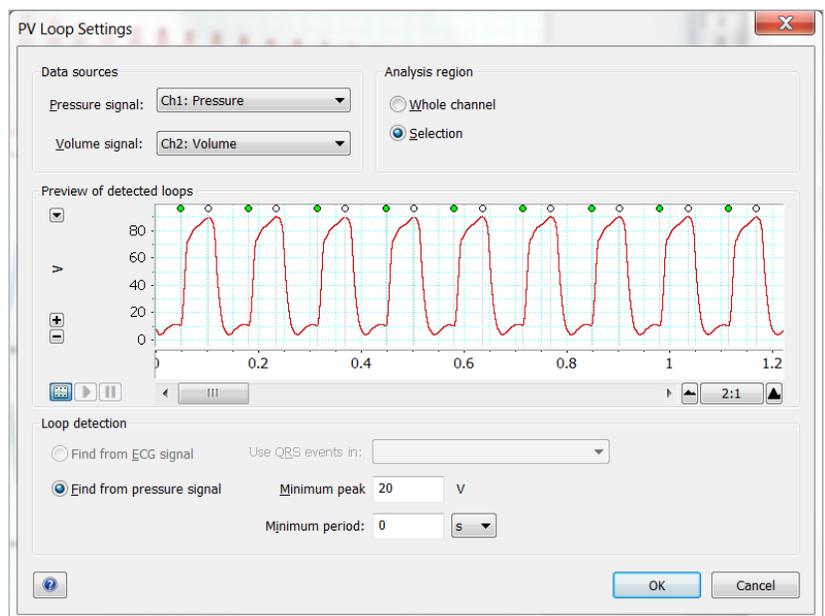
WORKFLOW

Click to activate the Workflow function. Workflow will appear at the left hand side of the screen. This is not required for analysis of admittance data as True-Volume information is already available. However, if traditional volume calibration info needs to be addressed (i.e. Compute parallel volume (V_p) from a saline bolus infusion data set), Workflow will provide assistance with these steps. Consult the ADI LabChart User Manual for specific details on Workflow.

SETTINGS

Open from the menu or hot-key to access the PV Loop Settings Dialog box. Ensure the following are correctly selected before moving forward with analysis:

1. Pressure Signal: select the appropriate Pressure Channel
2. Volume Signal: select the appropriate Volume Channel
3. Analysis Region: by selecting "Whole Channel" all registered PV cycles will be automatically included in the hemodynamic table. Typically this is not preferred, as families of specific loops will want to be studied. By choosing "Selection", you will be able to highlight areas of interest in the Main Window which will then populate in the hemodynamic table.
4. Preview of Detected Loops: this section allows the researcher to confirm that each heart beat is being registered correctly as a cycle. Green Dot markers denote End Diastole, while Yellow Dot markers denote End Systole.
5. Loop Detection: this section allows the user to define how cycles will be registered by the software. The default setting is "Find from pressure signal" and is the best choice.
6. Minimum Peak and Minimum Period: These two settings allow the researcher to adjust the threshold by which the software registers a cardiac cycle.



PV Loop Settings Dialog Box

Analyzing PV Loop Data in LabChart Cont.

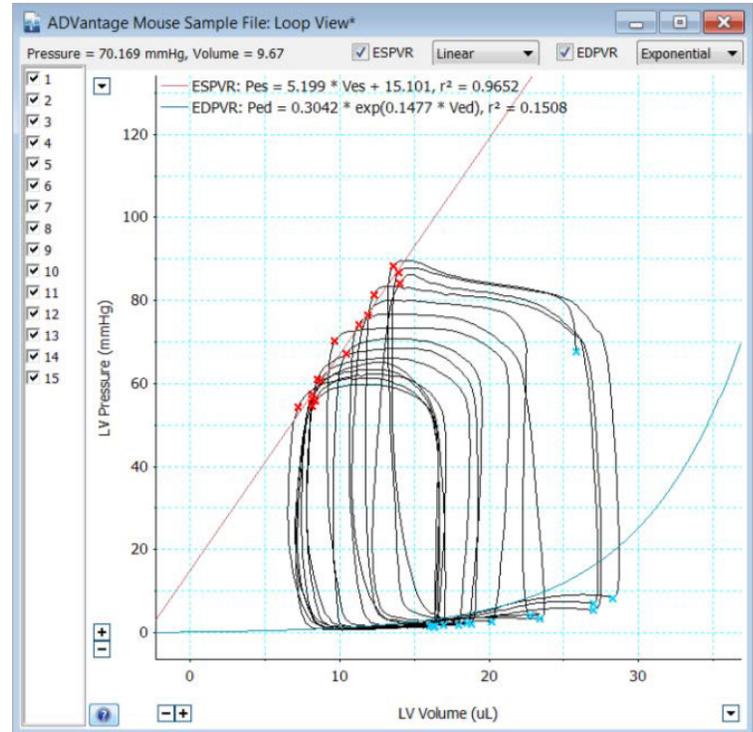
SHOW CYCLE MARKERS

By selecting this option, cycle markers (Green and Yellow tags marking end diastole and end systole, respectively) will appear in the Main Window view. This will help to confirm that the software has correctly registered each cardiac cycle for analysis.

