PHYSIOTEL DIGITAL L11R RESPIRATION CHANNEL CALIBRATION INSTRUCTIONS USING HANS RUDOLPH PNEUMOTACH AMPLIFIER CONNECTED TO SIGNAL INTERFACE

Calibration of the PhysioTel Digital L11R versus a Pneumotach requires acquisition of both respiratory signals in a synchronized manner. It also requires calibration of the pneumotach signal versus a reference. This technical note will document the steps required for acquiring signals simultaneously and provide a process for calibrating the pneumotach and the implant.

BACKGROUND

The respiratory impedance channel of the PhyioTel Digital L11R is intended to be calibrated after the animal has fully recovered from surgical implantation of the device. When not calibrated, the raw impedance signal from the L11R implant can be used to calculate respiration rate and look at relative respiratory volume changes from baseline. If more precise data is desired to measure and calculate respiratory volume and volume changes, the raw impedance signal must be calibrated to a source of known flow rate and volume.

EQUIPMENT NEEDED

Configuration of the PhysioTel Digital L11R implant requires a desktop computer with Ponemah 6.5 or greater installed. This technical note does not cover details of PhysioTel Digital hardware and implant configuration. For additional information on this please see the Ponemah manual or PTD configuration page on the DSI Support Center. The following additional equipment is needed to perform device calibration.

DSI P/N	Description
600-2029-001 or 600-2030-001	Respiratory Mask (Dog/Pig) or Respiratory Helmet (NHP) (with spare neck seals as p/n 600-2031-001)
600-130x-00x	Pneumotach of proper flow range for your species (See Flow Range Determination)
276-0944-001	Hans Rudolf Pneumotach Amplifier
271-0119-002	MX2 (Matrix 2.0) with USB Input for Signal Interface
271-0190-001	Signal Interface
600-1260-001	Mass Flowmeter for calibration verification
601-2200-001 or 601-2200-002	DSI Bias flow 220V (Optional – not needed if another constant flow source is available) or DSI Bias flow 110V (Optional – not needed if another constant flow source is available)

Flow Range Determination

Proper pneumotach selection depends upon what species and size of animal you are using and whether or not a heating unit is required. Please reference the below table.

Animal Size	Flow Range (L/min)	Pneumotach Model with heater	Pneumotach Model without heater	Region
2-5 kg	0 – 35	600-1303-001	600-1303-002	US 110V
5-20 kg	0 – 160	600-1305-001	600-1305-002	US 110V
2-5 kg	0 – 35	600-1303-011		EU 220V
5-20 kg	0 – 160	600-1305-011		EU 220V

CALIBRATION CONSIDERATIONS

Calibrating the L11R is a 2-part process.

- Part 1: Calibrate Pneumotach to known flow source
- Part 2: Calibrate L11R to Pneumotach

Note: It is not necessary to have the animal nearby when calibrating the Pneumotach in 1st calibration step.

CONNECTING HARDWARE

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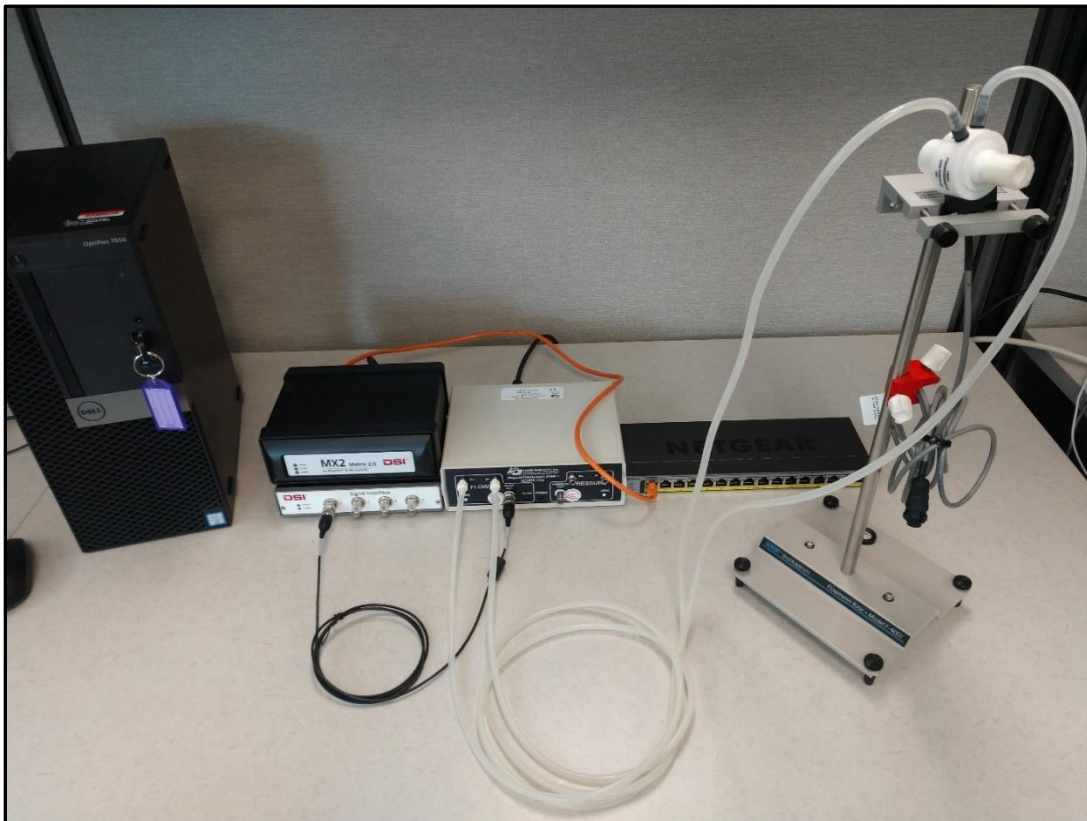
Connect all necessary equipment.

- Plug the Hans Rudolph Pneumotach Amplifier into a power source.
- Connect the Signal Interface to the MX2 using the supplied USB cable.
- Connect the MX2 to a POE port on the network switch. Note: The CLC will also connect to the same switch when configuring the PhysioTel Digital hardware.
- Connect the Pneumotach tubing to the Hans Rudolph Pneumotach Amplifier on the Flow side.
- Connect the analog Flow Out to the first available connection on the Signal Interface.
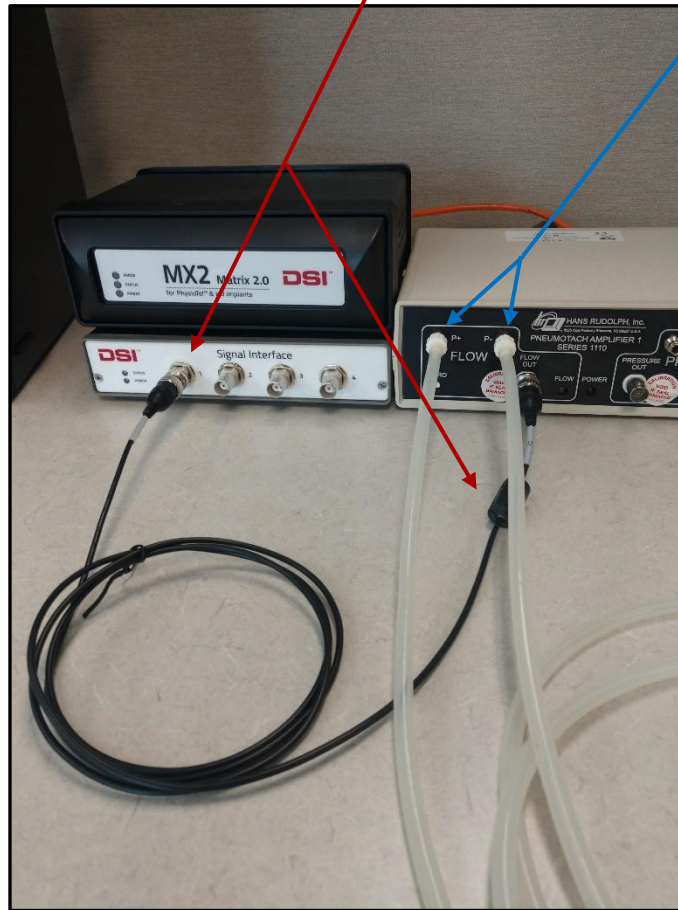
- Make sure all hardware is connected and powered on before launching Ponemah software.

