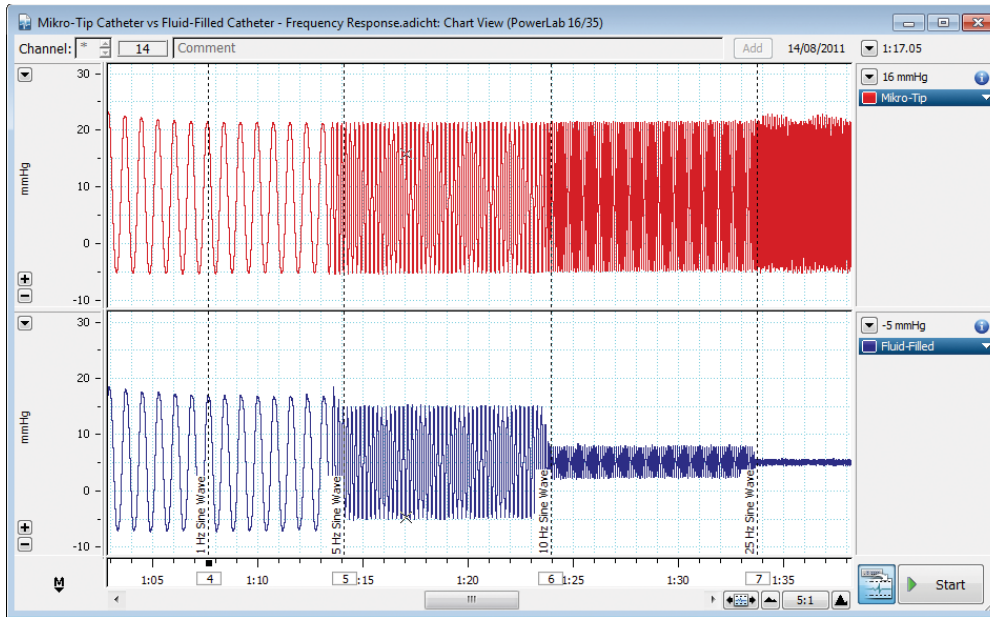


# Hemodynamic Pressure and Volume Signals

## PowerLab® Systems, LabChart® Software and Millar Mikro-Tip® and Ventri-Cath™ Catheters



Pressure signals recorded using a PowerLab system with a Millar Instruments Mikro-Tip catheter in the top channel and a traditional fluid-filled catheter in the bottom channel.

PowerLab® data acquisition systems, coupled with Millar Ventri-Cath™ and Mikro-Tip® catheters provide researchers with cutting-edge technology to record and analyze high-fidelity cardiovascular signals. Whether in large or small animals, with the transducer located at the tip of the catheter, you are able to place the sensor directly at the source of the signal and record real-time hemodynamic variables with unparalleled accuracy.

The Mikro-Tip and Ventri-Cath catheter designs offer significant advantages over traditional fluid-filled catheter models. Benefits include maintained signal integrity, no signal attenuation and the elimination of artifacts due to catheter movement. The solid state design and sensing technology of the Mikro-Tip and Ventri-Cath catheters ensure a true representation of pressure or pressure-volume signals and make them ideal for cardiovascular measurements in mice and rats through to rabbits and sheep.



### ■ Data Acquisition and Analysis

### Features & Benefits

- Excellent signal frequency response
- No motion artifact or signal attenuation
- Catheter sizes starting at 1F - the smallest available on the market
- MPVS Ultra system can be used with small and large animals
- LabChart PV Loop Module enables powerful online and offline analysis
- AAMI recognized Gold-Standard in Pressure and Volume measurement

# The Mikro-Tip® and Ventri-Cath™ Advantage

## Frequency Response

Millar catheters have a high bandwidth and respond well to pressure changes at high and low frequencies without loss of information. The LabChart recording on the right compares a pressure signal measured from a common source using both a fluid-filled and a Mikro-Tip® catheter. The signal recorded with the Mikro-Tip® catheter is unaffected by changes in the signal frequency. In contrast, the signal recorded from a fluid-filled catheter is attenuated above 5 Hz (typical rat heart rate) and distorted further at higher frequencies such as 10 Hz (typical mouse heart rate).