LOOP VIEW

Clicking this option in the menu or the hot-key will open up the Loop View Window. This XY-Plot will contain the data selected from the Main Window (or entire data set if "Whole Channel" is selected in the Settings menu). Loop View displays the detected pressure volume loops as an XY line graph of pressure against volume. The End Systolic Pressure Volume Relationship (ESPVR) and the End Diastolic Pressure Volume Relationship (EDPVR) regression information are also displayed.

1. Instantaneous Readouts: To display readouts of instantaneous pressure and volume, move the tracking cursor over the end diastolic (ED) and end systolic (ES) points.
2. Loop Selection: You can highlight a particular loop in the display area, and select the loops that you would like included in the analysis.
 - a. To identify a specific loop, click on the ES or ED point, or click on the loop number on the left hand side of the view. This highlights the loop in blue. The corresponding row of calculated parameters in the Hemodynamics Table is also highlighted.
 - b. Only loops with a check in the box next to their loop number are included in the analysis. By default all loops are included. To exclude a loop from the analysis, deselect it by clicking on the check mark in the corresponding box. Deselecting a loop removes it from all views and calculations
3. Regression Information: The ESPVR and EDPVR best fit regression can be drawn on the graph and the regression information displayed at the top of the plot. To display this information check the boxes to the left of the ESPVR and/or EDPVR labels above the plot. For ESPVR, a linear or quadratic curve fit can be calculated and for EDPVR, a linear or exponential curve fit can be calculated (NOTE: Linear option is only there to force a calculation in the event of negative EDP values).



Loop View showing pressure and volume in an XY plot. ED and ES points are shown. ESPVR and EDPVR lines are shown. Included loops are listed on the left.

Analyzing PV Loop Data in LabChart Cont.

	SW (mmHg*u)	CO (uL/min)	SV (uL)	Vmax (uL)	Vmin (uL)	Ves (uL)	Ved (uL)	Pmax (mmHg)	Pmin (mmHg)	Pmean (mmHg)	Pes (mmHg)	Ped (mmHg)	HR (bpm)	EF (%)	Tau (ms)
1	1065	6416	14.22	27.22	13.00	13.98	27.13	89.60	3.824	44.73	86.67	10.70	451.1	52.64	8.209
2	1139	7113	15.89	29.42	13.53	14.12	26.81	90.05	3.851	44.53	87.83	10.46	447.8	55.13	8.457
3	1112	6912	15.32	28.57	13.25	13.50	28.49	89.93	3.824	44.86	88.59	10.50	451.1	54.04	8.080
4	1121	6868	15.22	28.75	13.53	14.24	28.40	89.96	3.675	44.74	88.28	10.39	451.1	53.32	8.079
5	1119	6755	15.09	28.67	13.58	13.81	28.08	90.19	3.635	44.62	89.04	10.15	447.8	53.44	8.128
6	1188	7307	16.20	29.88	13.69	14.62	28.89	90.09	3.891	45.03	88.26	10.64	451.1	54.23	8.127
7	1031	7076	15.69	28.82	13.13	13.55	26.33	90.09	3.851	44.88	88.34	10.54	451.1	58.65	8.494
8	1192	7297	16.30	28.94	12.64	13.25	28.90	90.36	3.972	44.63	86.86	10.39	447.8	57.94	8.464
9	1186	7047	15.74	28.57	12.83	13.60	28.31	90.01	3.851	43.86	88.59	10.27	447.8	55.43	8.689
10	995.0	6671	14.90	28.12	13.22	13.60	27.29	89.69	3.648	42.86	88.25	9.411	447.8	57.13	9.109
Avq	1115	6946	15.46	28.70	13.24	13.83	27.86	90.00	3.802	44.47	88.07	10.35	449.4	55.20	8.384
Min	995.0	6416	14.22	27.22	12.64	13.25	26.33	89.60	3.635	42.86	86.67	9.411	447.8	52.64	8.079
Max	1192	7307	16.30	29.88	13.69	14.62	28.90	90.36	3.972	45.03	89.04	10.70	451.1	58.65	9.109
Count	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

