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improbable possible.

MPVS Duo Pressure-Volume System

Quick Start Guide

MPVS Duo Quick Start Guide

About the system

The Millar MPVS Duo Pressure-Volume (PV) measurement system combines the traditional conductance technology with the leading admittance PV loop measurement methods, delivering higher quality, reproducible data compatible with Millar PV catheters.

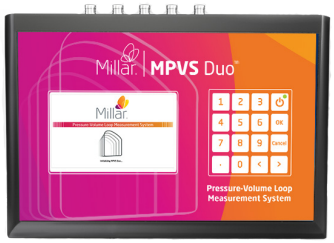
MPVS Duo provides users with guided steps and a linear menu structure that encompass all aspects of data collection, bringing the benefits of conductance, admittance and Millar catheters to your studies in an intuitive, user-friendly design.

MPVS Duo Initial Setup:

1. Basic Hardware Setup

Find a suitable location near the workstation or on a roll cart (not provided). MPVS Duo Hardware and Data Acquisition System/Computer should be positioned close to the operator.

Connect power jack to power input on MPVS Duo, connect BNC (4-5) from MPVS Duo to DAQ (not included), connect Micro HDMI to catheter port on MPVS Duo to catheter (full size HDMI).



MPVS Duo top down view. LCD and keypad shown

MPVS Duo with all connections attached

Table 1: MPVS Duo Specifications

General Features	
Dimensions	3.1" H, 11.4" W, 7.9" D
Weight	2.27 lb (1032g)
Display Size	5" 800x480
Display Type	HDMI LCD Module - Non-Touch
Power Supply	
MPVS Duo Power Box Supply	9V Input
Output	9V DC 4.5A = 40.5W
Connector	Barrel Jack 2.5mm, Positive Center
Power On/Off	Front keypad power button
Operational Technology	
Pressure	Solid-State MEMS Pressure
Volume	Conductance and Admittance PV
Catheter Support	Millar PV Catheters, Transonic Catheters
Inputs/Outputs	
Catheter Connector	Micro HDMI
Analog Output Type/Channels	BNC / 5 Channels
Voltage Range	0 - 4.095V
USB - For Update use	1 - MicroUSB Rear / 3 Full size

MPVS Duo BNC Cable

MPVS Duo Power Supply

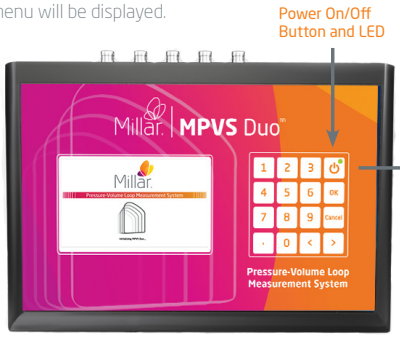
ADInstruments PowerLab: Millar's preferred system for data acquisition.

MPVS Duo Micro HDMI to Full Size HDMI

Millar Ventri-Cath Catheter

2. System Power Up

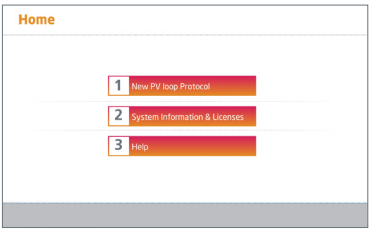
Turn on MPVS Duo using the **Power Button** on the MPVS Duo keypad. The Duo will start up and display the MPVS Duo PV Loop software. After connecting a PV catheter, the main menu will be displayed.



MPVS Duo top down view. LCD and Keypad shown.

Note: All navigation on MPVS Duo is performed via the front Keypad

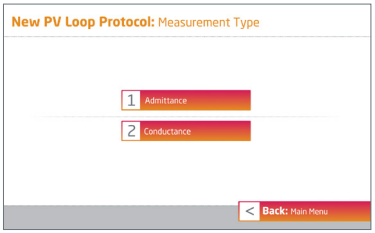
MPVS Duo PV loop startup screen



MPVS Duo home screen

Press 1 to start a *"New PV Loop Protocol"*. A step-by-step process will begin walking through how to collect PV loops with the MPVS Duo. **Press 2** to access *"System Information & Licensing"* and **Press 3** to access *"Help"* info. *"New PV Loop Protocol"* will be grayed out when no catheter is connected.

3. Choose Measurement Mode



MPVS Duo select measurement type

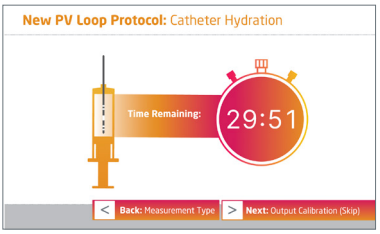
MPVS Duo supports both conductance and admittance measurement modes. **Press 1** on the keypad to select the admittance workflow and **press 2** to select the conductance workflow. See Table 2 for more info on differences in modes.