## Signal Integrity

The data on the right illustrates how poor frequency response characteristics of a transducer can affect signal integrity. Using a square wave produced by a signal generator, you can see that the Mikro-Tip® catheter signal (top channel) reflects the true waveform as displayed at 1 and 5 Hz. The same signal waveform detected using a fluid-filled transducer is distorted at 1 Hz and the original waveform components are completely lost at 5 Hz.

## Signal Artifact

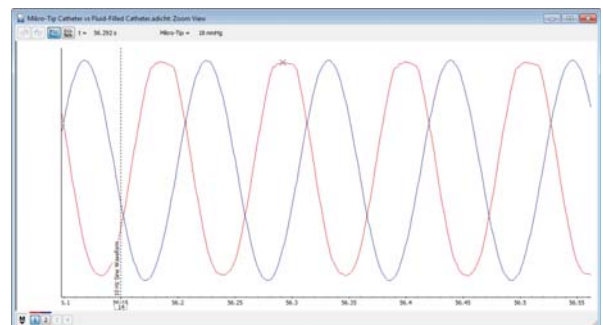
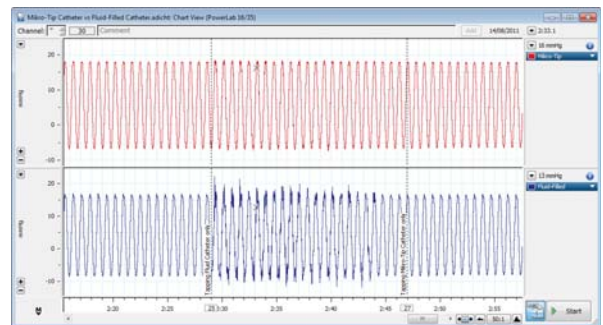
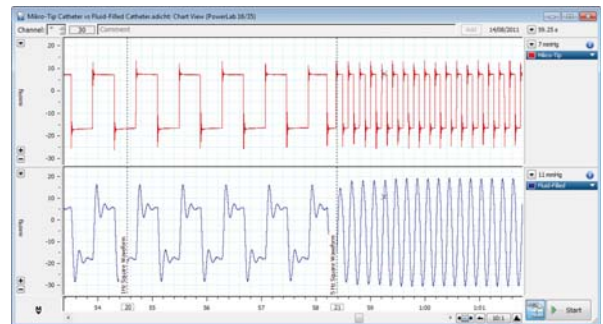
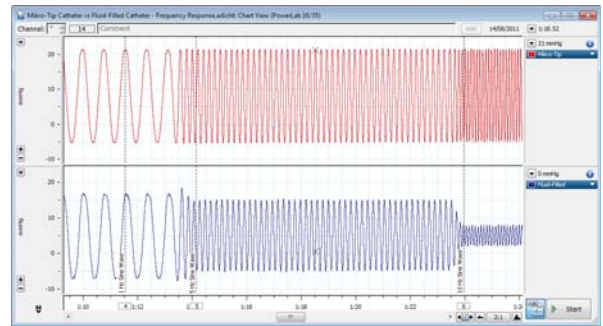
Signals from fluid-filled catheters are susceptible to interference due to air-bubble dampening, catheter movement, catheter blockage, sensor positioning and the distance of the transducer from the signal source. Effects of tapping both the Mikro-Tip® and the fluid-filled catheters are illustrated on the right. The signal from the Mikro-Tip® catheter is unaffected, while the signal from the fluid-filled catheter is noisy.

## dP/dt Measurements

The parameter dP/dt is commonly used as an index of cardiac contractility. It represents the change in left ventricular pressure as a function of time and is determined from the slope of the ventricular pressure waveform during systole. Maximum dP/dt is used as an index of the initial velocity of myocardial contraction. Using a fluid-filled catheter and transducer (blue signal), the recorded signal may be misrepresented resulting in inaccurate dP/dt values.