PART 1: CALIBRATING THE PNEUMOTACH

In the first part of calibration, the pneumotach must be calibrated to a source of known, constant flow. This can be a DSI Bias Flow unit or a compressed air tank with a regulator that can be controlled.

A two-point calibration is performed consisting of a low and a high value. The typical low calibration reference is no (zero) flow. The typical high calibration reference is a constant positive flow from an air tank, or a constant negative flow (vacuum) from a bias flow supply. As with any calibration one must take care to assure that the calibration covers the expected range of use during application.

To verify high flow rate, connect the Mass Flowmeter to power and to the flow source.

The Flowmeter is directional: Ensure the flow is in the correct direction when connecting the Flowmeter.
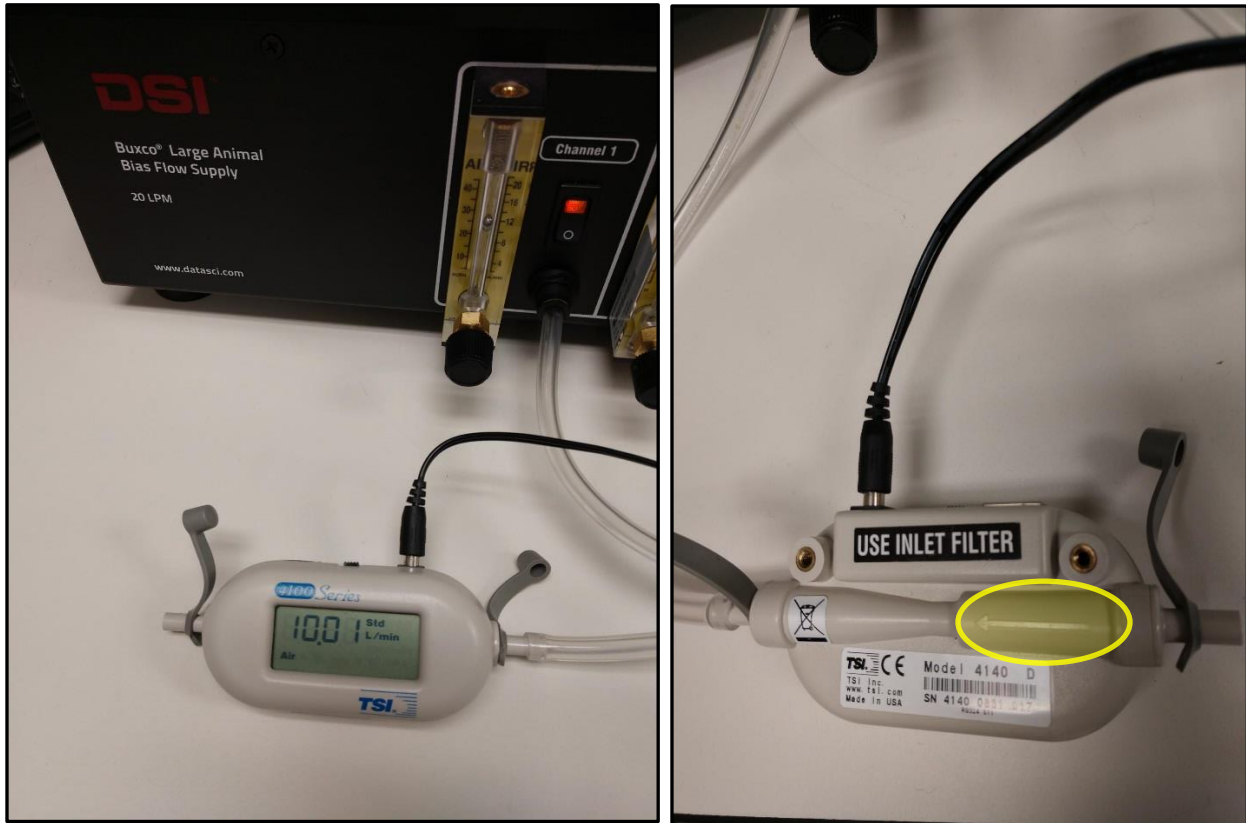

Open the Ponemah software and create a new experiment. Under the Hardware menu select **Edit PhysioTel/HD (MX2) Configuration**.

