MouseOx® 3.0/2.0
Small Animal Vital Signs Monitor

User's Manual

# Table of Contents:

Introduction

MouseOx 2.0 and 3.0 are Windows® compatible software that provide configuration, monitoring, data acquisition and playback tools for use with STARR Life Science's MouseOx Plus products and accessories.

Standard Features

- Continuous noninvasive monitoring of vital signs:
    - Oxygen Saturation
    - Heart Rate
    - Pulse Distention
    - Breath Rate
    - Breath Distention
    - Temperature

- Configurable alarms for each parameter
- Specialized anesthesia monitoring alarms
- Cardiac PhotoPlethysmoGram (PPG) waveform (300 Hz)
    - Display and analog signal output (IR)
- Switch between multiple subjects and monitor summary data using the MouseOx Multiplexer
- Stream parameters to 3rd-party data acquisition systems using the Starr Link output module
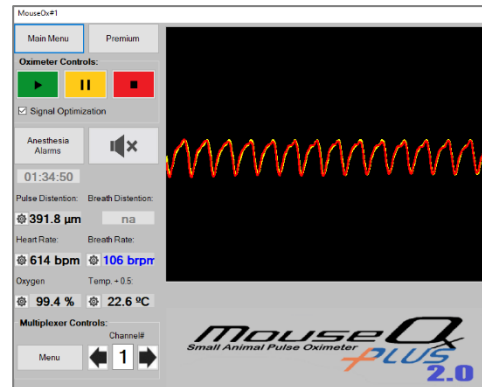
Premium Features (In addition to Standard Features)

- High speed data acquisition/recording (.tdms format)
    - Continuous "streaming" parametric data (15 Hz)
    - Continuous discrete data sampling (Snapshot) – user specified
    - Cardiac PhotoPlethysmogram Recording (300 Hz)
- Realtime display of all parameters
- Playback/Review of primary recorded data file
- Export all or parts of data files to ".tdms" or ".csv" formats for use with 3rd-party analysis software
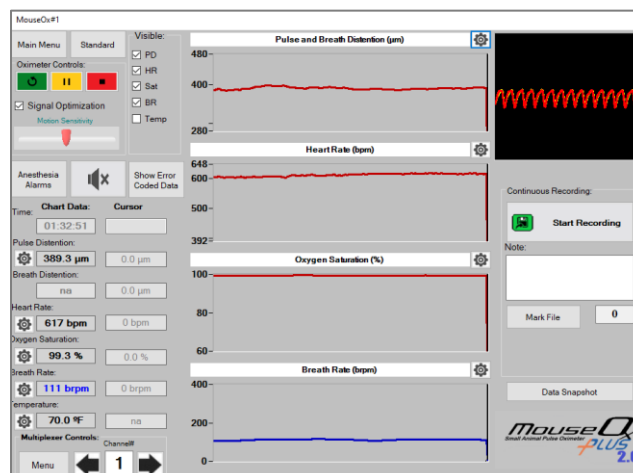
Conscious Software Module

Optional add-on that provides enhanced motion artifact rejection that maximizes the amount of valid data acquired in the presence of movement associated with conscious subjects. Accurate measurement of SpO2 using Pulse-Oximetry depends on the light path length remaining constant over the time period of each individual heartbeat. Excess anatomical movement can alter the path length and cause error. The Conscious/Awake algorithm anticipates motion artifact allowing it to be more selective thus minimizing data lost during anatomical movement. Motion Sensitivity can be adjusted to best match experimental conditions. **This software module is required for monitoring awake subjects.**

To purchase additional Software License Keys, contact Starr Life Sciences

System Requirements

Minimum Computer Requirements for 2.0

Processor - Pentium®-class processor, 1 GHz or higher; Intel i3 or better

Operating System - Windows® 8.1, 10 & 11
- Currently backward compatible with Windows XP, Vista and 7
  - Subject to change without notice
- MouseOx can run on Apple® computers with the use of **PC emulation software**

Computer Ports
- MouseOx - 1X USB 2.0/3.0
- Multiplexer - 1X USB 2.0/3.0
- Starr Link - 1X USB 2.0/3.0
- Recommended – Powered USB hub for multiple accessories

RAM - Minimum 4 GB RAM, 8GB or higher recommended

Hard Drive Space - 5 MB for software installation (does not include data files)

Minimum Screen Resolution - 1024 by 768 pixels

Additional Computer Recommendations for 3.0

MouseOx 3.0 software is essentially 6 versions of MouseOx 2.0 running simultaneously on a computer. This software has a larger computer processing requirement. All screen sizing and adjustments should be made before monitoring is started.

Processor - Pentium®-class processor, 1 GHz or higher; Intel i5 or better

Computer Ports
- All MouseOx systems must be connected to the computer through a powered USB hub
- One optional Starr Link - 1X USB 2.0/3.0

RAM - Minimum 16GB or higher recommended

ONLY USE POWER SUPPLIES PROVIDED BY STARR LIFE SCIENCES

Device Operating Voltage - 12 VAC

Operating Wall Voltage:

- 100/120 VAC @ 50-60 Hz
- 230/240 VAC @ 50-60 Hz

Operating Current:

- 200 mA - MouseOx® Plus
- 200 mA - Multiplexer™

USB Current Source Requirement:

- 85 mA - MouseOx® Plus
- 40 mA - Multiplexer™
- 180 mA – STARR-Link™

Recommended:

- Plug all equipment into an Uninterruptible Power Supply (UPS)
- Operate laptop computers with power supply attached
- Attach MouseOx and accessories to powered USB hub

Software Installation

Download 2.0

- Download software from **https://www.starrlifesciences.com/resource/mouseox-software-download/**
  - o *Installation media available upon request (CD ROM, USB Drive)*
- Select link to MouseOx 2.0 (Fig 3-1)
- Click "Save File" (Fig 3-2) – File is saved to default Windows® download location on your computer

- Run/Double Click "mouseox-plus-v2.exe" from download location – Figure 3-3 should appear

Perform steps 1-5 and follow the on-screen instructions

Fig 3-3

Activate Software

After computer restarts:

1) Connect MouseOx controller to PC using included USB cable
    a) Wait a few seconds to allow Windows to recognize MouseOx

Fig 3-4

Starr AC/AC
Power Supply

Standard
USB Cable

2) Start MouseOx 2.0 software: Windows <u>Start</u> button → <u>Starr Life Sciences</u>→ <u>MOX2.0</u>
    a) The MouseOx Plus Main Menu should appear. (Figure 3-5)

Fig 3-5

MouseOx Detected

    b) "MouseOx Detected" should appear in the upper left corner of the screen
        i) If "MouseOx <u>not </u>detected" is displayed see Appendix A – Troubleshooting, Section 3

3) Click <u>Configure</u> - Figure 3-6 should appear

Fig 3-6
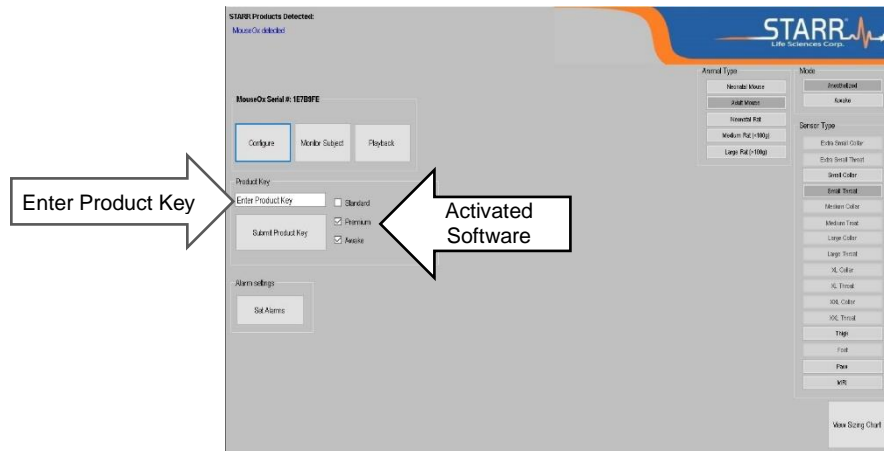
a) Enter your Software License Key (from Starr Life Sciences)
b) Click <u>Submit Product Key</u>
   i) Checks should appear next to activated software modules

Download 3.0/2.0

Note: The Mouse Ox 3.0 software installer will also include the latest 2.0 software. The 2.0 software is just automatically downloaded. This allows the user to use the simultaneous product with 2.0 software if a single subject id desired to be analized.

- Download software from **https://www.starrlifesciences.com/resource/mouseox-software-download/**
  - o *Installation media available upon request (CD ROM, USB Drive)*
- Select link to MouseOx 3.0 (Fig 3-7)
- Click "Save File" (Fig 3-8) – File is saved to default Windows® download location on your computer

MOUSEOX SOFTWARE DOWNLOAD   Fig 3-7

MouseOx and MouseOx Plus Software

Step 1: Click on appropriate link to download Installer.(Program can be saved to a USB drive and transferred to multiple computers)

» MouseOx Plus Rev 3.0 (Simultaneous product key an up to 6 MouseOx plus systems required)	This installer installs both MouseOx 3.0 and MouseOx 2.0 software. MouseOx 3.0 is for use of multiple MouseOx Plus systems used in simultaneous operation. A simultaneous product key is required in order to access 3.0 software. (Second Generation MouseOx, Serial # SLS-MP-xxxxx)
» MouseOx Plus Rev 2.0 (Single MouseOx plus system required)	This installer installs the MouseOx 2.0 software. This software is a modernized version of MouseOx 1.6. MouseOx 2.0 contains a playback feature for post data collection analysis. (Second Generation MouseOx, Serial # SLS-MP-xxxxx)
» MouseOx Plus Rev 1.6 (Single MouseOx plus system required)	This installer installs the MouseOx Plus 1.6 software. This software has improved resolution and more awake animal features and abilities. (Second Generation MouseOx, Serial # SLS-MP-xxxxx)
» MouseOx Revision 6.3.13 (Single Original MouseOx Legacy system required)	This installer installs the Original MouseOx Legacy software. This installer was designed for Windows XP. To run this software on newer versions of Windows a newer version of InstaCal is required. See Miscellaneous Software section bellow. (First Generation MouseOx, Serial # SLS-MO-xxxxx)

Fig3- 8

Opening MouseOx-Installer.exe
You have chosen to open:
MouseOx-Installer.exe
    which is: exe File (115 MB)
    from: https://www.starrlifesciences.com
Would you like to save this file?
                                        Save File   Cancel