Table 2: MPVS Duo Conductance vs Admittance Comparison

	Conductance	Admittance
Active Channels	Only Pressure, Magnitude (conductance), and Phase* channels active	Pressure, Magnitude, Phase, and Volume Channels activated
Volume	Use external calibration method - i.e., ADI PV Loop Module	Wei's Equation
Muscle Conductance	Saline Bolus or Cuvette	Determined in real-time from phase signal
*Positional Awareness	Phase signal only - new to conductance	From phase and volume signals

4. Hydrate Catheter

In order to minimize signal drift, immerse the sensing tip in saline for at least 30-minutes to properly hydrate the catheter's pressure sensing membrane.

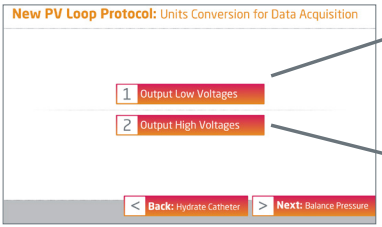


MPVS Duo catheter hydration

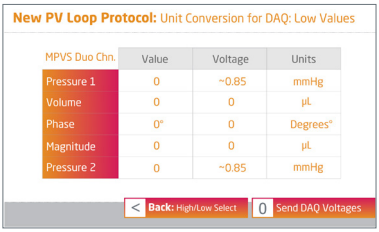
5. Output DAQ Voltages

MPVS Duo outputs low and high calibrations voltages that are used for calibrating the analog to digital data acquisition systems (DAQ). Within the users DAQ software, unit conversion can be performed. MPVS Duo has separate screens for both high and low voltage values.

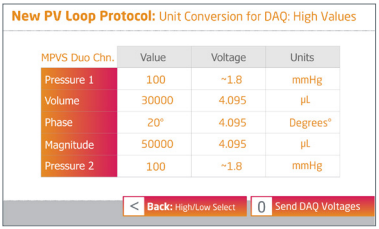
Press 1 on the keypad to access the "Output Low Voltages" menu, **Press 2** on the keypad for the "Output High Voltages" menu. Within each sub-menu, the correct physiological conversions will be shown under the "value" column and the estimated voltage value in the "voltage" column. On each sub-page **Press 0** on the keypad to output voltages to the DAQ.



MPVS Duo output voltage select screen



MPVS Duo output low voltages



MPVS Duo output high voltages

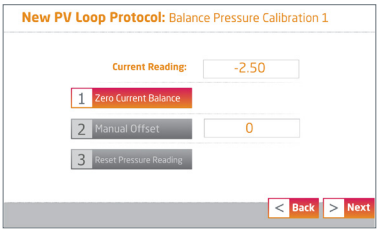
6. Balance Pressure Sensor

Each pressure sensor should be zeroed or "balanced" prior to use. Use MPVS Duo automatic zero feature to balance the pressure sensor. Do this immediately prior to inserting the catheter into the vessel, ventricle, or area of measurement.

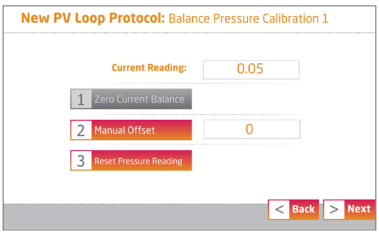
MPVS Duo will display the current raw reading from the pressure sensor in the "Current Reading" box. Typically, this value will vary around a few mmHg. **Press 1** on the keypad to auto-zero the sensor. The current reading box will now read ~0 mmHg. This is the new zeroed reading of the catheter.

MPVS Duo also has the option to apply a manual offset to the zeroed pressure signal. This must be done after the catheter has been zeroed. **Press 2** on the keypad and enter in the appropriate positive offset if required. Note: this is not required in a standard protocol, it is an option. **Press 3** on the keypad to reset to the raw pressure reading.

In all cases, the value shown in the current reading box will be the pressure output from the MPVS Duo outputs.



MPVS Duo before pressure balance



MPVS Duo after pressure balance

7. Collecting PV Loops

MPVS Duo supports conductance and admittance PV loop protocols, each with its own walkthrough.

- Conductance protocols require external volume conversion typically achieved with 3rd party PV Loop modules.
- Admittance protocols require study parameter setup but can output volume directly.