1. Locate the MX2 under the Available MX2s box and move it to Selected MX2s. Verify that the MX2 and the Signal Interface are detected, and status icons turn green.
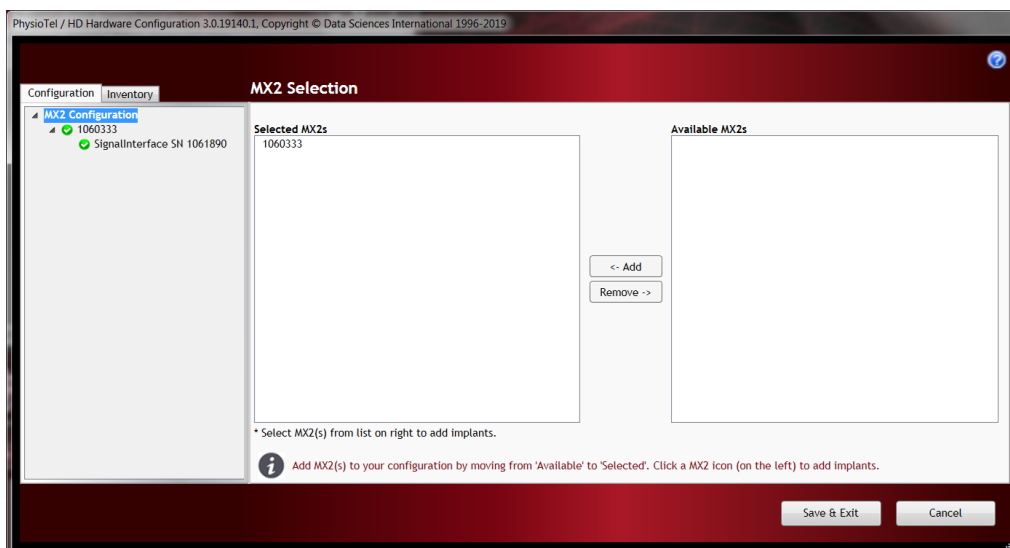
2. Click on the Signal Interface under the Configuration tab and enable channel 1 which will be used for the pneumotach. Set the Signal Type to Pulmonary Airflow and Sample Rate to 50Hz.
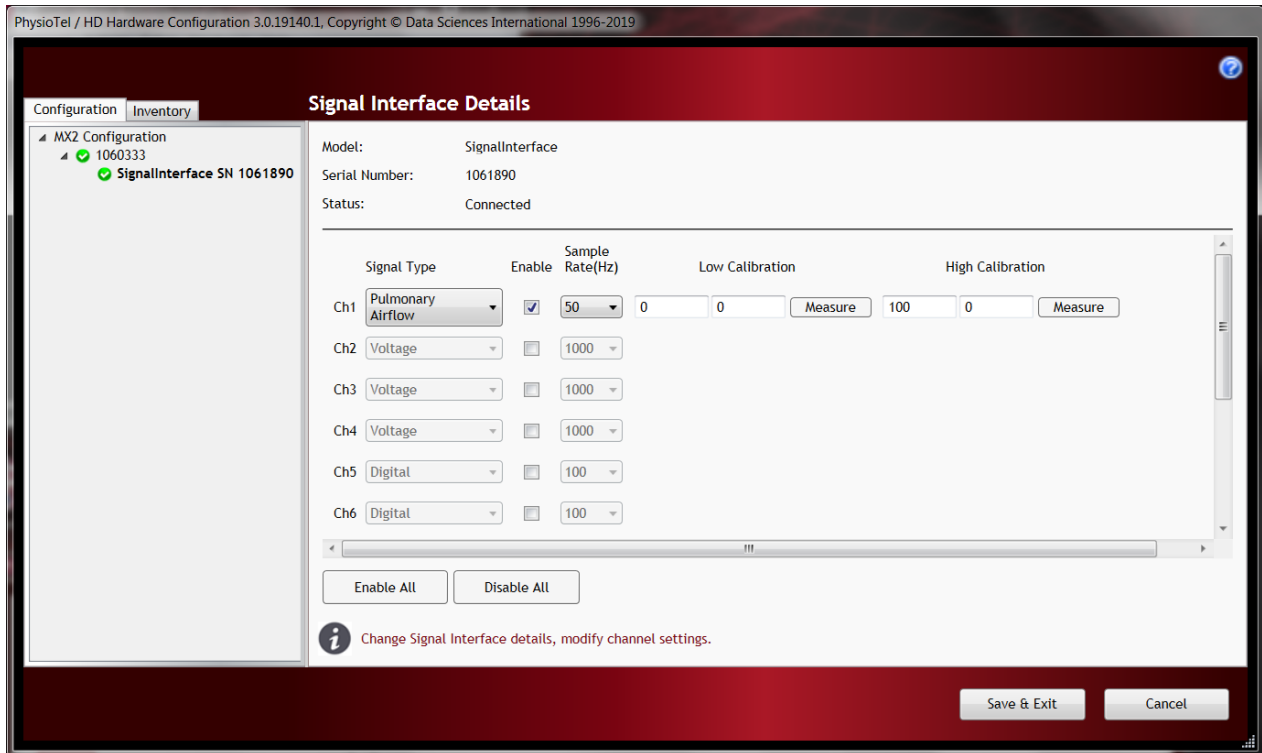
3. **Low Calibration** – There are two boxes for Low Calibration. The box on the left is the known low flow value and the box on the right is the voltage that corresponds to the low flow. Have the pneumotach open to air (no flow) and set the left box to a value of zero. Click the Measure button to the right of the Low Calibration boxes. A Sampling Analog Input window will appear, and the software will measure the input. When measurement is completed the sampling window will close and the average voltage will be entered automatically in the right box. NOTE: MX2 must be synchronized (green status indicator) to measure.
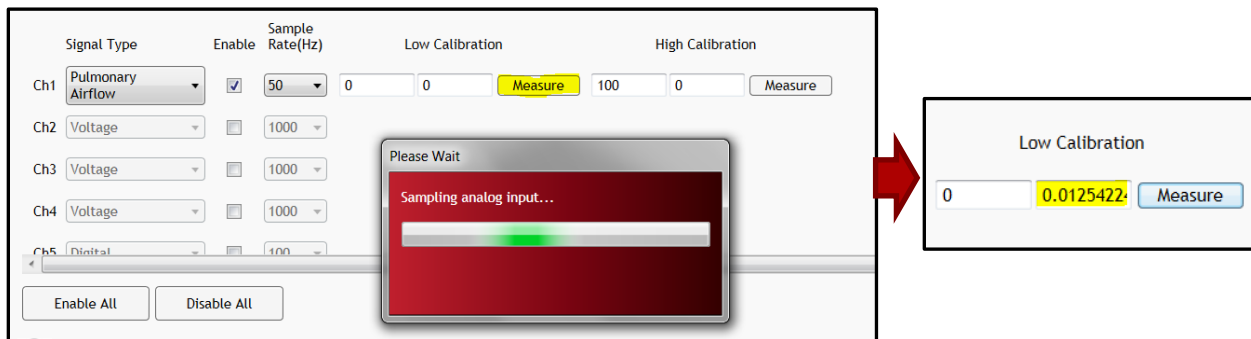
4. **High Calibration** – There are two boxes for High Calibration. The box on the left is the known high flow value and the box on the right is the voltage that corresponds to the high flow. Connect the pneumotach to the flow source and make sure air is flowing at the known rate. Enter the high flow value in the left box. (In the example it is 10L/min). Click the Measure button to the right of the High Calibration boxes. A Sampling Analog Input window will appear, and the software will measure the input. When measurement is completed the sampling window will close and the average voltage will be entered automatically in the right box. NOTE: MX2 must be synchronized (green status indicator) to measure.
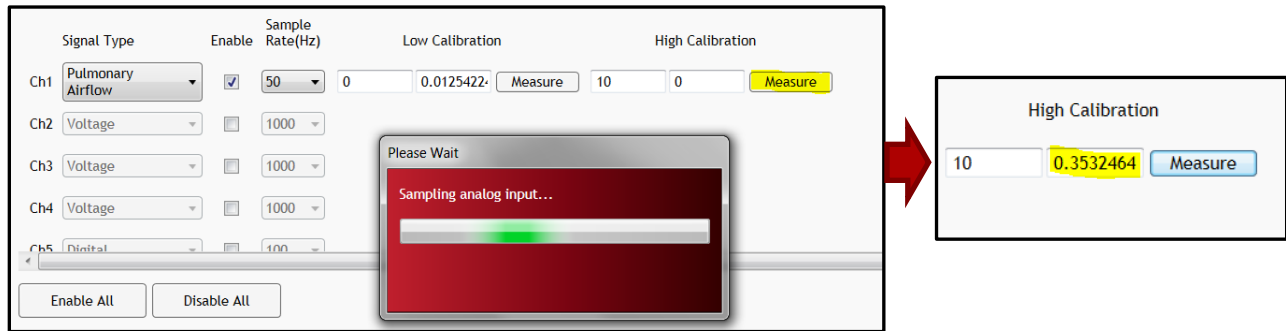
5. Click Save & Exit. A warning box may pop up saying that no implants are defined. This can be ignored by clicking OK.

PART 2: CALIBRATING THE L11R

In the second part of calibration the CLC and MX2/Signal Interface hardware will be used simultaneously to calibrate the L11R respiration signal. The implanted L11R is sampled simultaneously with the pneumotach attached to a mask (dog) or helmet (primate). The two signals are then compared in the Ponemah software to complete calibration. Calibrating the L11R impedance channel versus a pneumotach assumes the user has:

1. Followed part 1 of the calibration technical note to set up and calibrate the pneumotach connected to the MX2/Signal Interface via the Hans Rudolph Amp.
2. Configured an L11R implant - Ensure the desired L11R implant is turned on and configured using the Hardware – Edit CLC Configuration menu. For additional information on PhysioTel Digital implant configuration please see the Ponemah manual or PTD configuration page on the DSI Support Center.