## Millar Pressure & PV Catheter Features

- Ultra miniature catheters from 1F through to large 7F catheters
- Provide minimally invasive, continuous recording of pressure or pressure-volume
- PV catheter provides both pressure and volume signals
- Multi-segmented platinum electrodes for variable ventricle sizes (PV catheters)
- Suitable for use with multiple surgical techniques
- No risk of artificial pressure or volume changes caused by catheter flexing
- Suitable for *in vitro* studies such as working heart applications
- Internationally recognized Gold-standard

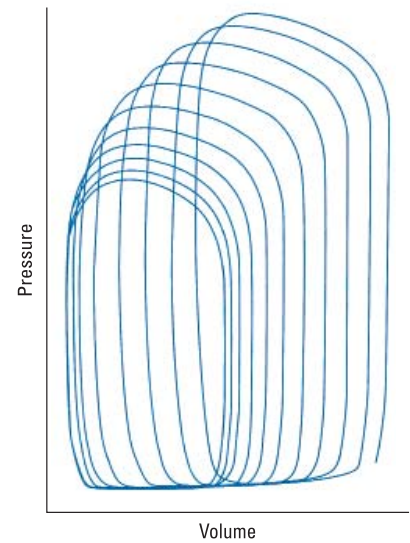


# Cardiovascular Pressure-Volume Systems

## MPVS Ultra™ System (Small and Large Animals)

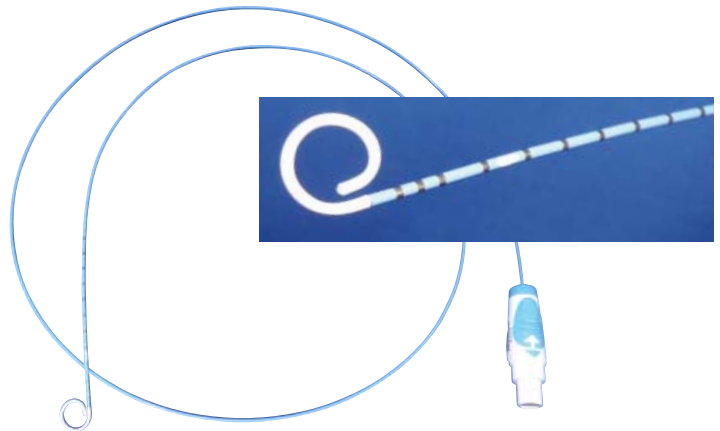
The MPVS Ultra™ system simultaneously and continuously measures high-fidelity left ventricular pressure (LVP) and volume from *in vivo* beating hearts using a single catheter with a high-fidelity pressure sensor and electrodes. Compatible with ultra-miniature catheters that are ideal for transgenic mice as small as 16 grams and multi-segmented catheters for large animals (domestic livestock), the MPVS Ultra provides an extensive range of cardiovascular applications. The intuitive Control Interface software streamlines setup and calibration, allows easy conversion of conductance measurements to true volume units and provides a variety of validated calibration methods.

The MPVS Ultra™ Foundation Research System, including a PowerLab and the latest LabChart Pro software, allows you to record and analyze pressure and volume signals. The LabChart PV Loop Module allows continuous real time PV loop plots during drug and hemodynamic interventions, thereby allowing the user to monitor and evaluate the mechanical properties of the heart in both normal and abnormal states. Analysis can be performed either during or after recording.



### Features & Benefits

- State-of-the-art technology
- Suitable for small and large animal applications
- Flexible volume determination using selectable catheter segments
- Built-in volume calibration technique using Rho cuvette and Baan's equation
- Software-controlled user interface
- Dual pressure inputs
- Seamless integration with PowerLab and LabChart
- Compatible with all Millar small animal PV catheters and large animal Ventri-Cath™ PV catheters



## MPVS Ultra™ Single Segment (Small Animals)

For small animal research, the MPVS Ultra Single Segment Foundation system for mice or rats provides the most economical solution to rodent pressure-volume studies. The system includes two pressure amplifiers, a single segment of volume measurement and intuitive software control, all at a fraction of the cost of comparable imaging technologies.