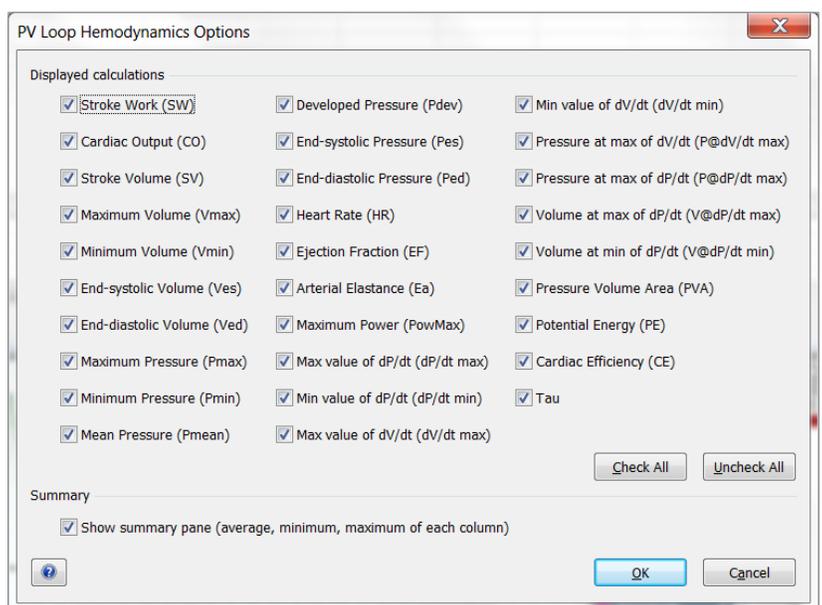
Hemodynamics Table window displays individual loop data and summary values from all selected loops.

HEMODYNAMICS TABLE

Clicking this option in the menu or hot-key will open the Hemodynamics Table Window. Beat-by-beat information will be displayed in a tab-delimited format for all selected loops.

NOTE: In "Analyze While Sampling" mode, the contents of the parameters table are updated upon detection of each loop during data acquisition. Use the Scroll/Review button to toggle between automatic scrolling of newly added rows and reviewing of previously added rows. This feature can be used when data is being recorded at the bench top, but does not apply to pre-recorded data.

When analyzing pre-recorded data the table's contents are updated to show the data for the current Selection or for Whole Channel recorded data.



Hemodynamics Table Options dialog box for selecting which parameters are displayed.

1. Loop Selection: Clicking on a row highlights that row of data and also highlights the related loop in Loop View. To select which loops are included/excluded in your analysis, use the Loop View.
2. Column Format: Double clicking on the column heading opens the Column Format dialog. In this dialog you can select the number of significant figures the parameters are displayed with and apply it to all the columns.
3. Options and Summary Information: The Hemodynamics Table can display:
 - a. Columns for any of the calculated parameters. To select the parameters to be displayed, open the Hemodynamics Options dialog by clicking Options at the bottom of the Hemodynamics Table.

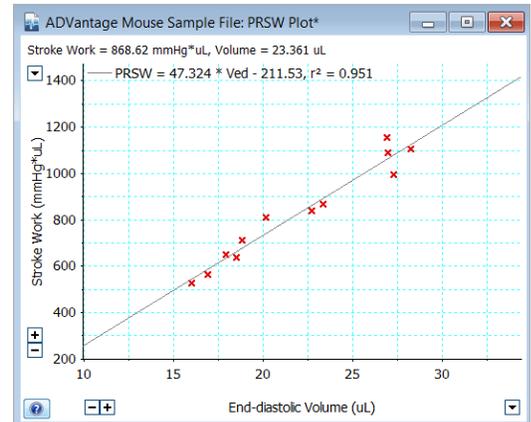
Analyzing PV Loop Data in LabChart Cont.

- b. Summary rows at the bottom of the table show the average, minimum and maximum values, and the number of values, for each column. To turn on summary rows, click Options and select "Show summary pane" in the Hemodynamics Options dialog.
4. Exporting Data: There are two methods for exporting the contents of the Hemodynamics Table:
- Click Export, then select either tab-delimited text file (.txt) or comma-delimited text file (.csv) and click Save. The output file can be imported into spreadsheet programs.
 - In the hemodynamics table, select the data of interest by holding down the left mouse button and dragging the cursor. Once the data is selected (highlighted in blue), press CTRL-C on the keyboard. Data will be transferred to the Clipboard. Open up an appropriate spreadsheet program, select the cell where you wish to import the first data point and press CTRL-V on the keyboard. NOTE: individual loop data and Summary data (AVG, MIN, MAX, COUNT), must be copied separately.