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1. Verify implant channels – From the main Ponemah window go to the Setup – Subject Setup menu.
    a. Verify all channels are set to the correct analysis type. The Impedance channel must be PVO.
    b. Enable the checkbox for the Signal Interface Pulmonary Airflow channel.
        Note: Enabling the channel will only be available prior to data collection; After data is collected enabling/disabling channels is not allowed.
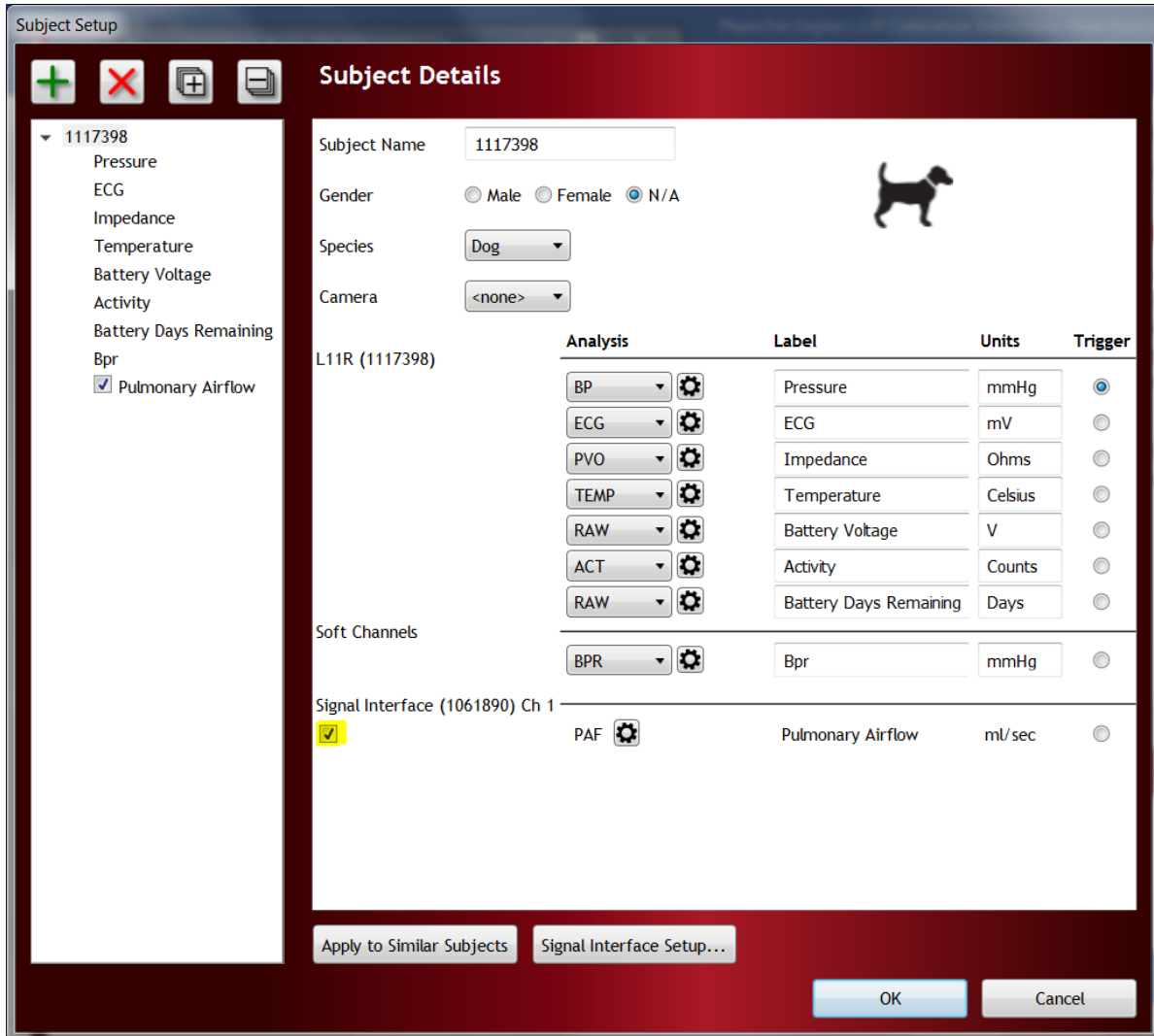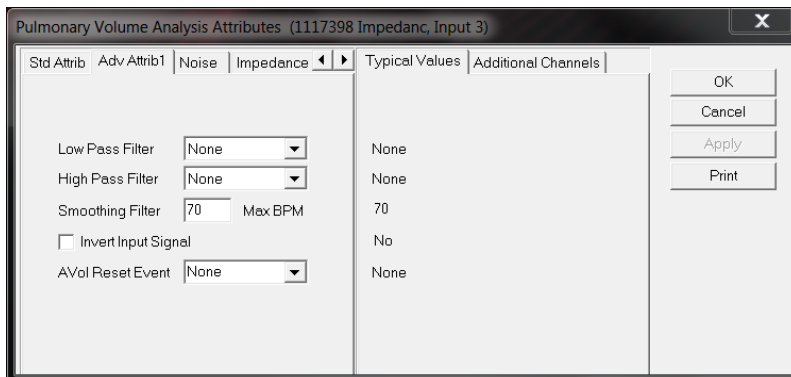
2. Check PVO analysis settings.
    a. Click the Settings Icon ⚙ next to the PVO channel.
    b. In the Std Attrib tab ensure that the Calculated Flow Units is set to the unit that was used during the pneumotach calibration in part 1.
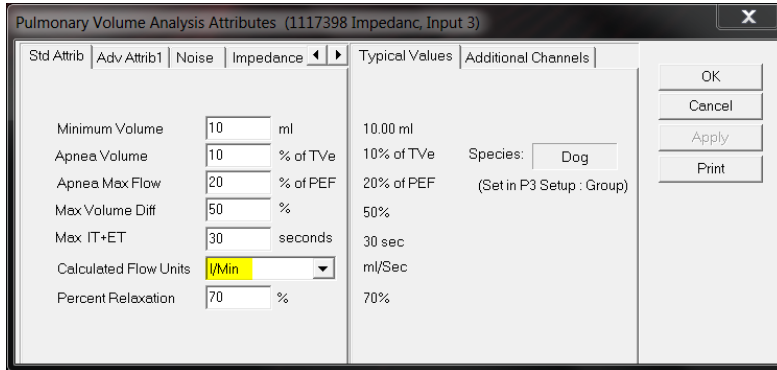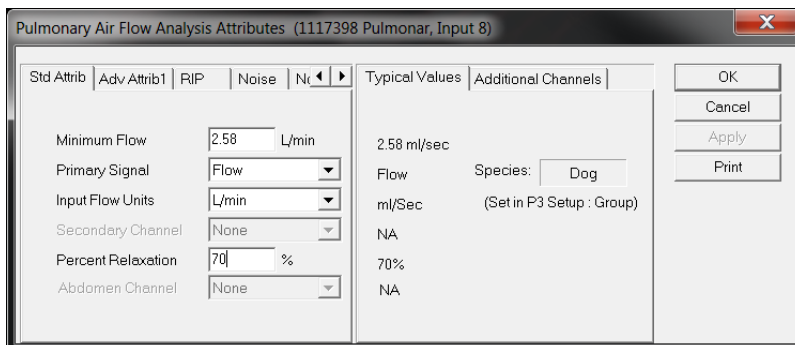

    c. In the Adv Attrib1 tab filters may be applied to help filter noise. See the Appendix for L11R - PVO filtering recommendations.
   d. Select OK to close.