- Run/Double Click "mouseox-plus-v3.exe" from download location – Figure 3-3 should appear
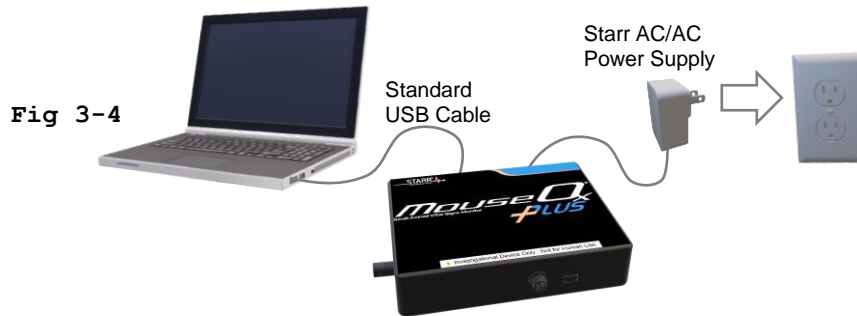
Perform steps 1-5 and follow the on-screen instructions
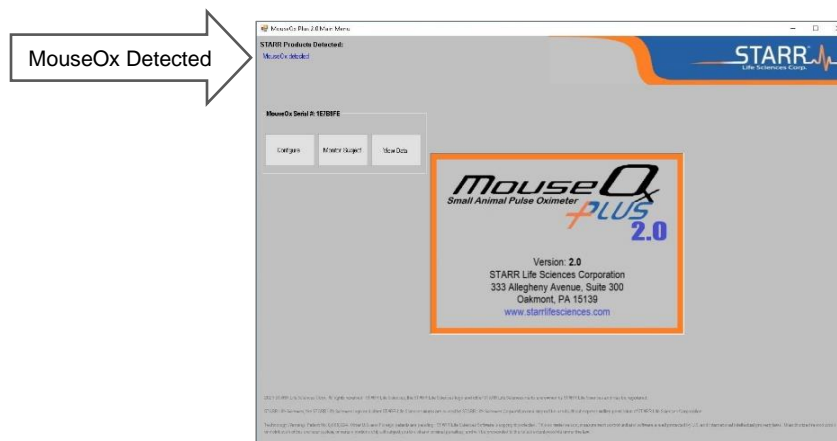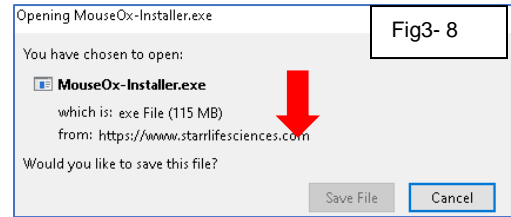
Fig 3-9

Activate Software

After computer restarts:

4) Connect MouseOx plus systems that you want to use in simultaneous operation to the PC or a powered USB hub. Another option is to only have MouseOx Plus with simultaneous key code controller to PC or a powered USB hub using included USB cable,
   a) Wait a few seconds to allow Windows to recognize MouseOx

Fig 3-10

Starr AC/AC Power Supply

Standard USB Cable
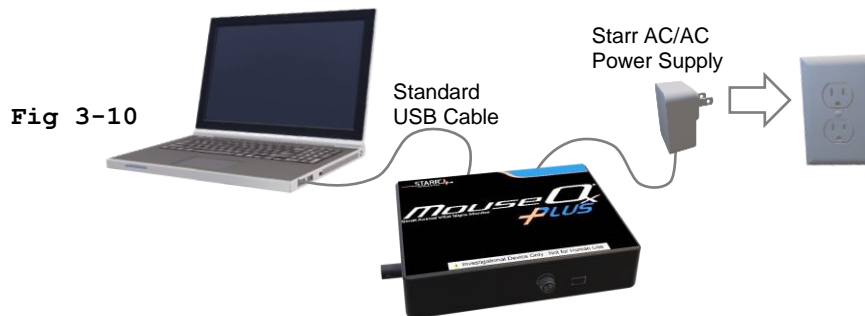
5) Start MouseOx 3.0 software: Windows <u>Start</u> button → <u>Starr Life Sciences</u>→ <u>MOX3.0</u>
   a) The MouseOx Plus Main Menu should appear. (Figure 3-11)

Fig 3-11
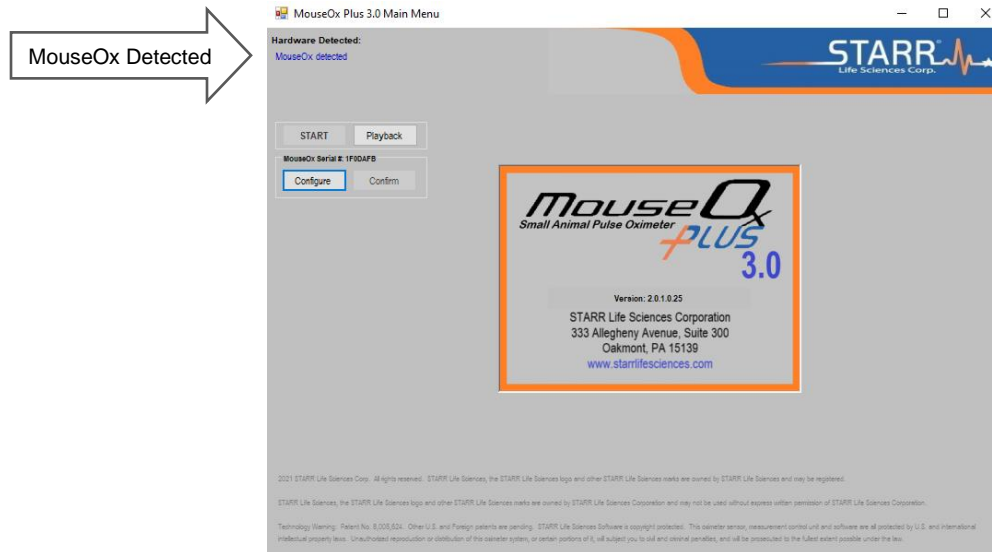
MouseOx Detected

   b) "MouseOx Detected" should appear in the upper left corner of the screen
      i) If "MouseOx <u>not </u>detected" is displayed see Appendix A – Troubleshooting, Section 3

6) Click Configure - Figure 3-6 should appear

Fig 3-12
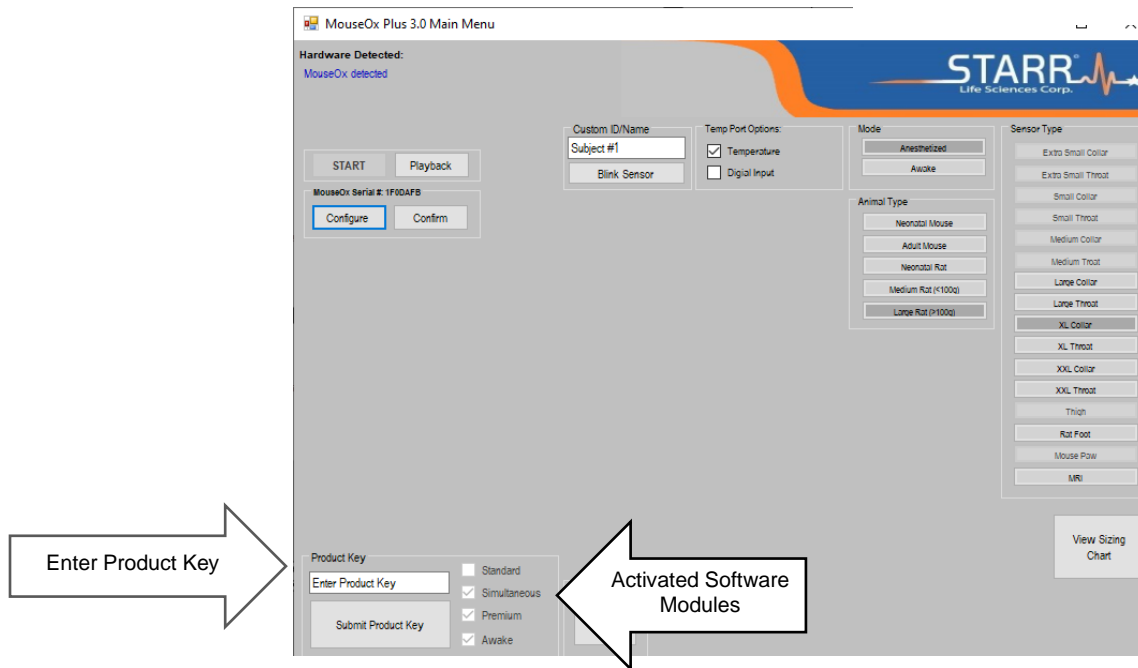
a) Enter your **Simultaneous Software License Key** (from Starr Life Sciences)
b) Click Submit Product Key
   i) Checks should appear next to activated software modules
c) If any other MouseOx plus systems are detected by the software they will become detected by the software. You can always close this software and connect any addition MouseOx systems to the computer through a powered USB Hub. As long as the Simultaneous MouseOx is detected by the software, all other detected MouseOx systems will be detected and unlocked.

Computer Settings

To avoid disruption of data collection

- Disable Windows Sleep, Standby and Hibernate Modes on your PC
- Disable automatic Windows time changes (Daylight Savings, time zone) and set system time manually.