## Ventri-Cath™ Large Animal Pressure-Volume Catheters

The Ventri-Cath™ is the latest multi-segment pressure-volume (PV) catheter for complete cardiovascular assessment in large animals (e.g. dogs, pigs etc.). From a single input connection, the Ventri-Cath™ provides real-time pressure and volume signals for complete monitoring and analysis of ventricular function.

The affordability of the Ventri-Cath™ series increases the research community's access to Millar gold-standard pressure-volume technology. A CEC-10PV PV Extension Cable (VC to MPVS Ultra, 10ft) or 850-5140 Ventri-Cath Adaptor Cable is required for connection to recording devices.

### PV Applications

- Baseline and occlusion PV loop analysis
- Phenotyping and gene manipulation studies
- Cardiac hypertrophy
- Cardiovascular remodelling
- Toxicology
- Pharmacology (rapid drug screening)
- Cardiac resynchronization therapy
- Ischemia/reperfusion studies

# Data Acquisition and Analysis

PowerLab data acquisition systems provide recording, analysis and display of up to 32 channels simultaneously in real time with samplings speeds of up to 200 kHz per channel (400 kHz aggregate). They are ideal for monitoring and analyzing cardiovascular parameters including left ventricular pressure and volume, heart rate, systolic and end-diastolic pressure, rate of pressure change (dP/dt), rate of volume change (dV/dt) and more.



Recording channels can be easily calibrated into meaningful units such as mmHg or mL and analysis results can be exported in a variety of formats including \*.xls, \*.txt or \*.csv files.

All PowerLab research systems come with LabChart Pro, and include cardiovascular analysis modules such as the PV Loop Module and the Blood Pressure Module. LabChart Pro also comes with 5 years of free software upgrades.

## PV Loop Module

The PV Loop Module for LabChart records and analyzes left ventricular pressure and volume data for hemodynamic research in animals. It automatically calculates a wide range of hemodynamic variables including: stroke work and volume, cardiac output, heart rate, ejection fraction and many more. The module can be used to analyze data online or offline.

The Module also allows easy conversion of data to absolute volumes using cuvette calibration and enables the researcher to correct for parallel conductance using saline calibration - all within a single data file.

## Features

### Loop View

- Examine individual loops
- Select or exclude loops from analysis
- Calculate and display End-systolic and End-diastolic PV relationships

### Easy Calibration

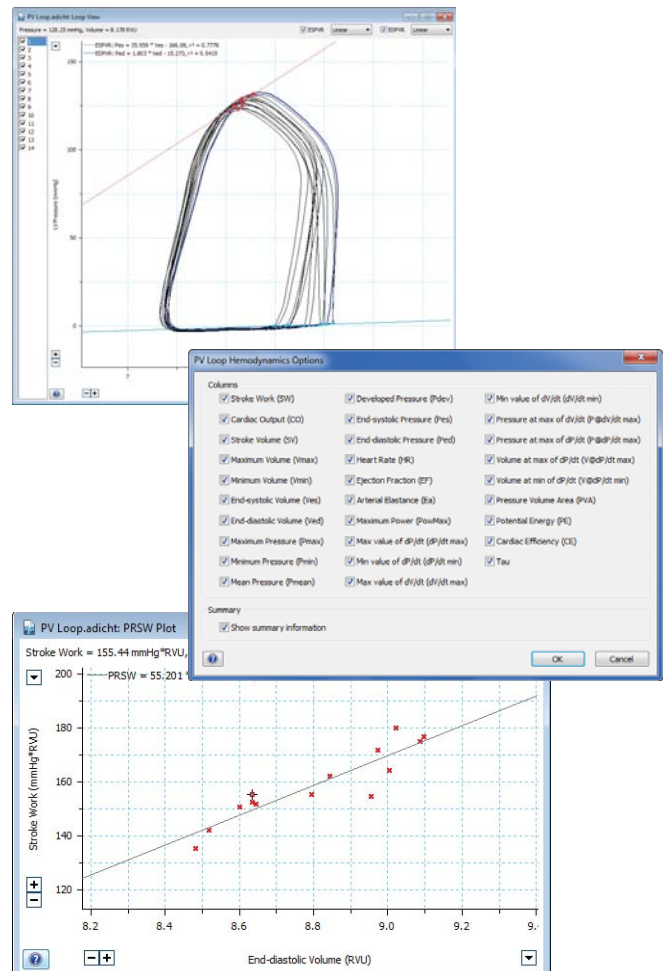
- Cuvette calibration can be computed and applied to the volume channel
- Built-in settings files with known volumes of common cuvettes provided
- Multiple calibration methods fully supported e.g. saline or cuvette calibration