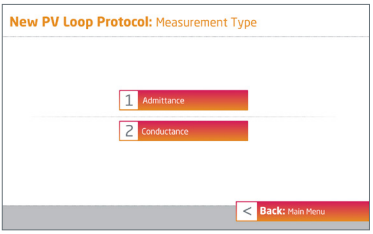
In both workflows, a reference Stroke-Volume (SV) measurement should be completed using external measures such as a flow probe, echocardiography, etc. This value is used in both PV loop calculations.

Conductance

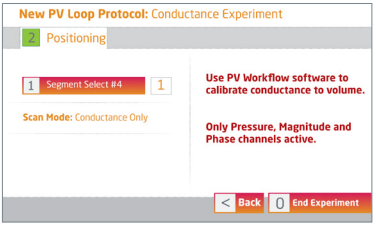
MPVS Duo conductance mode is very similar to traditional conductance measurement devices where data is collected and analyzed in 3rd party software.

- Single value parallel muscle contribution is removed via saline bolus post experiment. Volume conversion, alpha calibration, and cuvette calibration are done using 3rd party PV loop modules.
- MPVS Duo provides the traditional conductance outputs "Conductance (Magnitude channel)" and "Pressure" to provide users a familiar workflow.
- MPVS Duo also provides a phase output channel to be used to aid in positioning of the catheter during PV loop experiments. ***Note: In conductance mode this signal is used for positional awareness only.***
- MPVS Duo has one principal display for the conductance workflow displaying segment select, and other important information indicating what the user must do post processing in external 3rd party module.
- While on screen, MPVS Duo is outputting all conductance related channels that are to be sampled by the users DAQ system. Standard Conductance PV loop analysis can be performed with the user's 3rd party PV loop modules.
- If using a large animal catheter, **press 1** on the keypad to change the segment used. The current segment will be displayed in the text box. The number next to "Segment Select #" is the available segments for the catheter. Small animal are single segment and large animal are multi-segment.
- To finish an experiment and go back to the main menu **press 0** on the keypad.

Standard Conductance Workflow



MPVS Duo select measurement type



MPVS Duo Conductance experiment screen

MPVS Duo back BNC connections

Output signals
- Pressure
- Conductance (Magnitude)
- Phase - Positioning only

For data acquisition and analysis, Millar prefers the ADInstruments PowerLab system and PV Loop Analysis Software Module for LabChart.

Admittance

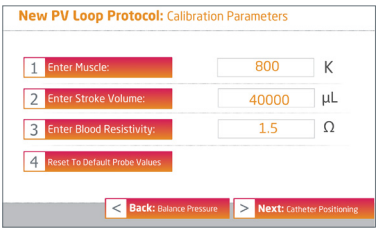
MPVS Duo admittance workflow mode provides users with live real-time volume output without the need for calibration techniques such as saline bolus or cuvette calibration.

- Provides dynamic separation of the blood and muscle properties of the heart via magnitude and phase signals.
- Four main outputs: "Pressure", "Volume", "Magnitude" and "Phase". The Volume channel uses internal algorithms to calculate blood volume from the magnitude and phase channels, dynamically calculating Gb, muscle conductance, etc.
- This allows users to optimize their catheter position with live volume feedback and PV loops. Users can use 3rd party analysis tools to further process their data.
- MPVS Duo contains three specific screens to walk through users in collecting admittance based PV loops.

Study Parameters

MPVS Duo admittance mode requires 3 study parameters:

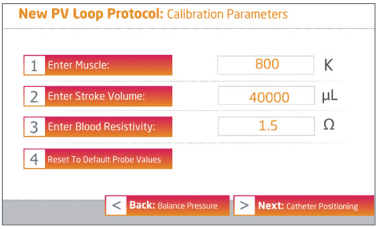
- **Muscle** properties are typically set to 800K for a normal heart, for infarcted hearts users can input 900K. All units are in K, i.e., enter 800 for 800K.
- **Stroke Volume (SV)** is used as a method to calibrate the volume signal. External measurements are recommended to obtain this value.
- **Blood Resistivity** default values are loaded directly from the attached catheter. Experimental interventions, such as the administration of fluid, can change the blood resistivity of the animal model. To compensate, blood resistivity can be measured and adjusted from the default value.
- To change the default values, press the associated number on the keypad. **Press 1** for Muscle Properties, **Press 2** for SV, **Press 3** for Blood Resistivity and **Press 4** to restore defaults.
- Once the calibration parameters are satisfactory, **select > Next** to advance to Cather Positioning.