Running the Software

Configure Subject

Click <u>Configure</u> on the MouseOx Plus Main Menu (Fig 4-1 should appear)

Make Selections
- You must select a Mode, Animal Type and Sensor type.
- Animal Type and Mode selections will determine which sensor choices are available
- Click <u>View Sizing Chart</u> for guidance regarding animal size
- After selections are made click <u>Monitor Subject</u>

Fig 4-1

Mode
- **Awake** (If Conscious Software Module is active)
  - Awake Mode assumes lots of motion. The software will assume rapid changes in the signal are caused by motion artifact. Rapid changes will result in data rejection and delayed signal optimization until the rate of apparent physical movement slows.
- **Anesthetized**
  - Anesthetized Mode assumes limited motion
  - Rapid changes of the signal will be assumed to be caused by rapid changes in physiology, not by motion (e.g. reactions to experimental interventions). This can be used for conscious, active animals but will allow more motion artifact distortion of signals.
  - Motion is more likely to trigger signal optimization

Animal type
- Sets initial signal levels and tunes signal optimization appropriately for the size of animal selected

Sensor type

There are 16 variations of the pulse-oximetry sensor. The various sensors are designed to accommodate different measurement sites and a wide range of animal sizes. See Sizing Chart on Configuration Screen

- **Collar** – Designed to be placed dorsally around the neck of the subject. Intended for use with conscious ambulatory subjects or prone anesthetized subjects.
- **Throat** – Designed to be placed ventrally around neck of the subject. Intended for use with supine anesthetized subjects.
- **Mouse Thigh** – Designed specifically for placement on thigh/femur of an anesthetized mouse.
  Note: Has been used successfully to measure SpO2 across the head of neonatal mice and the base of the tail of large anesthetized rats

UM-MOX 3.0 / 2.0 Rev 2.0
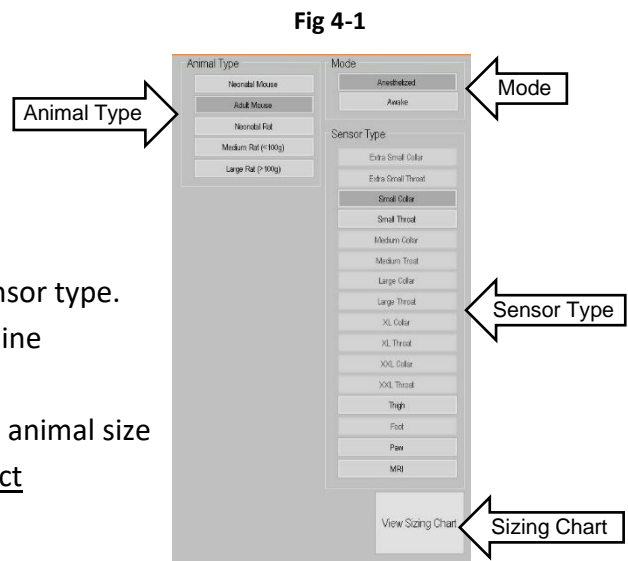
- **Rat Foot –** Recommended for placement on the foot of an anesthetized rat.

  Note: Has been successfully used on the feet of other small animals, rabbit ears and the head of neonatal mice.

- **Mouse Paw –** Recommended for placement on the paw of an anesthetized mouse.

  Note: Has been successfully used on the tail of anesthetized mice.

- **MRI –** Sensor has 5'-7' of fiber optic cable allowing the sensor to be placed on the subject within the body coil/cage without causing interference.

Note: Standard MouseOx sensors are often used successfully on subjects in an MRI as long as the sensor itself is not located within the body coil/cage

Note: MouseOx pulse-oximetry sensors have been used successfully on many different anatomical locations on many different animals (pulse>90 BPM). E.g., neck, wrist, foot, tail, ear; marmosets, rabbits, guinea pigs, chickens, hamsters, tree shrews, degus, ferrets, squirrels, chinchillas, Canada geese, gerbils, Reese's monkeys, armadillos.

Monitor Subject(s)

Make sure the MouseOx power supply is plugged in and the sensor is properly attached to the subject.

Fig 4-2
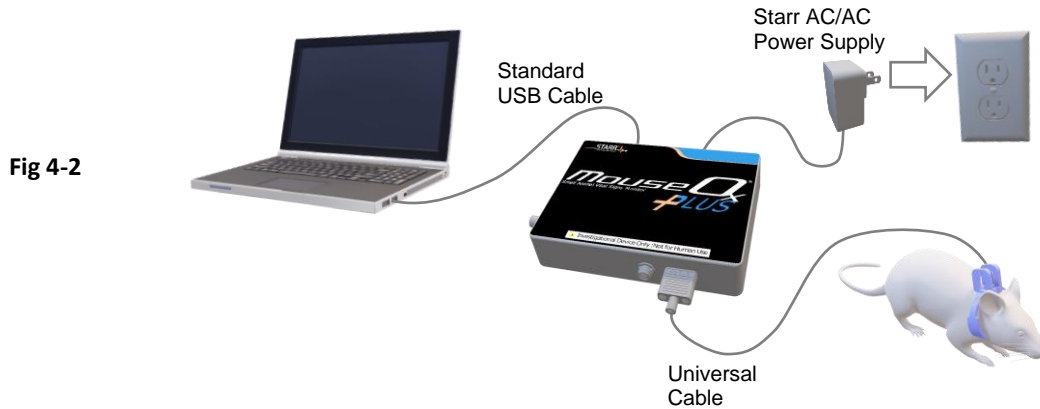
Click <u>Monitor Subject</u> on the Main Menu

Depending on your software license either Fig 4-3 or 4-4 will appear

- Standard Software Figure 4-3
- Premium Software figure 4-4

Fig 4-3   **Fig 4-4**
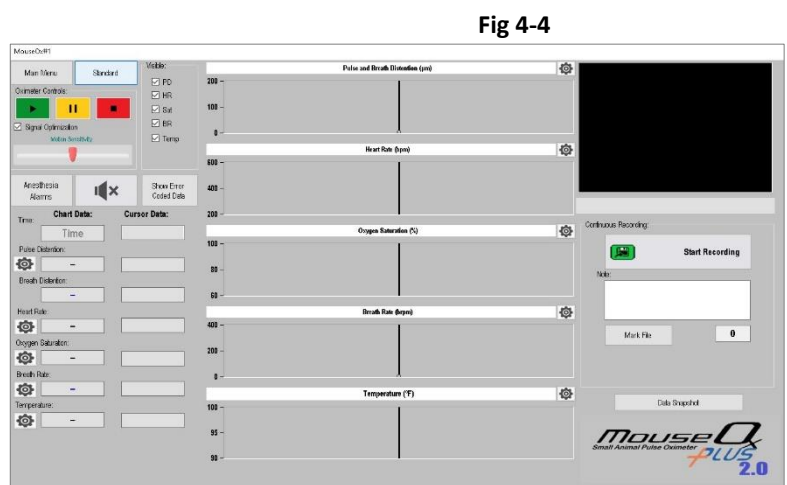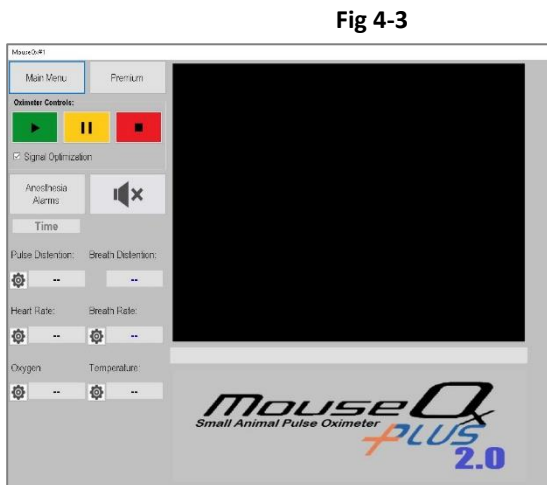
<u>Standard/Premium</u> button – Toggles between Standard/Summary screen and Premium/Detail screen

<u>Main Menu</u> – takes you to Main Menu/Configure screen

Oximeter Controls

Fig 4-5

PhotoPlethysmoGram (PPG)

Oximeter Controls

Fig 4-6

Trend Line Graphs

Data Cursor *Click/Drag*

Click ▶(Start Monitoring)

- The red LED on the MouseOx sensor should turn on
- A waveform should appear in the PhotoPlethysmoGram window (Standard Fig 4-5, Premium Fig 4-6)
- The message "Signal Optimization" will appear under the window until optimum signal is achieved
- Data fields and trend line graphs will display no data or "greyed" values until Signal Optimization is finished
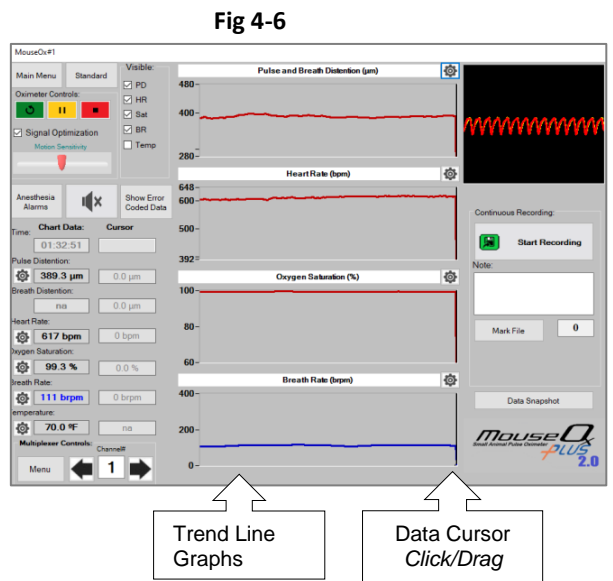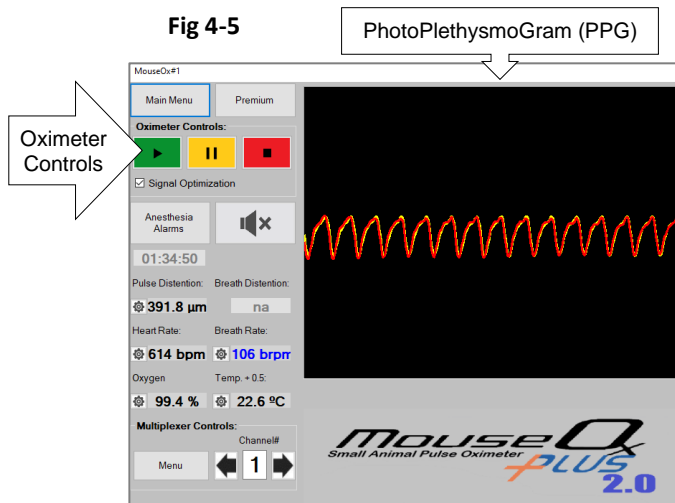- If a signal is not acquired within 2 minutes adjust the sensor placement and click Reset ↺

Click ▌▌(Pause)

- Stops data acquisition but doesn't reset oximeter control settings.
- Can be useful to pause monitoring before adjusting sensor placement.
- Click ▶ to resume data acquisition

Click ↺ (Reset)

- Resets controller without disrupting data acquisition
- Resets electronics/software to initial values determined by initial subject configuration.

Click ■(Stop)

- Stops data acquisition and resets controller settings
- If you click ↺**(Reset)** Signal Optimization will resume

Signal Optimization - ON/OFF Check box

Recommended setting = On. There are circumstances when it is useful to turn it off (See Appendix D for more detail)

Show Error Coded Data - ON/OFF Check box (Premium Only)

Determines whether error coded data is displayed on Trend Line Graphs

Motion Sensitivity (Conscious Software Module)

Moving the slider to the right will increase motion sensitivity and maximize motion artifact rejection. If you have difficulty getting data from a conscious moving animal, move the slider to the left to relax rejection criteria.