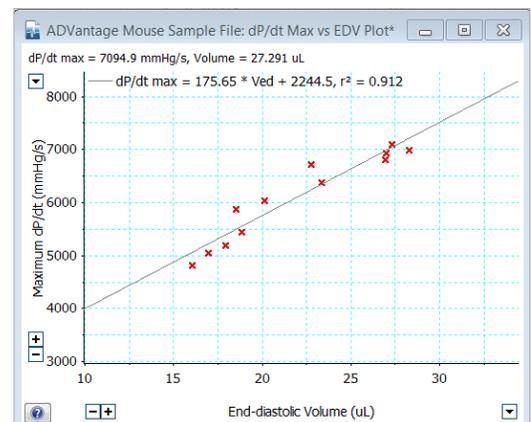
PV LOOP PLOTS

The next section of the menu lists the four available load-independent PV loop plots:

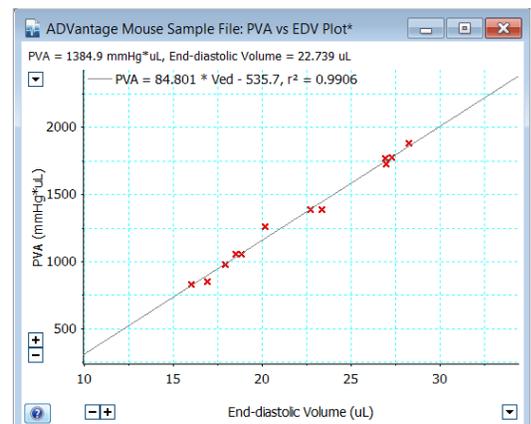
1. PRSW: Preload recruitable stroke work (PRSW) is determined by the linear regression of stroke work with the end diastolic volume. The slope of the PRSW relationship is a highly linear index of myocardial contractility that is insensitive to preload and afterload. During heart failure, myocardial contractility is reduced which decreases the slope of the PRSW relationship. Recent studies also indicate that the volume axis intercept of the PRSW relationship (not the slope) may be a better indicator of the severity of contractile dysfunction.
2. dP/dt Max vs. EDV: a linear regression of the maximum derivative of pressure to end diastolic volume. The slope generated is also used to address changes in contractility. In general, a steeper slope suggests a more responsive change in contractility, while a shallow slope suggests a poor response to load change.
3. PVA vs. EDV: The Pressure-volume area (PVA) represents the total mechanical energy generated by ventricular contraction. This is equal to the sum of the stroke work (SW), encompassed within the PV loop, and the elastic potential energy (PE) (PVA = PE + SW). Pressure-Volume Area vs. End diastolic volume therefore represents a linear regression of mechanical energy to volume during load change: a steeper slope suggests a more responsive, healthier heart, while a shallow slope suggests contractile dysfunction.



PRSW: Stroke Work vs End Diastolic Volume



Maximum dP/dt vs End Diastolic Volume



Pressure Volme Area vs End Diastolic Volume

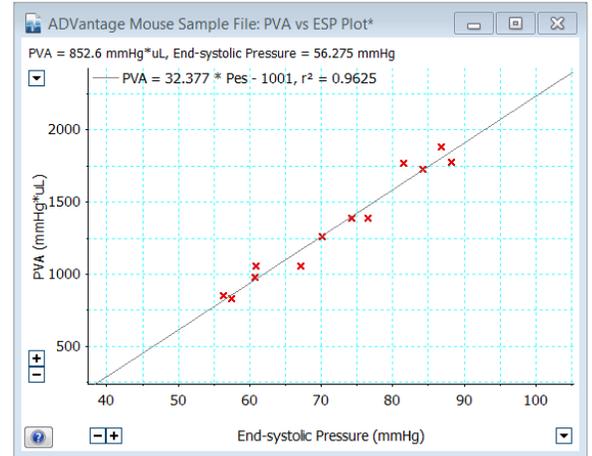
Analyzing PV Loop Data in LabChart Cont.

4. PVA vs. ESP: Pressure-Volume Area vs. End systolic Pressure represents a linear regression of mechanical energy to peak pressure during load change: a steeper slope suggest a more responsive healthier heart, while a shallow slope suggests contractile dysfunction.

ANALYSIS FUNCTIONS

Reselect Analyzed Data, Clear Analysis, and Analyze Selection are used to register, clear, or reselect (if changes are made but you wish to revert to the original sample of data points) data of interest.

Highlight data to be analyzed and select the appropriate analysis option. Choose from Baseline or Occlusion analysis based on the type of data.



Pressure Volume Area vs End Systolic Pressure



Transonic Systems Inc. is a global manufacturer of innovative biomedical measurement equipment. Founded in 1983, Transonic sells "gold standard" transit-time ultrasound flowmeters and monitors for surgical, hemodialysis, pediatric critical care, perfusion, interventional radiology and research applications. In addition, Transonic provides pressure and pressure volume systems, laser Doppler flowmeters and telemetry systems.

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