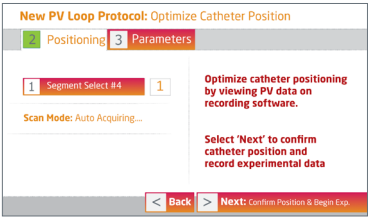
MPVS Duo PV loop study parameters

Standard Admittance Workflow

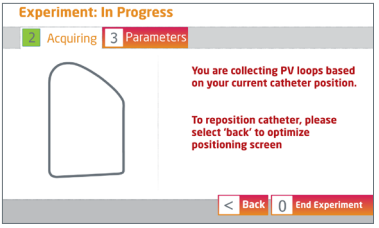
Choose Admittance Measurement Type



MPVS Duo PV loop study parameters



MPVS Duo optimize catheter position screen



MPVS Duo experiment page

MPVS Duo back BNC connections

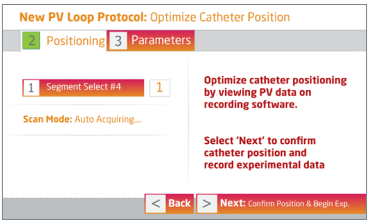
Output signals pressure, magnitude, phase, volume

For data acquisition and analysis, Millar prefers the ADInstruments PowerLab system and PV Loop Analysis Software Module for LabChart.

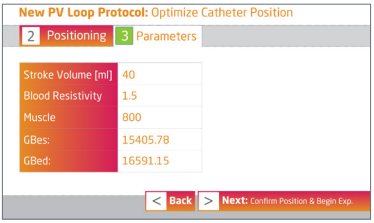
Admittance Optimize Catheter Position

The user is now prepared to advance the catheter into the ventricle and optimize the catheter's position by viewing PV loop data directly on 3rd party software. With MPVS Duo's unique ability to provide immediate feedback, users can view live PV loops to ensure the data is within expectations. Typical values are shown in Table 4.

- The user can **press 1** to change segment if using a large animal catheter. Segment selection should correspond to the largest segment where all the electrode rings fit within the ventricle. With single segment catheters, only segment 1 will be valid.
- This screen is tabbed based, **Press 3** to view the current study parameters and current Gb_{ES} and Gb_{ED}. **Press 2** to return to Positioning. The active tab will highlight in green.
- Once catheter position is stable and resultant PV Loop data is satisfactory, **select > Next** to confirm catheter position and begin experiment.
- **Press < Back** to return to the study parameter page and enter new values if required.
- Manual scan mode can be enabled in the settings.
- Timing notices are provided to the user at set intervals to remind them to enter experiment mode. These are customized in settings.



MPVS Duo optimize catheter position screen

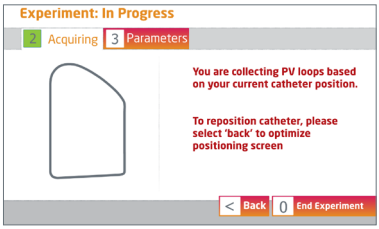


MPVS Duo parameters page

Admittance Experiment Mode

At the "Experiment: In Progress" screen, users will have optimized catheter positioning and will be ready to record experimental data.

- Entering this screen locks the baseline scan (Gb_{ED} and Gb_{ES}) values. They can no longer be changed, regardless of whether continuous auto scan is enabled. This is intended to optimize data stability over the recording protocol.
- If catheter repositioning is required, **press < Back** to return to the Optimize Catheter Position screen. **Press 3** to view locked in parameters, **press 2** to return to acquiring page - main experiment page.
- **Press 0** from the experiment page to end the experiment and return to the home screen. A cancel experiment screen notice will appear for confirmation.



MPVS Duo experiment page

Table 3: Default Study Parameters Table

Blood Resistivity	
Mouse	1.2 ohm-m
Rat	1.4 ohm-m
Large Animal	1.5 ohm-m

Muscle Properties - Heart Type	
Normal	800K
Infarcted	900K
Hypertropic	750K

Table 4: Typical Signal Ranges

Signal Ranges*	Mouse	Rat	Large Animal
Systolic Pressure (mmHg)	90-120	100-130	70-100
Diastolic Pressure (mmHg)	1-6	1-6	1-6
Heart Rate (BPM)	>450	>350	>50
Magnitude Range	900-200uS	1400-2600uS	10-20mS
Magnitude Amplitude	≥300uS	≥500uS	≥2.5mS
Phase Range (deg)	2-8	2-7	1-5
Phase Amlitude (deg)	2	2	2

*These are just suggested typical ranges for each measurement. They will vary based on animal type, weight, protocol, etc. It is best to use previous studies or protocols as references.

Other Notes:

- Use 1Khz sampling for rodent models and 200hz or more for large animal.
- Use only provided or authorized cables. Failure to do so may result in incorrect data.
- Follow Millar catheter IFU for proper handling and cleaning.
- USB ports are for upgrade purposes only.
- Ensure system is properly shut down before removing power connection. Failure to do so could result in corrupt operation.