Anesthesia Alarms

Opens settings for specialized anesthesia monitoring alarms (See Appendix B for more detail)

◀◦/◀)) (Silent/Alarm) – Turn audible alarm On/Off

Parameter Alarms – Click ⚙ next to each parameter to set alarm conditions

Trend Line Graphs (Premium Only) -Displays approximately 16 seconds of data for each parameter.

- Pulse Distention – Pulse Perfusion expressed as measurement of distance of pulsatile deflection (μm)
- Breath Distention – Calculated measurement of deflection of capillary bed due to work of breathing
  - Enabled in Anesthetized Mode only
- Heart Rate (bpm)
- Oxygen Saturation SpO2 (%)   **Fig 4-7**
- Breath Rate (brpm)

Visible:
☑ PD
☑ HR
☑ Sat
☑ BR
☑ Temp
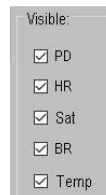
Visible (Premium Only) –Select which Trend Line Graphs are visible (Fig 4-7)

Data Cursor (Premium Only) – As you click/drag the Data Cursor in the Trend Line displays, values will be displayed in the Cursor Data fields (Fig 4-6)

UM-MOX 3.0 / 2.0 Rev 2.0

Recording Data (Premium Only)

Continuous Recording – Record continuous streaming data

- While MouseOx is actively monitoring a subject Click (Start Recording) - Fig 4-8 should appear

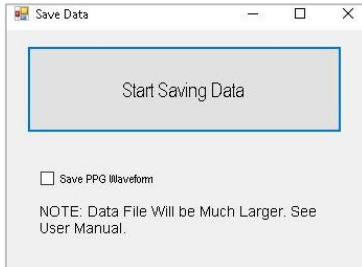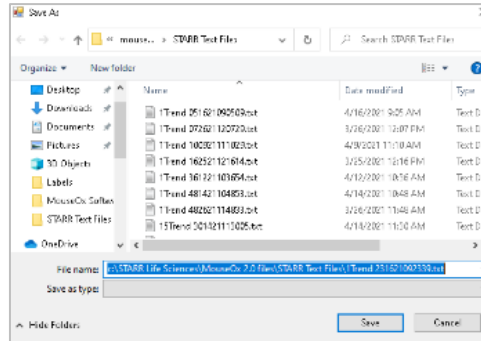**Fig 4-8**

Fig 4-9

- Data from the Monitor Subject Screen will be saved as a "MouseOx Primary Data File" to the hard drive @ 15 Hz in ".tdms" format.
- Default file name is a Windows date/time code with format mmddyyhhmmss. You can change the name but you must keep the .tdms extension.
- **Save PPG Waveform** – select to record the PPG waveform @ 300Hz
- File size
  - o Without PPG waveform ~ 150k/min, 9MB/hr, 216 MB/day
  - o With PPG waveform ~300k/min, 18MB/hr, 432 MB/day

Notes:

- *Currently MouseOx Playback can only open a "Primary MouseOx Data File.tdms"*
- *If you click Pause while recording, the Elapsed Time in the data file will be incorrect. The Computer Clock data will still be correct*
- *You can open the file using MouseOx Playback or Microsoft Excel with the TDM Importer Add-In from Measurement Computing*
- *Parametric data is recorded at 15 Hz, PPG waveform is recorded at 300 Hz*

Note/File Marker (Premium Only)

While MouseOx is recording data you can insert a File Marker/Note into the data file at any time. These File Markers/Notes are saved in the Primary Data File.

Fig 4-10

- Optional - Enter text into "Note" field (Fig 4-10)
- Click Mark File
  - o File Marker Index is incremented
  - o File Marker Index and Note text are inserted into Primary Data File
  - o Vertical line placed on Oxygen Saturation trend graph
  - o Note field cleared
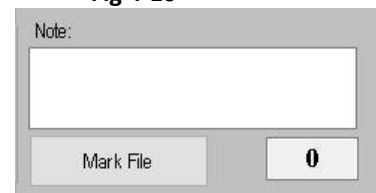
  Note: Carriage returns in the Note field can cause formatting issues when opening data files

  Note: After Mark File has been used once the keyboard space-bar can be used to trigger a file marker

Schedule Recording (Premium Only)

Schedule Recording is a pop-up menu that can set up a run time off time scenario. for example, if data needs to be collected once an hour the system can turn on for a few minutes every hour then shut off until the next cycle is ready to start again. The intended use is for very long-term studies so that the system doesn't have to create data files that are just too large. This feature is only available if continuous recording is active.
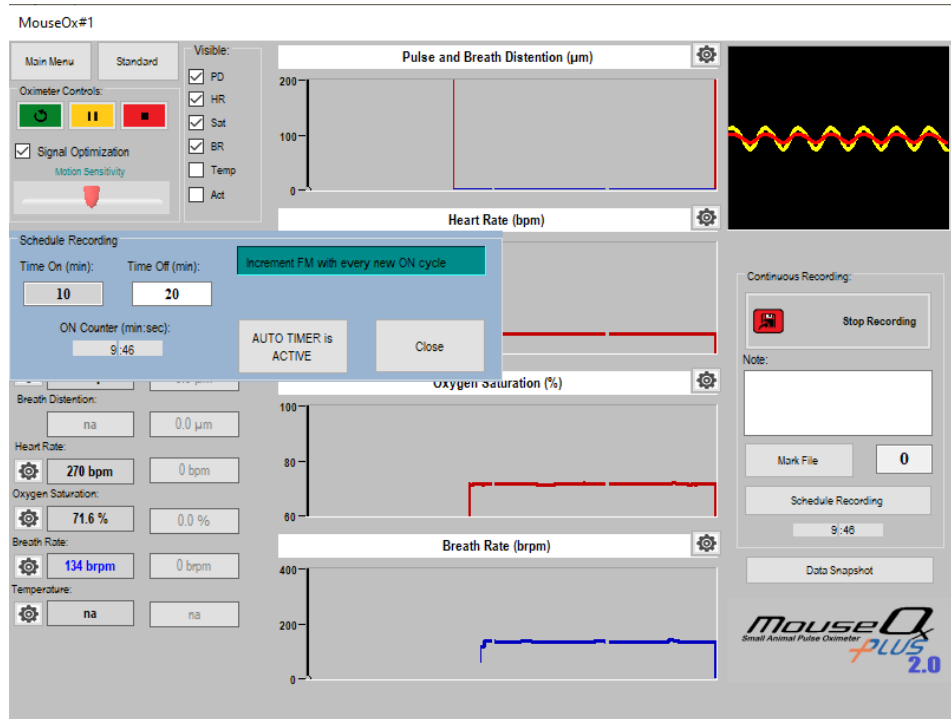
- Time On (min): - Key in the desired time for the system to be active and powered on.
- Time Off (min): - Key in the desired time for the system to be inactive and powered off.
- Counter (min:sec): -This is a countdown timer to indicate time left until the next state.
- Increment FM with every On Cycle – This will increment the FM (file marker) every time the system turns on. This will be useful for analyzing the data so the different points of time can be identified.

Data Snapshot (Premium Only)

A Data Snapshot is a set of discrete values for each parameter obtained by averaging valid data over a specified period. This is contrasted with "Continuous Recording" which acquires all parameters continuously at 15 Hz.

Note: Data Snapshots can be triggered manually or automatically at a recurring interval.

Note: Data Snapshot runs independently of Monitoring and/or Continuous Recording

- Click Data Snapshot - Fig 4-11 should appear

Fig 4-11
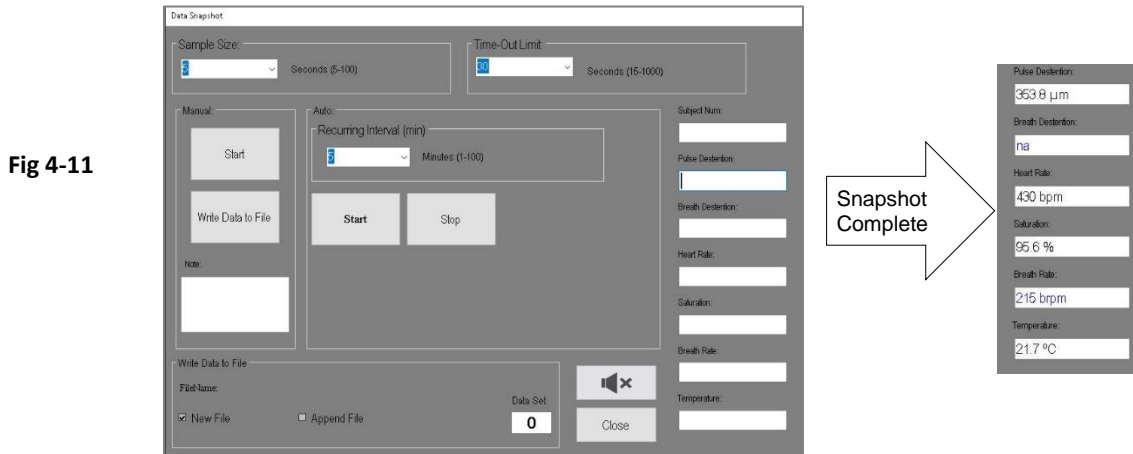
- Manual Snapshot
  - o Enter a value for Sample Size in seconds
    - ▪ Error coded data will be omitted and not count towards the cumulative sample time
  - o Enter a value for Time-Out Limit in seconds
    - ▪ If Sample Size can't be accumulated for a parameter within the Time-Out Limit the Snapshot terminates for that parameter
    - ▪ Excessive error codes can cause frequent Snapshot termination which indicates a noisy, potentially low-quality signal
  - o Click Start
    - ▪ The cumulative average will appear grey in each field until the valid sampling criteria has been met.
    - ▪ The final value will be displayed in black/blue
  - o Note - Optional - text in the Note field will be written to file with Snapshot data

- o Click <u>Write Data to File</u>
  - If writing to file for the first time or the "New File" box is selected Fig 4-12 should appear