### Multiple Plots and regression analysis including:

- Preload-recruitable stroke work (PRSW)
- dP/dt max vs. End Diastolic Volume (EDV)
- Pressure Volume Area (PVA) vs. EDV
- PVA vs. End Systolic Pressure ESP

### Total Compatibility

- Export PV Loop data from the Data Pad as \*.xls, \*.txt or \*.csv files
- Synchronize PV Loop with Movie View and playback PV Loop data alongside video



# Data Acquisition and Analysis

## Blood Pressure Module

The Blood Pressure Module for LabChart (Windows) provides real time or offline automated detection and analysis of a range of cardiovascular parameters from arterial or ventricular pressure signals as shown below.

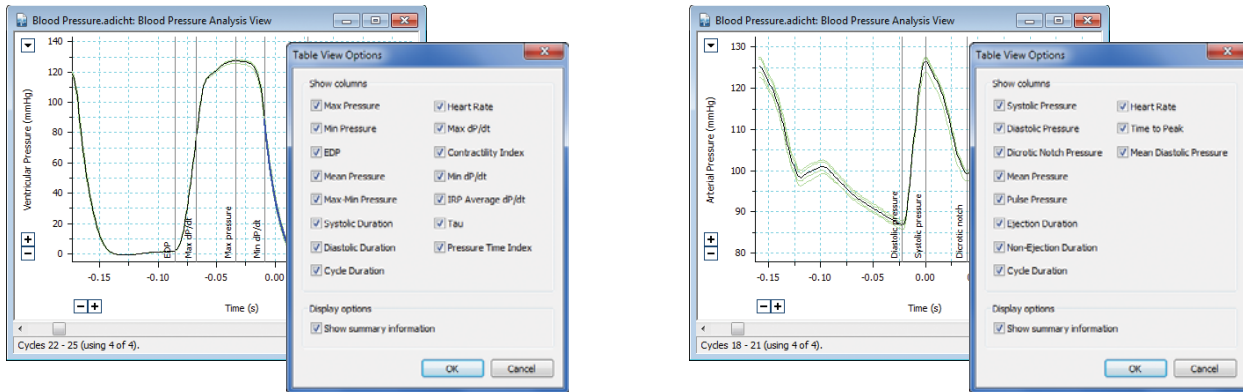


Table View Options for Ventricular Pressure and a Blood Pressure Table View generated by the Blood Pressure Module for LabChart.

## Pressure & Pressure-Volume Catheters

The following is a selection of Mikro-Tip and Ventri-Cath Catheters. For more options or to discuss your particular application please contact your nearest ADInstruments representative.