3. Check PAF analysis settings.
    a. Click the Settings icon ⚙ next to the Signal Interface PAF channel.
    b. In the Std Attrib tab ensure that the Primary Signal is set to Flow and that the Input Flow Units are set to the unit that was used during the pneumotach calibration in part 1.

c.   In the Adv Attrib1 tab there are no filters applied by default. A low pass and high pass filter may be applied to help filter noise. See the Appendix for pneumotach filtering recommendations.

d.   Select OK to close.
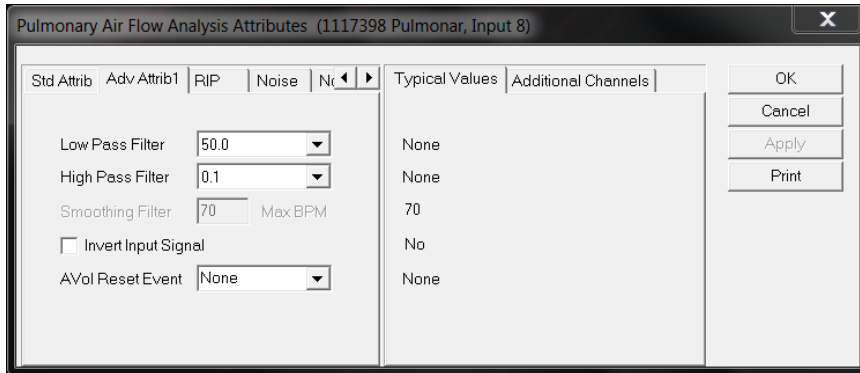
4.   Click Signal Interface Setup at the bottom of the page.
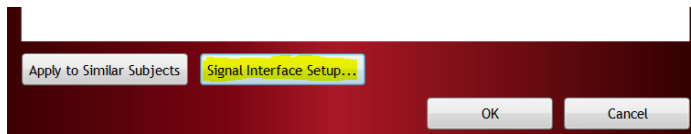

a.   Verify the units are set to the unit that was used during the pneumotach calibration in part 1.

b.   Channel label can be modified as Pneumotach.
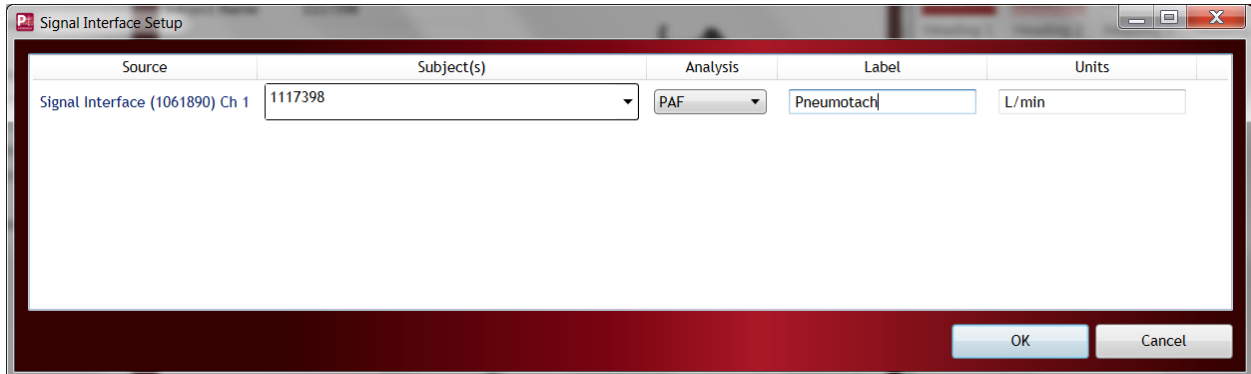
c.   Click OK to close Signal Interface Setup.

d.   Click OK again to close the Subject Setup.

5. Go to the Setup – Experiment Setup menu and select Graph Setup on the left to configure graph pages.
    Note: For the calibration procedure it is recommended to manually configure a graph page to view the respiration channels only.

    a. Enable a graph page and set up with desired signal presentation. In the example both the pneumotach channel and impedance channel are shown with a flow and a volume presentation.

   b. Once graph page is configured, select OK to close the Setup.
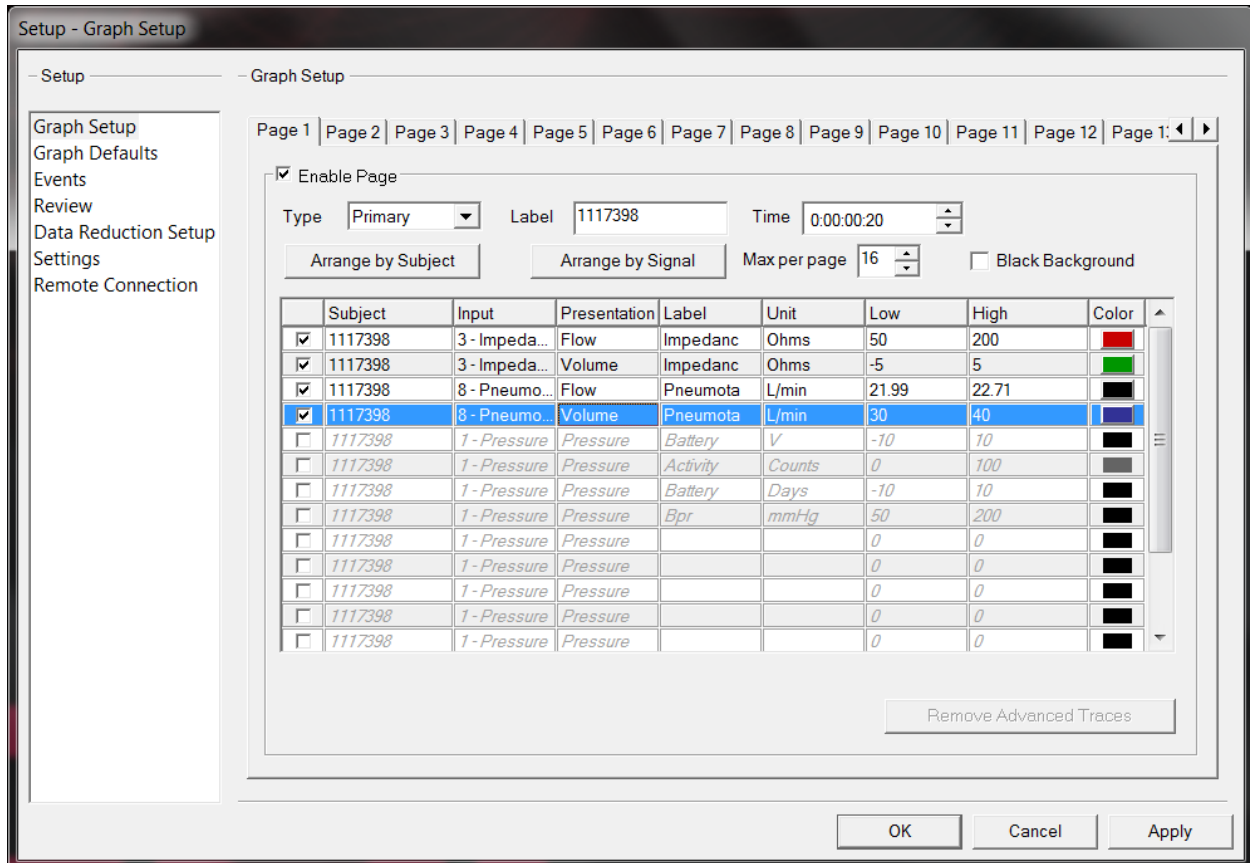
6. Begin acquisition.