Fig 4-12
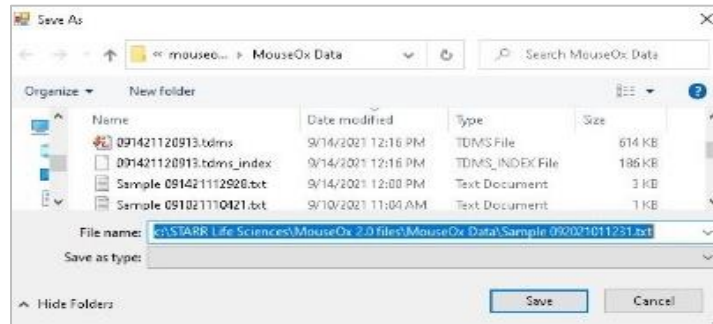
  - The default filename contains the prefix "Snapshot" and the Windows Date/Time code (MMDDYYhhmmss)
  - You can change the name but must keep ".csv" file extension
  - Subsequent Snapshot data will be appended to the same file unless you select "New File"
- Automatic Snapshot - same as Manual except:
  - o Enter a value for Recurring Interval in minutes
    - This is the time between Data Snapshots
  - o Click <u>Start</u>
    - "Recurring Snapshot is Active" message is displayed
    - If you enter a new value for Sample Size while Recuring Snapshot is active the new setting will take effect instantly.
    - If you change the Sample Interval while Recurring Snapshot is active you must click <u>Stop</u>/<u>Start</u> for the setting to take effect.
    - In order to start a new file, you must click <u>Stop</u>, check the "New File" Box then Click <u>Start</u>
    - While Recurring Snapshot is active you can click <u>Stop/Start</u> at any time to initiate a new sample. The Sample Interval will resume from the new start point.
- Click <u>Close</u>
  - o Returns to Monitor Subject screen
  - o Recurring Snapshot continues to run until you click the Auto <u>Stop</u> button on the Data Snapshot screen
  - o Recurring Snapshot can run concurrently with Continuous Recording

Fig 5-1

Viewing Data

Open Data File

From the Main Menu Click Playback – Fig 4-13 should appear

Click Open File

Select the file to open from the Windows dialog Box
and click Open *(Must be a MouseOx Primary Data File)*

Data should appear in the Graphs, Notes and
Time fields – Fig 5-2

Fig 5-2

View

Visible

Select the check box next to each parameter to view/hide

Compression (X-Axis)

Max = 100% (view entire file)
Min = 0%

Cursor

Click and drag the Data Cursor (Fig 5-2) on any strip chart.

Computer Time: displays the time of day recorded from the computer clock at the time of recording

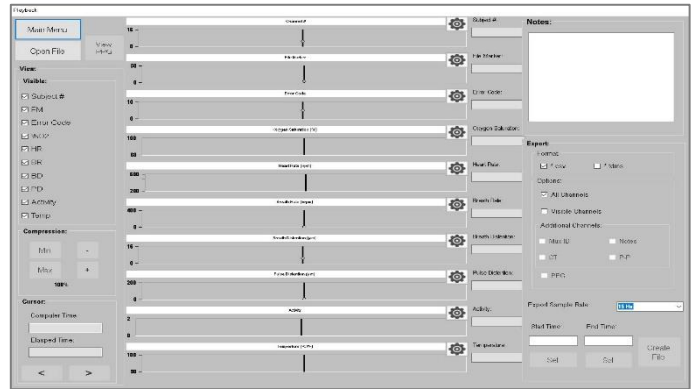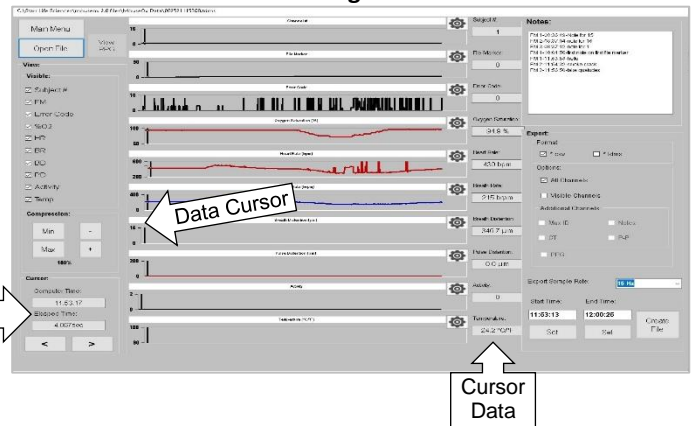Elapsed Time: Displays elapsed time in seconds from the beginning of the file. Start = 0.0 sec

Click View PPG

If PPG waveform is present in data file Fig 5-3 should appear

Notes

Displays any Notes that were entered during data acquisition

Fig 5-3

Export

Export all or part of the current data file as ".csv" or ". tdms" format
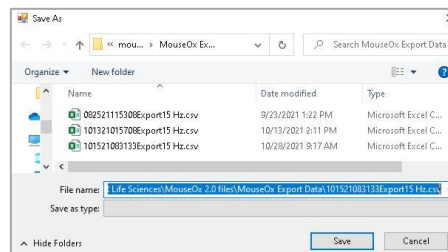
- **Format**
  - Select .csv or. tdms
    - Csv = comma separated values. For use with spread sheet software
- **Options**
  - All Channels
    - Exported file will contain all data channels and can be opened in MouseOx Playback
  - Visible Channels
    - Only selected/Visible data channels on the Playback screen will be exported
  - Additional Channels
    - ID – Custom subject description (Multiplexer)
    - Notes – Entered during initial data acquisition
    - CT – Computer Time/Clock
    - P-P – Cardiac Peak-to-Peak Interval
  - PPG – Unfiltered cardiac PhotoPlethysmoGram waveform (if recorded in original data file)
    -
- **Export Sample Rate**
  - Select 1Hz or 5Hz to export compressed parametric data. Compressed data is omitted.

    Note: MouseOx Primary Data files are recorded at 15Hz/parametric data, 300Hz PPG.

- **Start Time**
  - Click and drag the Data Cursor to the desired starting point and click Set
- **End Time**
  - Click and drag the Data Cursor to the desired end point and click Set
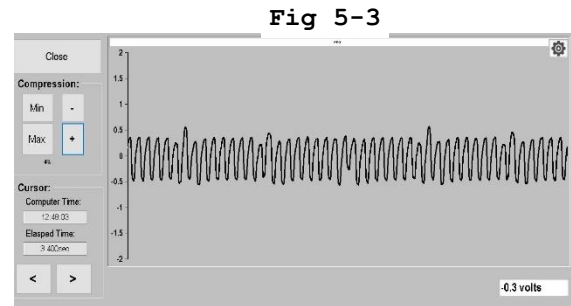
Click Create File – Fig 5-4 should appear

Fig 5-4

The default file name contains a Windows date/time code and MouseOx format code. You can change the file name but do not change the tdms/csv extension.

Default save location is C:/Starr Life Sciences/MouseOx 2.0 Files/MouseOx Export Data

Note: National Instruments provides an "add-in" for Microsoft Excel and Apache Open Office that allows TDMS files to be imported directly.

Temperature Probe

The MouseOx Plus Temperature Probe can be used to measure the core body temperature of a small animal or to monitor ambient temperature during experimental procedures. The sensor probe is made of implant grade titanium and is MRI compatible.

3 standard lengths are available (2, 4 & 7 meter). Contact Starr Life Sciences for custom lengths
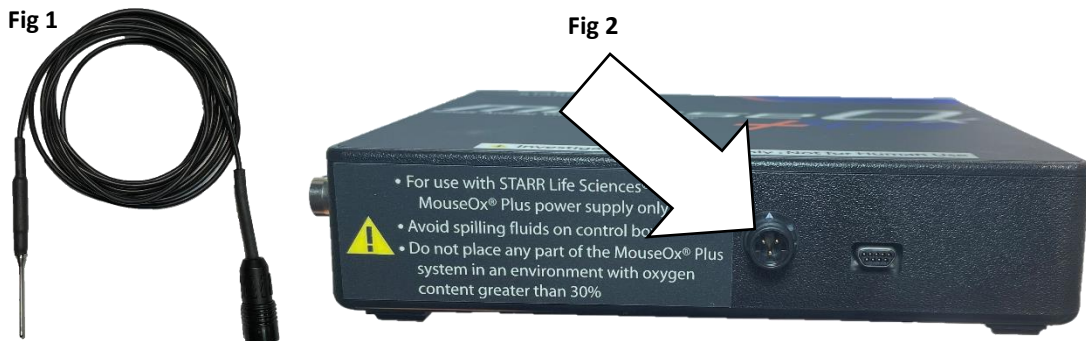
SNSR-TEMP-2M

SNSR-TEMP-4M
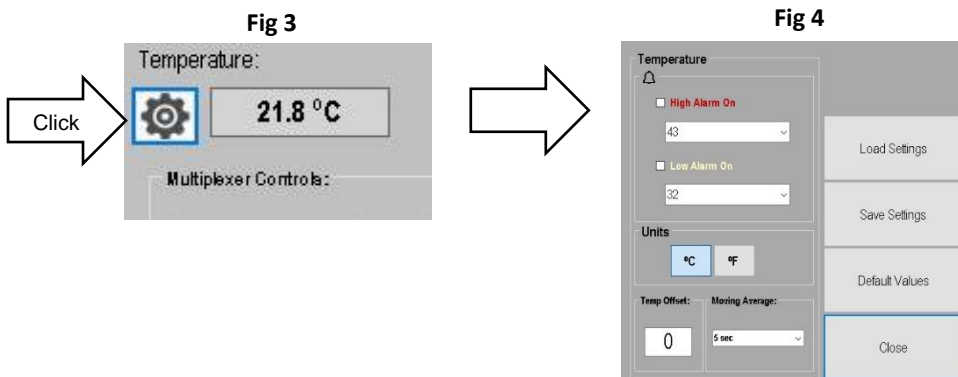
SNSR-TEMP-7M (Recommended for MRI)

User Instructions

Plug the sensor (Fig 1) into the 3-Pin connector on the front of the MouseOx control box (Fig 2)

Fig 1   **Fig 2**

Settings

Settings for the Temperature Probe are available through the Temperature Settings ⚙ button on the Monitor Subject screen (Fig 3)

Fig 3   **Fig 4**

- High/Low Alarms – Optional - Enter values for High/Low threshold alarms. Check box to set as active.
- Select °C/°F (Default: °C)
- Temperature Offset – The standard accuracy/precision of the MouseOx Temperature Probe is listed below. If you would like to apply a calibration/correction offset temperature, enter a correction value and click Save Settings

- E.g., Place a calibrated temperature device alongside the MouseOx Probe in a water bath. Add warm water until the calibrated temperature device indicates approximate expected body temperature and record the difference between the calibrated device and the MouseOx Temperature Probe. Use the offset function to apply the difference.
- Moving Average – The Temperature Probe has a very fast response time. Select a moving average filter size to reduce displayed noise if desired.
- Click <u>Save Settings</u>
- Click <u>Apply/Close Window</u> – All settings are saved and will be reloaded by default