### Pressure Catheters

SPR-1000	Pressure Catheter (1F, Single, Straight, PI, 20cm)*
SPR-671	Pressure Catheter (1.4F, Single, Straight, Ny, 15cm)
SPR-407	Pressure Catheter (2F, Single, Straight, Ny, 140 cm)
SPR-320	Pressure Catheter (2F, Single, Straight, PU, 140cm)
SPR-882	Pressure Catheter (3F, Single, Straight, Ny, 140cm)
SPR-721	Pressure Catheter (2.5F, Dual, Straight, PU, 135cm)
SPR-524	Pressure Catheter (3.5F, Single, Straight, Ny, 100cm)*
SPR-340	Pressure Catheter (4F, Single, Curved, PU/W, 120cm)
MPR-500	Pressure Catheter (5F, Single, PU, 70cm)*
SPR-350	Pressure Catheter (5F, Single, Curved, PU/W, 120cm)
SPR-360	Pressure Catheter (6F, Single, Curved, PU/WD, 120cm)
SPR-370	Pressure Catheter (7F, Single, Curved, PU/WD, 120cm)

### Mouse Pressure-Volume Catheters

PVR-1030	Mouse PV Catheter (1F, 4E, 3.0mm, 4.5cm, PI)*
PVR-1035	Mouse PV Catheter (1F, 4E, 3.5mm, 4.5cm, PI)*
PVR-1045	Mouse PV Catheter (1F, 4E, 4.5mm, 4.5cm, PI)*
SPR-839	Mouse PV Catheter (1.4F, 4E, 4.5mm, 4.5cm, PI)
SPR-853	Mouse PV Catheter (1.4F, 4E, 4mm, Taper)
SPR-864	Mouse PV Catheter (1.4F, 2P, 4E, 4.5mm, Carotid)
SPR-848	Mouse PV Catheter (1.4F, 2P, 4E, 4.5mm, Apical)
SPR-866	Mouse PV Catheter (1.4F, 6E, Selectable Seg, 4mm/6mm)

### Rat Pressure-Volume Catheters

SPR-847	Rat PV Catheter (1.4F, 4E, 9mm, PI, 15cm)
SPR-869	Rat PV Catheter (2F, 4E, 6mm, PI, 15cm)
SPR-838	Rat PV Catheter (2F, 4E, 9mm, PI, 15cm)

### Rat Pressure-Volume Catheters cont.

SPR-878	Rat PV Catheter (2F, 4E, 12mm, PI, 15cm)
SPR-858	Rat PV Catheter (2F, 4E, 14mm, PI, 15cm)
SPR-901	Rat PV Catheter (2F, 2P, 4E, 9mm, Carotid, 15cm)
SPR-902	Rat PV Catheter (2F, 2P, 4E, 9mm, Apical, 15cm)
SPR-819	Rat PV Catheter (1.4F, 6E, Selectable Seg, 9mm/14mm)

### Multi-Segmented Pressure Volume Catheters

SPR-877	PV Catheter (3F, 10E, 2.5mm, DField, 120cm)
SPR-889	PV Catheter (3F, 10E, 3mm, SField, U-tip, 80cm)
SPR-894	PV Catheter (3F, 10E, 4mm, DField, U-tip, 80cm)

### Recommended for dogs, pigs and sheep

VENTRI-CATH-507	Ventri-Cath Catheter (5F, 12E, 7mm, DField, Pigtail, 122cm)
VENTRI-CATH-507S	Ventri-Cath Catheter (5F, 12E, 7mm, DField, Straight, 122cm)
VENTRI-CATH-510	Ventri-Cath Catheter (5F, 12E, 10mm, DField, Pigtail, 122cm)
VENTRI-CATH-510S	Ventri-Cath Catheter (5F, 12E, 10mm, DField, Straight, 122cm)
VENTRI-CATH-512	Ventri-Cath Catheter (5F, 12E, 12mm, DField, Pigtail, 122cm)
VENTRI-CATH-512S	Ventri-Cath Catheter (5F, 12E, 12mm, DField, Straight, 122cm)
VENTRI-CATH-515	Ventri-Cath Catheter (5F, 12E, 15mm, DField, Pigtail, 122cm)
VENTRI-CATH-515S	Ventri-Cath Catheter (5F, 12E, 15mm, DField, Straight, 122cm)
SPR-562-1	PV Catheter (6F, 2P, 12E, 7mm, DField, Pigtail, PU, 125cm)*

1F= 0.33 mm

E= Electrode number

P= Pressure transducer number

\*= Non-repairable

Note: Catheter interface cables are required for connection to ADInstruments Bridge Amplifiers

# Ordering Information

## ADInstruments Foundation Systems

ADInstruments provides both Pressure and Pressure-Volume Foundation Systems. To allow full customization of each system, the Mikro-Tip Catheters need to be selected separately. If you need assistance with selecting the appropriate catheters for your application please do not hesitate to contact us.