    a. In the Sampling Control window select the play button for the desired subject to begin data collection.
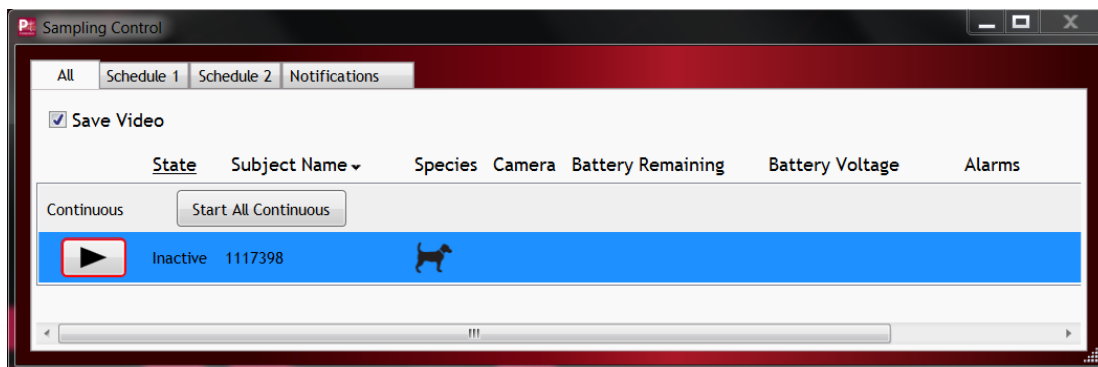
b. Ponemah will begin data collection and the graph page will begin to display incoming data.

c. The data collection for the calibration period may be collected for as long or short as desired; however, for calibration purposes a maximum data segment of 5 consecutive minutes may be used.

d. It is strongly recommended to only calibrate during periods when the impedance signal baseline is consistent and bad data marks are not present.

e. Prior to calibration it is recommended to acclimate the animals to the mask (dog) or helmet (primate) so that they are relaxed during the data collection. The data will preferably be with the animal in a posture representative of the posture which they will be in during a normal data collection.

7. Put on the mask (for dog) or helmet (for primate) and wait until the animal is relaxed and the data being collected is stable and relatively clean. Ideally, Ponemah will be identifying and triggering cycles for both the pneumotach channel and the impedance channel as in the example. If cycles are not identified the analysis can be adjusted later.
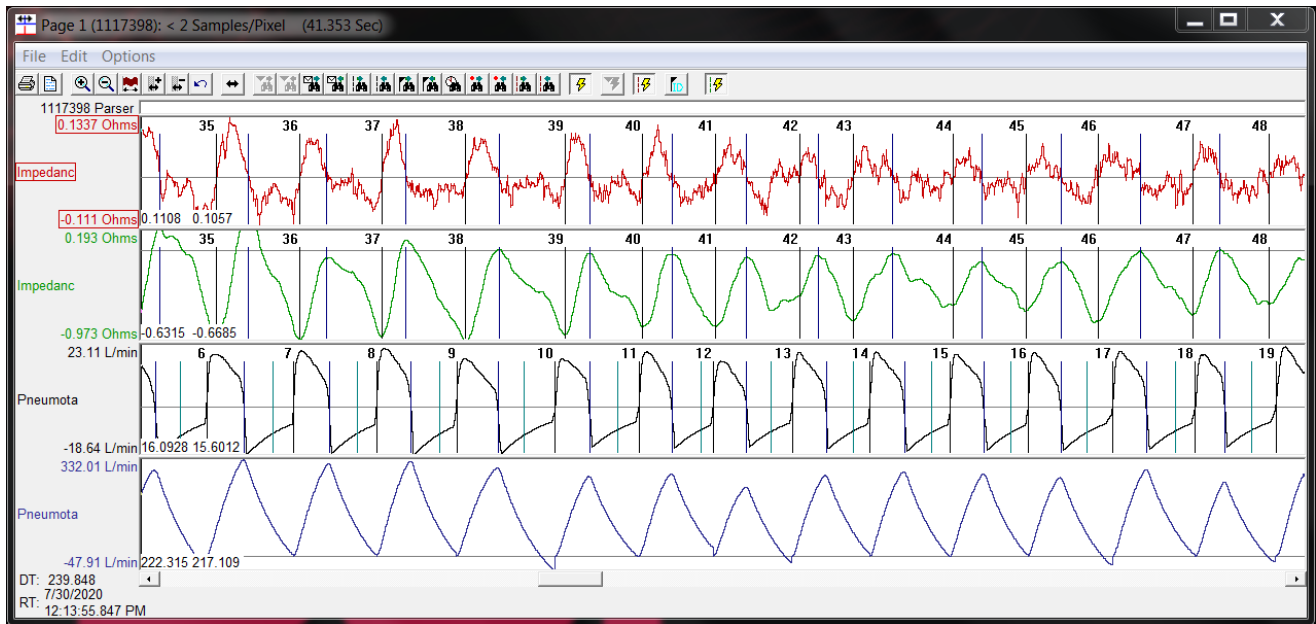

8. Data collection can be run as long as desired but should have **AT LEAST 50** good breaths within a 5-minute segment. When enough data has been collected, select the pause button in the Sampling Control to stop collection.

9. Calculate and apply calibrations in Review Mode.

f. From the main Ponemah window select Actions – Start Review. Choose the subject to load and select all channels and entire time range.

g. In the graph page right click on the PAF channel (pneumotach) and select Analyze. Verify cycles are triggering. If not, adjust settings as needed in Std Attrib.
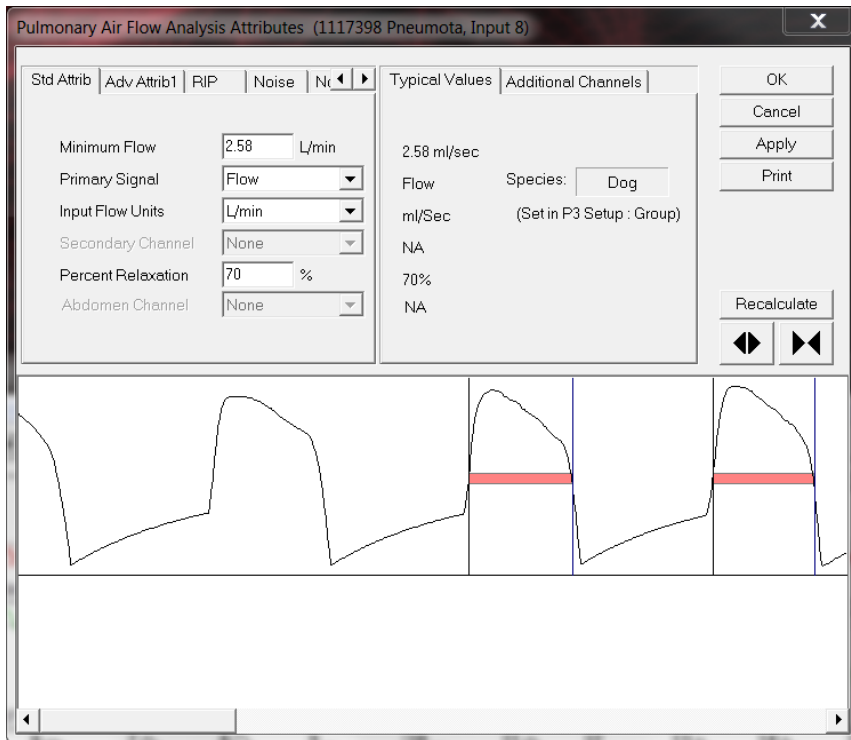
c. Observe the main graph page and verify that pneumotach and impedance signals are in sync and inspiration correlates with a positive shift in signal. If inspiration is not positive select the Adv Attrib1 tab and choose the Invert Input Signal box.