Apply Temperature Offset when using MUX8X8

The MUX8X8 allows you to attach 8 pulse-oximetry sensors and 8 Temperature Probes through a single MouseOx Plus Controller. In order to apply offset correction values to multiple Temperature Probes use the following instructions:

While MouseOx is actively monitoring and temperature probes are attached to the MUX8X8:

1. Click <u>Menu</u> in Multiplexer Controls
2. Select "8 Chan + Temp" at top of form
3. Click <u>MUX Summary</u>, Fig 5 will appear
4. Click on the Temp Offset field associated with the active channel
5. Enter the correction factor into the Offset Field and click <u>Apply Offset</u>
6. Click ⬆ ⬇ to select the next channel and repeat the process
7. When finished click <u>Apply Offset</u> & <u>Close</u>
8. Click <u>Save Multiplexer Configuration</u> before exiting the Multiplexer Menu
9. The temperature offset for each channel is displayed on the Monitor Subject screen (Fig 6)

Fig 5

Channel # ⬆⬇	Custom ID/Name	Oxygen Saturation (%)	Heart Rate (bpm)	Breath Rate (brpm)	Pulse Distention (µm)	Breath Distention (µm)	Core Temperature (°C/°F)	Apply Offset (°F)	Close
#1	Subject#1	95.5	429	215	352.4	na	76.2 °F	0.2	
#2	Subject#2	95.6	429	215	352.2	na	76.0 °F	-0.1	
#3	Subject#3	95.6	429	215	349.7	na	76.0 °F	-.015	
#4	Subject#4	95.6	429	215	348.1	na		Enter Offset → .14	
#5	Subject#5							0	
#6	Subject#6							0	
#7	Subject#7							0	
#8	Subject#8							0	

Temperature +0.14:

76.1 °F   74.1 °F

Fig 6

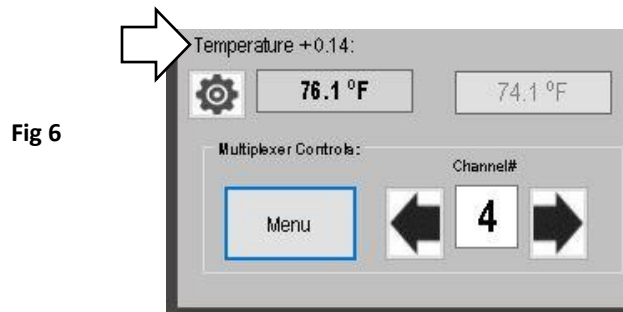Multiplexer Controls:

Menu   ⬅ 4 ➡   Channel#

Specifications

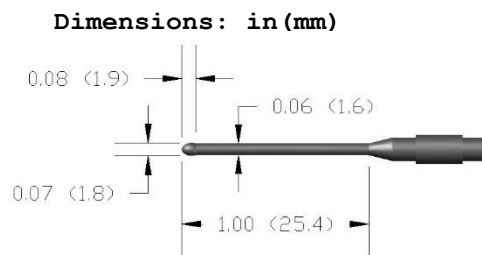**Measurement Resolution**

+/- 0.1 °C or °F

Measurement Range

15 °C - 50°C (59 °F - 122°F)

Measurement Response Time

Update 0.72 sec

Probe Material: 6AL4V ELI ASTM F-136° Implant Grade Titanium.

Dimensions: in(mm)

MouseOx 3.0

MouseOx 3.0 software is required for simultaneous operation of the MouseOx 2.0 software. This software removes the Multiplexer features of the 2.0 software and adds a group of MouseOx Navigation buttons to switch to the different 2.0 main software screens available for each MouseOx that is connected and detected by the computer.

Key Code Process

The MouseOx 3.0 software is intended to be used with the latest MouseOx systems. The MouseOx with the simultaneous key code associated with it will be a system designed with the 1408FS Plus daq card. This system uses the bulk communications protocol. The software will accept standard MouseOx plus systems, however computer processing speed may limit the performance. the systems with the Bulk protocol hardware will require less processing from the computer. The simultaneous MouseOx and simultaneous keycode must be connected and accepted by the MouseOx 3.0 software first. Once this is accomplished the additional MouseOx systems will be detected or if the program is closed and any additional MouseOx systems are connected they will be detected the next time the MouseOx 3.0 software is opened.
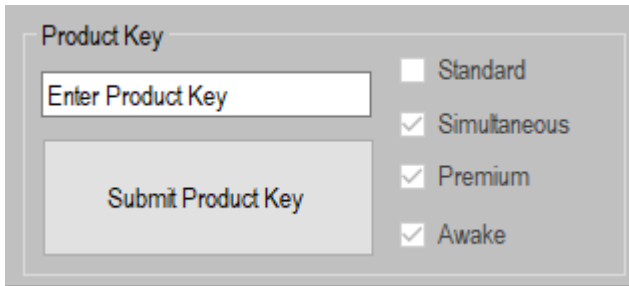
Configure

Since there are multiple MouseOx systems intended to be used in this 3.0 configuration. Each MouseOx system must be configured so that the software has all the start-up and calibration information for each MouseOx. The start-up conditions are the mode and animal type, the calibration information is the sensor type. To do this simply select "Configure" for each MouseOx, select the required constants for each MouseOx, then select "Confirm". During this configure step the user will have the opportunity to key in subject identification and blink the sensor LED so that the MouseOx being configured can be identified.
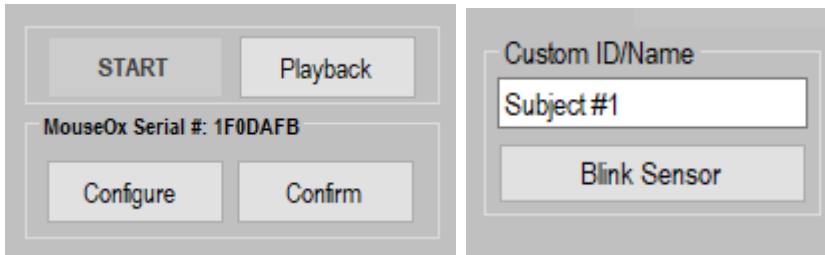
Accessibility

MouseOx #1 is the master MouseOx. The controls for this MouseOx effect the other MouseOx systems detected. "Play" can be selected for each of the MouseOx systems detected, however the "Play" button from the MouseOx #1 screen is the play that runs them all. This is for timing requirements. To move to each of the MouseOx systems just use the controls at the bottom left of the screen. *Note: No other MouseOx system can run if MouseOx #1 isn't running.*

As each additional MouseOx screen is opened it will go to the front of the already opened screens. Each screen is movable and sizable. It is recommended to do all screen sizing and display adjustments before running the system.
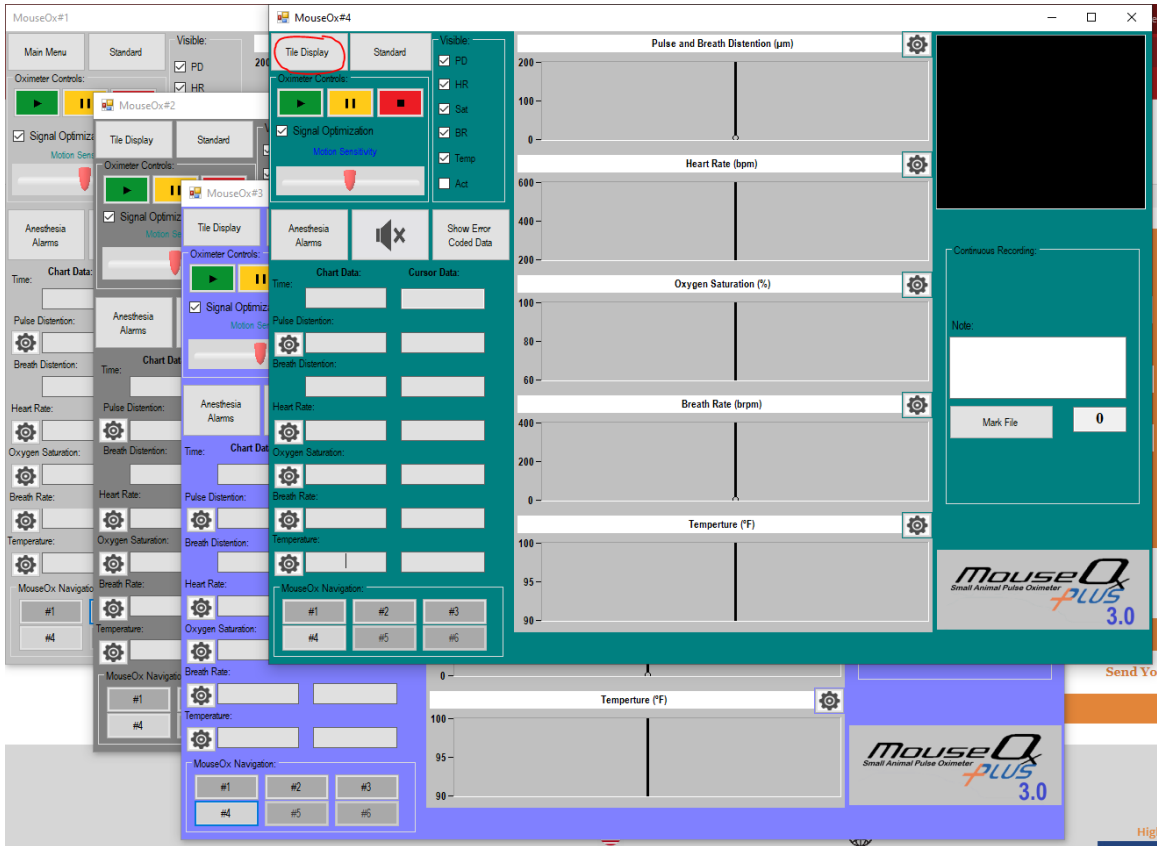
Each screen except MouseOx#1 has a "Tile Display" button. If "Tile Display" is pressed from a premium MouseOx screen all detected MouseOx systems premium screens will be evenly spaced and displayed. See image:
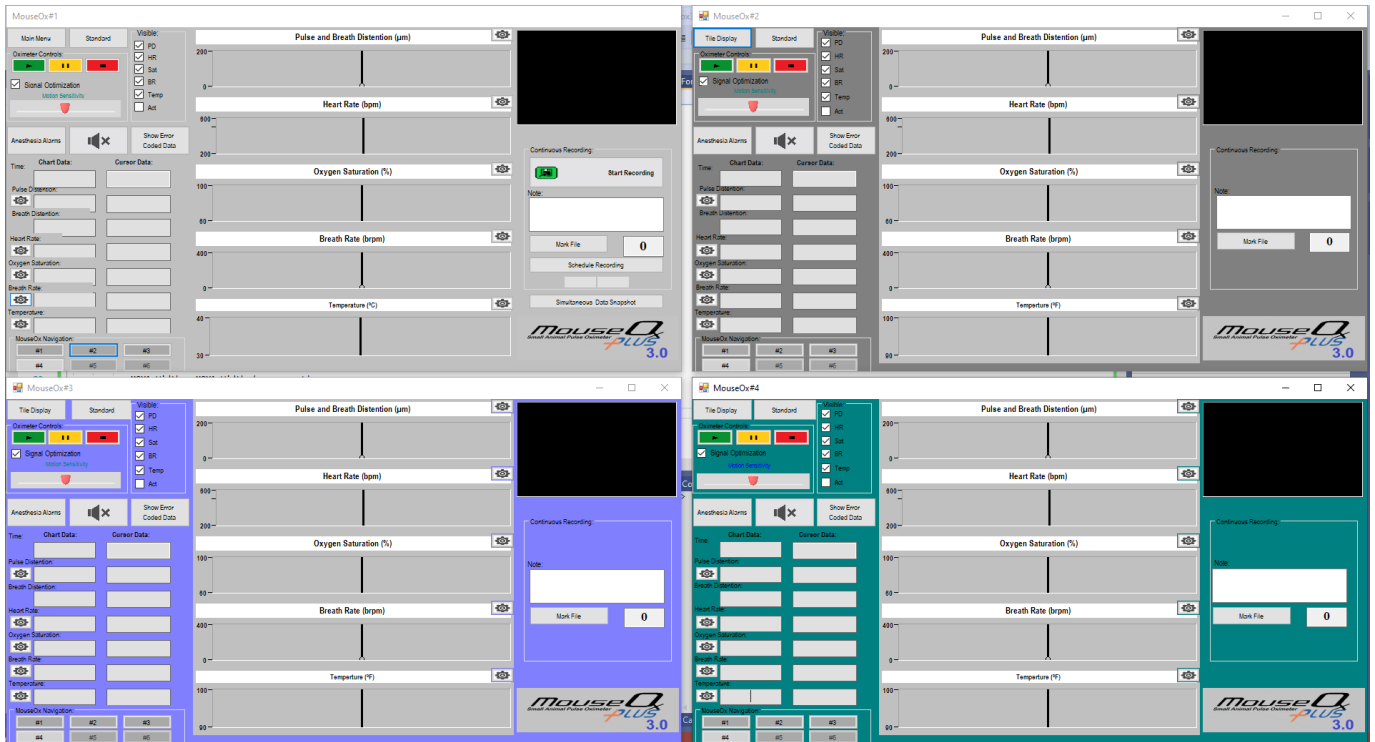
If "Tile Display" is pressed from a standard MouseOx screen all detected MouseOx systems standard screens will be evenly spaced and displayed. See image:

STARR-Link

The 3.0 software will accept the use of the STARR-Link. The STARR-Link is now custom configurable. This way if only Saturation and Heartbeat are desired for each of the MouseOx systems being used, the user can configure the STARR-Link to output only the desired information. Go to the STARR-Link section while in the configure section for any MouseOx and select the "Configure" button. The STARR-Link configure form will be made visible. Use the list boxes available to make the desired selections.
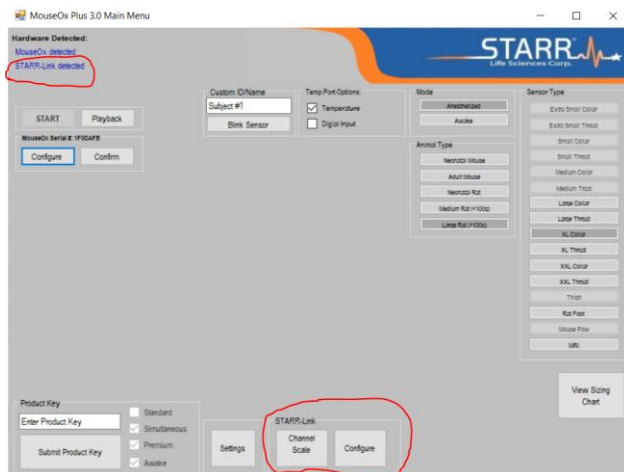
Simultaneous Data Snapshot

The data snapshot in the MouseOx 3.0 software is the same as the data snapshot provided in the 2.0 software. The main difference is that the Data snapshot provided with 3.0 allows for simultaneous analysis of the measured parameters.

Playback

The playback features of the MouseOx 3.0 software are the same as defined in the 2.0 playback section with the addition of the multiple data files being viewed simultaneously. Each MouseOx data set is color coded based on the check boxes in the upper right portion of the screen. The cursor data is also color coded. The export options allow the user to pick which subject to create a file for, or to create an individual file for each subject.

Using the "View" features, the "Compression" features, and the "Cursor" features the data can be visibly analyzed. Each graph also has a settings button to allow scaling and panning of the data visible in each graph.

Multiplexer

The Multiplexer allows a single MouseOx Plus Controller to switch between multiple subjects. MouseOx software allows the user to manually switch between subjects or to automate cyclic recording of all channels.

There are 3 versions of the Multiplexer available:

1. MOX-MUX16   16 oximeter ports
2. MOX-MUX8   8 oximeter ports
3. MOX-MUX8X8   8 oximeter ports, 8 temperature ports

Attach all cabling and power supplies according to Figs 1 & 2

Fig 1

Starr AC/AC Power Supply

USB Cable

Patch Cable

USB Cable

Starr Universal Cables
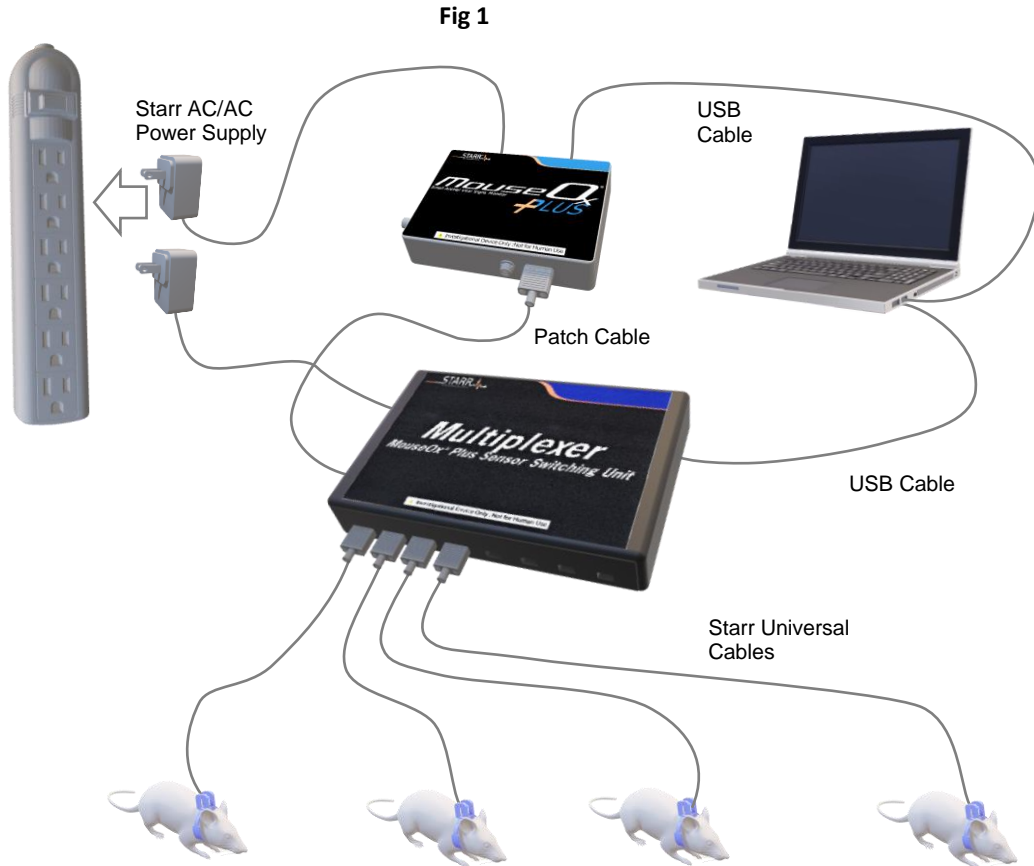
Attach the MouseOx to the Multiplexer using the appropriate "Patch Cables" shown in Fig 2

Fig 2

CBL-MUX8X8-PATCH

Required for Multiplexer with 8 temperature ports

CBL-MUXPTCH

Required for all Multiplexers
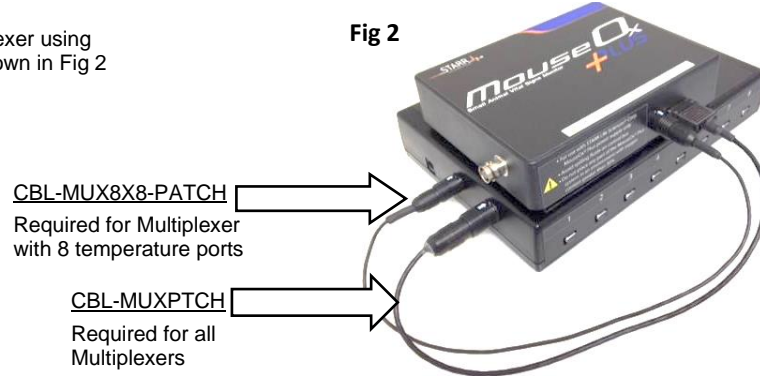
Run/Restart MouseOx software

- "Multiplexer Detected" will be displayed on the MouseOx 2.0 Main Menu
- "Multiplexer Controls" will become visible on the lower left corner of the Monitor Subject screen (Fig 3).