PL3508B35 Mikro-Tip® Blood Pressure Foundation System	PL3516B49 MPVS Ultra Foundation System
1 x PL3508 PowerLab 8/35 Series with LabChart (Win & Mac)	1 x PL3516 PowerLab 16/35 Series with LabChart (Win & Mac)
1 x MLS260/7 LabChart Pro software	1 x MLS260/7 LabChart Pro software
1 x ML221 Bridge Amp	1 x 880-0168 MPVS-Ultra Pressure-Volume Unit (large and small animals)
1 x AEC-10C Catheter Interface Cable	1 x 910-1060 Rho Calibration Cuvette kit
1 x AEC-10D Catheter Interface Cable	1 x 880-0169 MPVS-Ultra Cable Pack (3m) required for connecting PV catheters to the MPVS-Ultra Pressure-Volume Unit
<b>PL3508B48/M MPVS Single Segment Foundation System for Mice</b> <b>PL3508B48/R MPVS Single Segment Foundation System for Rats</b>	
Both Systems Include:	
1 x PL3508 PowerLab 8/35 Series with LabChart (Win & Mac)	
1 x MLS260/7 LabChart Pro software	
1 x 880-0168SS MPVS-Ultra Single Segment Pressure-Volume Unit	
1 x 880-0170BNC MPVS-Ultra Single Segment Cable Pack	
1 x 910-1048 Volume Calibration Cuvette (Rat PV Catheters) (with PL3508B48/R only)	
1 x 910-1049 Volume Calibration Cuvette (Mouse PV catheters) (with PL3508B48/M only)	
<b>Includes:</b> 1x CEC-10E PV Extension Cable (3 m) for pressure and volume measurement 1x PEC-10D Pressure Extension Cable (3 m) for 2nd sensor pressure measurement 1 x 880-0172 MPVS-Ultra BNC Cable pack required for connecting the MPVS-Ultra	

Additional Items
880-0168U MPVS Ultra Upgrade (Converts SS Unit to MS Unit) for small & large animals
910-1049 Volume Calibration Cuvette (1.5 to 4.0 mm)
910-1048 Volume Calibration Cuvette (2 to 15 mm)
910-1060 Rho Calibration Cuvette Kit

Software		
MLS060/7 LabChart (Win and Mac)	MLS330/7 GLP Client and MLS335 GLP Server (Win)	
MLS260/7 LabChart Pro (Includes the modules listed below. Modules are also available for individual purchase.)		
MLS390/7 Dose Response (Win)	MLS310/7 Heart Rate Variability (Win and Mac)	MLS340/7 Cardiac Output (Win)
MLS065/7 DMT Normalization (Win and Mac)	MLS240/7 Metabolic (Win and Mac)	MLS320/7 Video Capture (Win and Mac)
MLS370/7 Blood Pressure (Win)	MLS062/7 Spike Histogram (Win and Mac)	MLS395/7 Circadian Analysis (Win)
MLS360/7 ECG Analysis (Win)	MLS380/7 Peak Analysis (Win)	MLS375/7 PV Loop (Win)

ADInstruments also offers solutions for researchers working in GLP and 21 CFR Part 11 environments. Please contact your ADInstruments representative for more information.

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PowerLab systems and signal conditioners meet the European EMC directive. ADInstruments signal conditioners for human use are approved to the IEC60601-1 patient safety standard and meet the CSA C22.2 No. 601.1-M90 and UL Std No. 2601-1 safety of medical electrical equipment standards.



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