d. Select OK and reanalyze the entire channel.
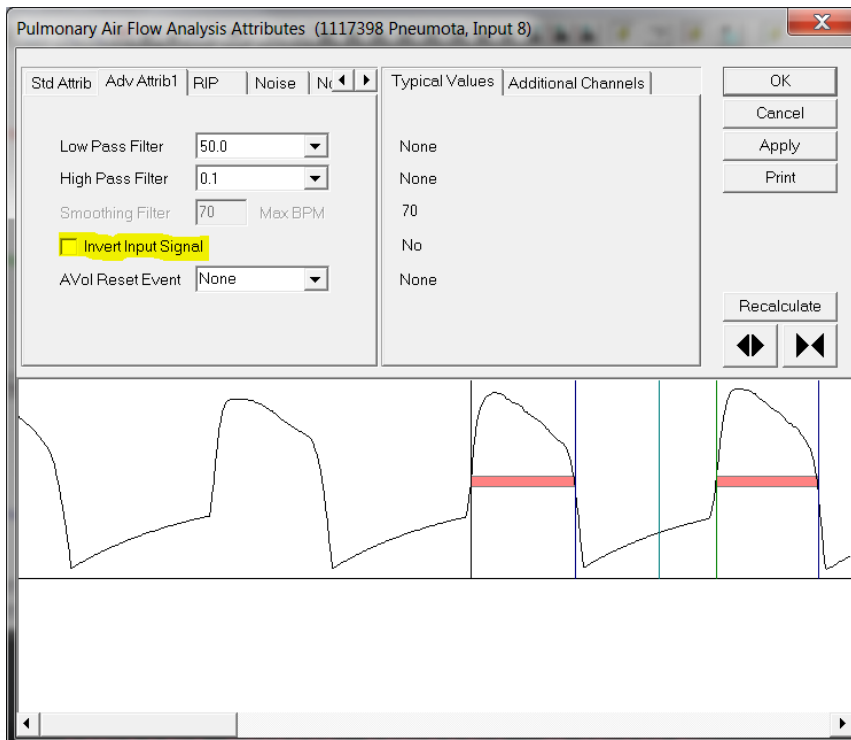
e. In the graph page right click on PVO channel (impedance) and select Analyze. Verify cycles are triggering. If not, adjust settings as needed in Std Attrib.

f. Select OK and reanalyze the entire channel.
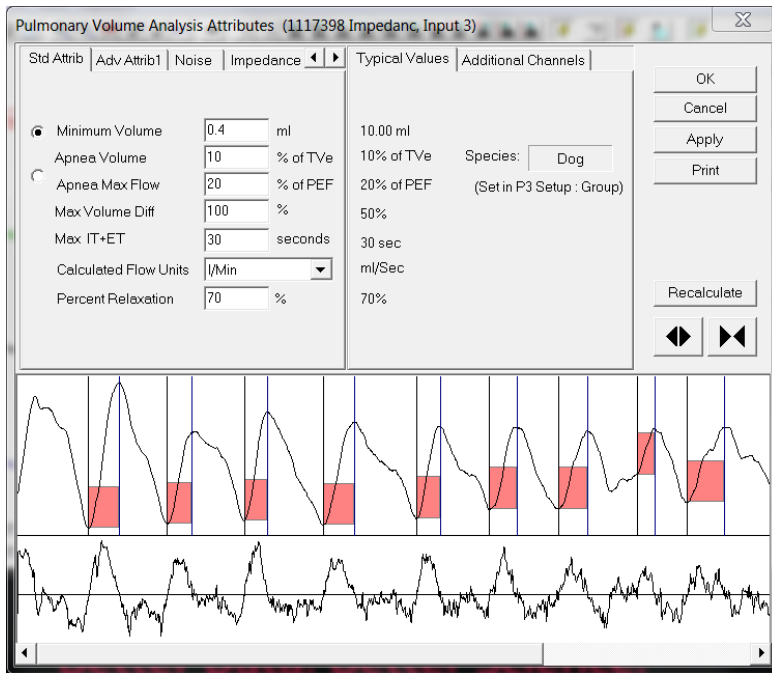
g. Go to Impedance tab in the PVO module, check the box Enable Impedance Calibration and select the pneumotach channel for calibration in the drop-down menu.

h. Select the Calibration.. button.
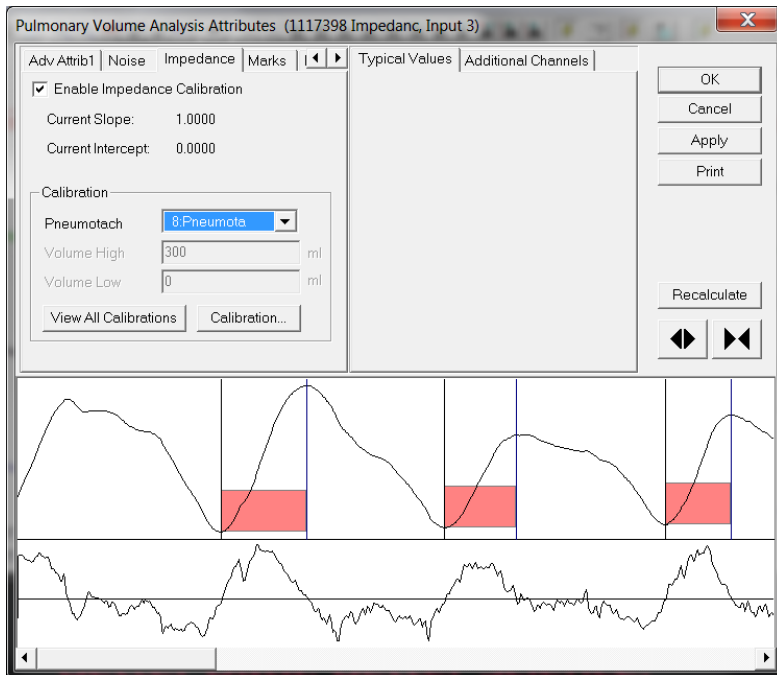
Note: The Fixed Volume entry is disabled when using the Pneumotach option.

i.   The Impedance Calibration Dialog will display up to a five-minute segment of data from the user selected area. The green bar located near the top of the dialog is the Calibration Segment Bar. The Calibration Segment Bar allows the user to select which breaths to calibrate versus the pneumotach signal. The bar can be shortened or elongated using the computer mouse. Multiple segments can be added to maximize the number of typical breaths used in the calibration. Additional segments are added by right clicking in the Calibration Segment Bar area.
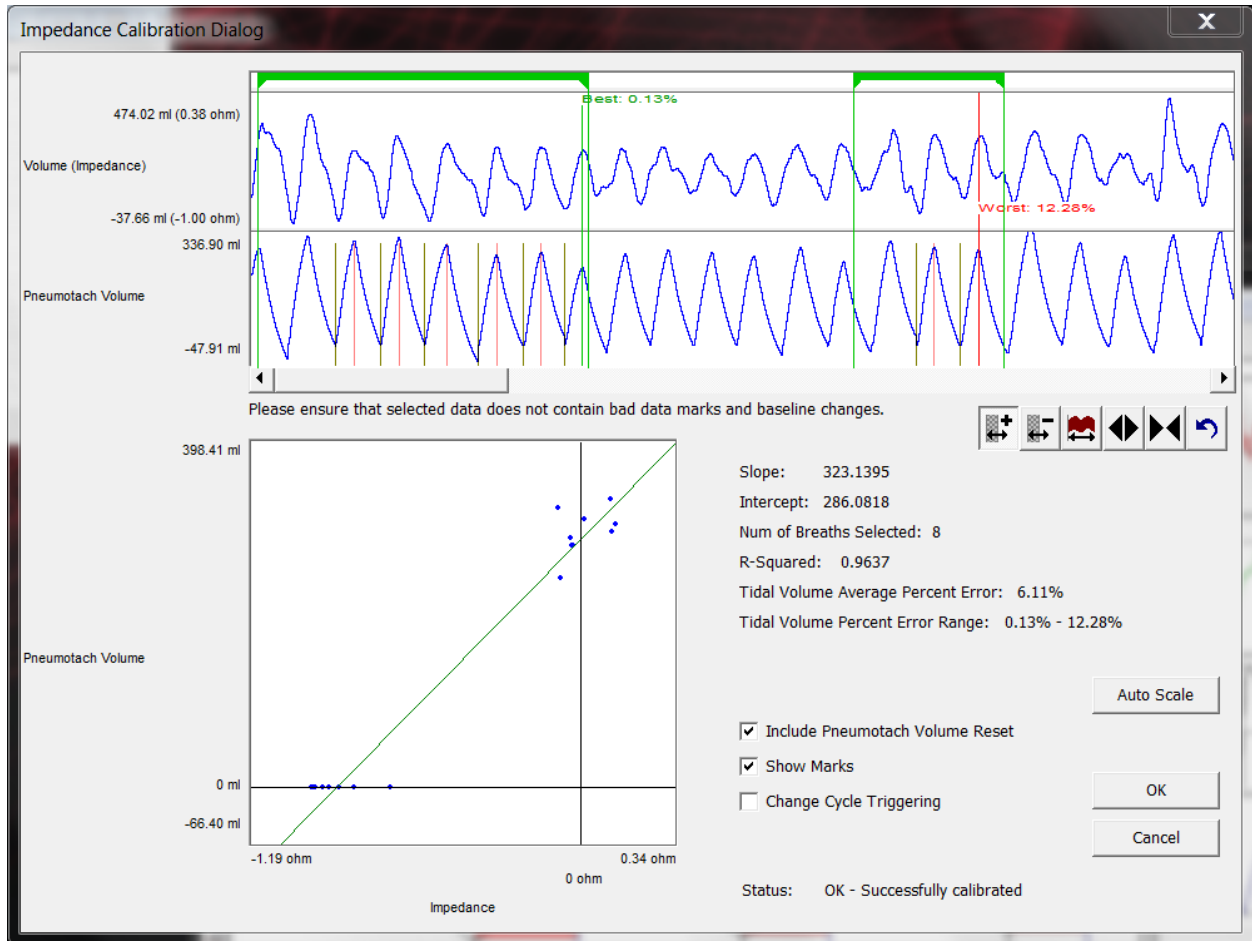
j.   After placing the Calibration Segment Bar(s) the slope and intercept will automatically be calculated. Also displayed are the Number of Breaths Selected (determined by the placement of the Calibration Segment Bar(s)); Number of Breaths Used in the calibration; the Average Percent Error [(Vtotal - VPneumo)/VPneumo] of the breaths used in the calibration and the Percent Error Range.

k.   It is best practice to find segments of data that are clean and that the worst % error is minimized.

l.   Once the error is minimized and the calibrations are acceptable, select the OK button.

     m. The calibration Slope and Intercept value from the Impedance Calibration dialog will be automatically entered.
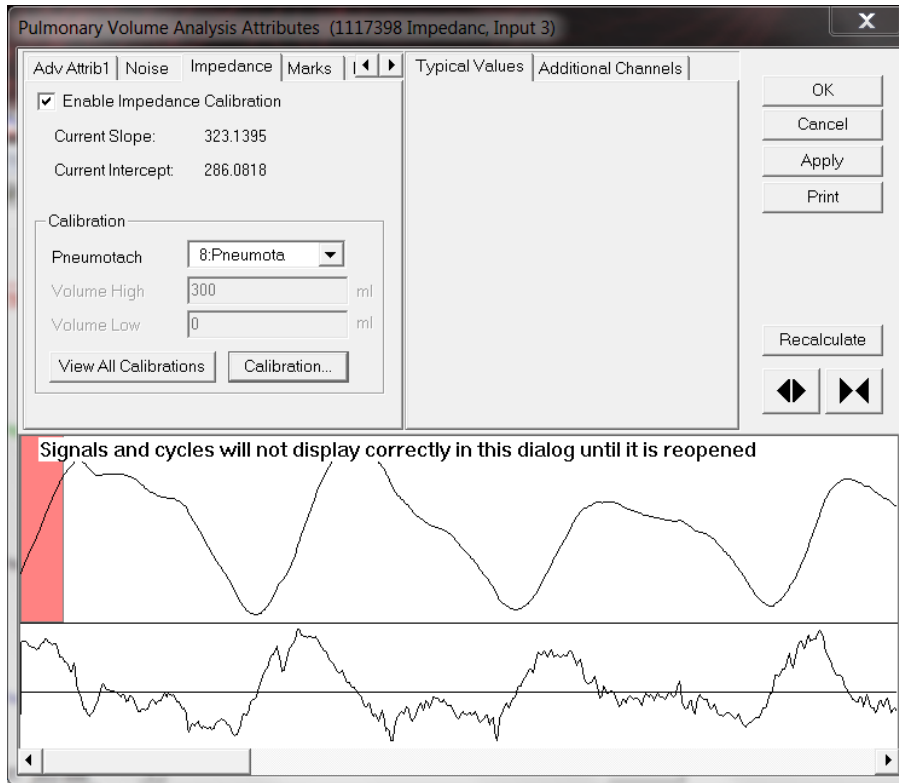
     n. Select OK and reanalyze the entire dataset with the new calibration applied. Graph scaling and analysis settings may need to be updated after the calibration is applied.

     o. The calibration will need to be completed for each L11R implant.

10. Considerations for future recordings.

     h. The calculated Slope and Intercept from the calibration session will be saved in the settings for each implant if data collection is resumed in the same Ponemah Experiment. However, if a new Experiment is created the calibration must be repeated or the slope and intercept from previous experiment can be copied and entered.

     i. The measured respiratory impedance for a subject can change over time as the subjects' size and weight changes. Calibration can be repeated as often as desired but should be done on a regular basis to ensure volume calculations are as accurate as possible.

APPENDIX

Filtering Considerations

-   Set the filtering by keeping in mind the respiration rate of the animal. Any filtering applied to the calibration sessions **MUST** also be consistently applied throughout the study. For example, if you use a 30 Hz low pass filter for the calibration session, a 30 Hz LPF must be applied on the study days the calibrations are used on.
-   Apply either a low pass filter **OR** a smoothing filter, but not both.

Channel/Waveform	Minimum Sample rate to apply Low/High Pass filter	Low Pass Filter	High Pass Filter	Smoothing filters
Systemic Blood Pressure	≥100 Hz	≥30 Hz	None	N/A
Left Ventricular Pressure	≥500 Hz	None	None	N/A
ECG	≥500 Hz	None	< 0.5 Hz	N/A
Respiration - JET with PAF module	≥50 Hz	≥10 Hz	<1.5 Hz	≥20
Respiration – L11R with PVO	≥50 Hz	≥10 Hz	None	≥20
Respiration - Pneumotach	≥50 Hz	≥30 Hz	<1 Hz	N/A

Table 1: Recommended Sample Rates and Filters to Apply