Fig 3

Channel # - Displays current active channel number. Data from this channel is displayed on the Monitor Subject screen and is recorded to file if recording is active

Click ⬅/➡ buttons to manually select which Multiplexer channel is active and displayed on the Monitor Subject screen

Note: ⬅/➡ are disabled if Auto-Cycle is active

Configure Multiplexer

Click Menu in Multiplexer Controls (Fig 3) - Fig 4 should appear

8 Channel/16Channel/8 Channel + Temp

Select 8-Channel, 16-Channel or 8 Chan + Temp to correspond with the version of Multiplexer being used

- Selection determines whether 8 or 16 channels are displayed on forms (Fig 4/5)

Fig 4   **Fig 5**
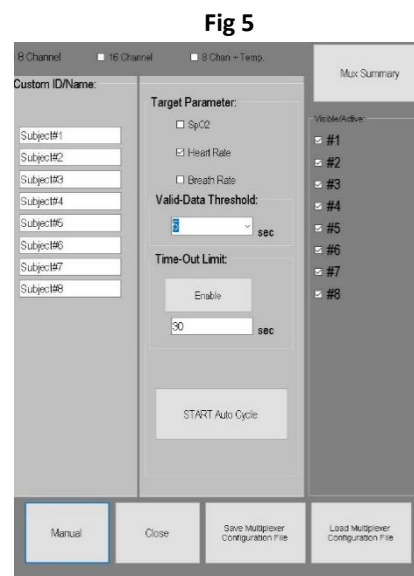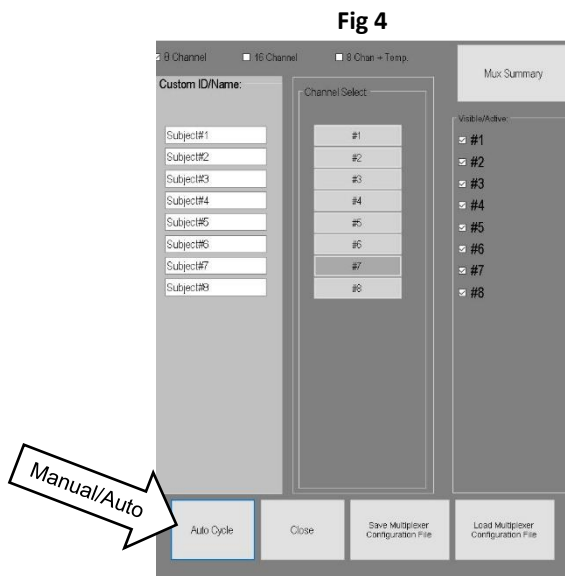
Custom ID/Name (Optional)

Enter a descriptive name to be associated with each channel. Text will be recorded in the MouseOx Primary Data File along with the data associated with that channel

Visible/Active Channels

Select which Multiplexer channels are visible/active during Manual and Auto-Cycle operation

Click Manual/Auto-Cycle

- Manual (Fig 4) - Manually select which channel is active using the Channel Select buttons
- Auto Cycle (Fig 5) - Automatically cycle through Visible/Active channels

Auto-Cycle controls (Fig 5)

When active, Auto Cycle will step through each Active/Visible Multiplexer channel when the following settings are satisfied

Target Parameter

MouseOx will monitor/record all data from each channel until it accumulates sufficient valid data for the specified "Target Parameter". The amount of data required to proceed is determined by the Valid Data Threshold

Valid-Data Threshold

Enter the number of seconds (5-99999) worth of Target Parameter data required in order to proceed

Time-Out Limit

If Time-Out Limit is reached before the Valid Data Threshold is achieved the MUX will proceed to the next active channel

Click Start Auto Cycle

Initiates the Auto-Cycle process starting with the first channel in the Visible/Active list.

- As each channel becomes active data is displayed on the Monitor Subject screen and is highlighted on the Mux Summary screen.

- Clicking STOP/START Auto Cycle will reset the cycle to the first active Channel selected.

Click <u>Mux Summary</u> – Fig 6 should appear (8 or 16 channels depending on Multiplexer)

- Active channel is highlighted green
- Most recent measurements are displayed for each channel until subsequent update/refresh
- <u>Apply Offset</u> – See Temperature Probe section for detailed instructions
- Click ⬆ ⬇
  - Increment/Decrement active channel
  - Works with Manual or Auto Cycle

Fig 6

Channel # ⬆⬇	Custom ID/Name	Oxygen Saturation (%)	Heart Rate (bpm)	Breath Rate (brpm)	Pulse Distention (µm)	Breath Distention (µm)	Core Temperature (°C/°F)	Apply Offset (°F)	Close
#1	Subject#1							0	
#2	Subject#2							0	
#3	Subject#3							0	
#4	Subject#4							0	
#5	Subject#5							0	
#6	Subject#6							0	
#7	Subject#7							0	
#8	Subject#8							0	

Recording While Using Multiplexer

- Continuous Recording runs independently of Multiplexer operation
- Data from the active channel is recorded to file while it is displayed on the Monitor Subject screen
- Active Channel# and Custom ID will be recorded along with each data set

Click <u>Close</u> to return to the Monitor Subject screen

- The current active Multiplexer channel is displayed in the Multiplexer Control box (Fig 3)
- Auto-Cycle will continue to function until you click <u>STOP Auto-Cycle</u> on the Multiplexer Menu

Using Data Snapshot with Multiplexer

The Manual and Automatic Data Snapshot functions run independently of the Multiplexer. When a Multiplexer is detected by MouseOx software the Multiplexer Features appear on the Data Snapshot screen (Fig 7)

Fig 7
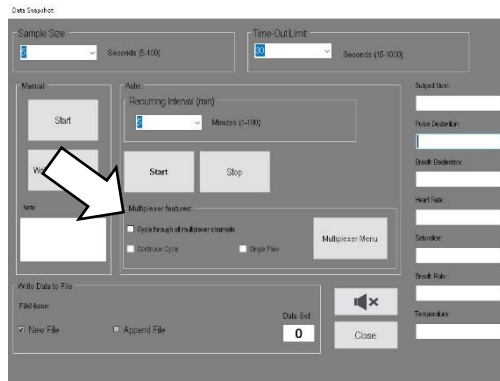
Manual Snapshot – Works same as if no multiplexer is present. See "Data Snapshot" section of this User Manual

- Select any Multiplexer channel using the ◀/▶ buttons on the main screen or ▲/▼ buttons on the Multiplexer Summary form
- Click the Start button in the "Manual" section on the Snapshot screen
- When Snapshot is finished click Write Data to File

Automatic Snapshot

- Single Channel Recurring – Works same as if no Multiplexer is present with additional ability to manually choose which Multiplexer channel is active
  - Select any Multiplexer channel using the ◀/▶ buttons on the main screen or ▲/▼ buttons on the Multiplexer Summary form
  - On Snapshot screen set Sample Size, Time-Out Limit and Recurring Interval
  - DO NOT select "Cycle Through All Channels"
  - Click Auto Start button - First time through enter file name and location
   *Note: If you change Mux channel during Auto-Execution, subsequent data will be recorded from new active channel*
  - Click "Auto" Stop button when finished
- All channels (1 Pass) – Automatically step through all Visible/ Active channels 1 time
  - Set Sample Size & Time-Out Limit (No Recurring Interval)
  - Select "Cycle Through All Multiplexer Channels" check box
  - Select "Single Pass" check box
  - Click Auto Start button - First time through enter file name and location
- All Channels Recurring - Automatically step through all Visible/ Active channels then repeat at specified Recurring Interval
  - Set Sample Size, Time-Out Limit and Snapshot Interval
  - Select "Cycle Through All Multiplexer Channels" check box
  - Click Auto Start button - First time through enter file name and location
  - Click Auto Stop button when finished
- All Channels Continuous - Automatically step through all Visible/ Active channels then repeat
  - Set Sample Size & Time-Out Limit (No Recurring Interval)
  - Select "Cycle Through All Multiplexer Channels" check box
  - Select "Continuous Cycle" check box
  - Click Auto Start button - First time through enter file name and location
  - Click Auto Stop button when finished

Cleaning the Multiplexer

The Multiplexer and all accompanying cables should be cleaned using only light detergent and water.

Appendix A – Troubleshooting

1. Software Versions

Some problems can be resolved by downloading and installing the latest versions of MouseOx and InstaCal software from https://www.starrlifesciences.com/resource/mouseox-software-download/

2. Power Supply

A large number of technical support requests result from users inadvertently using the wrong power supply. Make sure you are using the original power supplies that came with your STARR products.

- The MouseOx and accessories each require a specialized 12 Volt ~AC power supply
- RECOMMENDED: Only use power supplies purchased through STARR Life Sciences or authorized distributors

3. "MouseOx not detected"

To simplify troubleshooting, first unplug any MouseOx accessories that are connected to your computer (STARR-Link, Multiplexer).

- Make sure the USB cable is properly connected to the MouseOx and your PC - Make sure USB connectors are fully inserted into each socket.
- Close/Restart the MouseOx software.

If the "MouseOx not detected" error message is still present

- Close the MouseOx software
- Run InstaCal software (Start➜Measurement Computing➜InstaCal)
    - o If the HID Registry Update utility dialog box appears, click Yes and follow the on-screen instructions
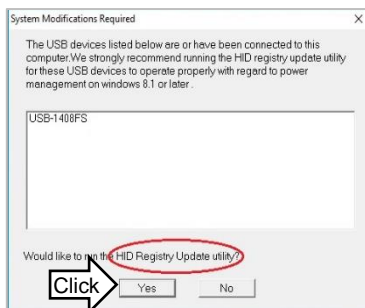
- The Instacal PC Board List should appear showing the USB-1408FS(-Plus)

Starr Product Codes
- USB-1408FS(-Plus) = MouseOx
- USB-1024LS = Multiplexer
- USB-3103 = STARR-Link
- USB-DIO32HS = DP1224

- If USB-1408FS does <u>not</u> appear on the list
  - o Check USB connections again and click the InstaCal Refresh ↻ button
  - o If the USB-1408FS still does not appear, contact STARR Life Sciences.
- If USB-1408FS does appear on the list
  - o Run the MouseOx software
  - o If the "MouseOx not detected" error message is still present
    - Close the MouseOx software
    - Unplug the MouseOx USB cable
    - Click the InstaCal Refresh ↻ button
    - The message "USB-1408FS with serial #xxxxxx…has not been detected" should appear
      - Click <u>OK</u>
    - The InstaCal PC Board List should show no "Boards" attached
    - Reconnect the MouseOx USB cable
    - Click the Instacal Refresh ↻ button
  - o If the USB-1408FS does <u>not</u> appear, contact STARR Life Sciences
  - o If the USB-1408FS does appear
    - Run the MouseOx software
    - If the "MouseOx not detected" error continues to appear, contact STARR Life Sciences

Note: This procedure can be used to troubleshoot connectivity of the STARR products listed above

Note: DO NOT use the "Calibrate" and "Test" functions found in InstaCal. Doing so can permanently damage the MouseOx and will void the product warranty.

Appendix B – Alarms

MouseOx provides visual and audible alarm indicators. There are 2 types of alarms:
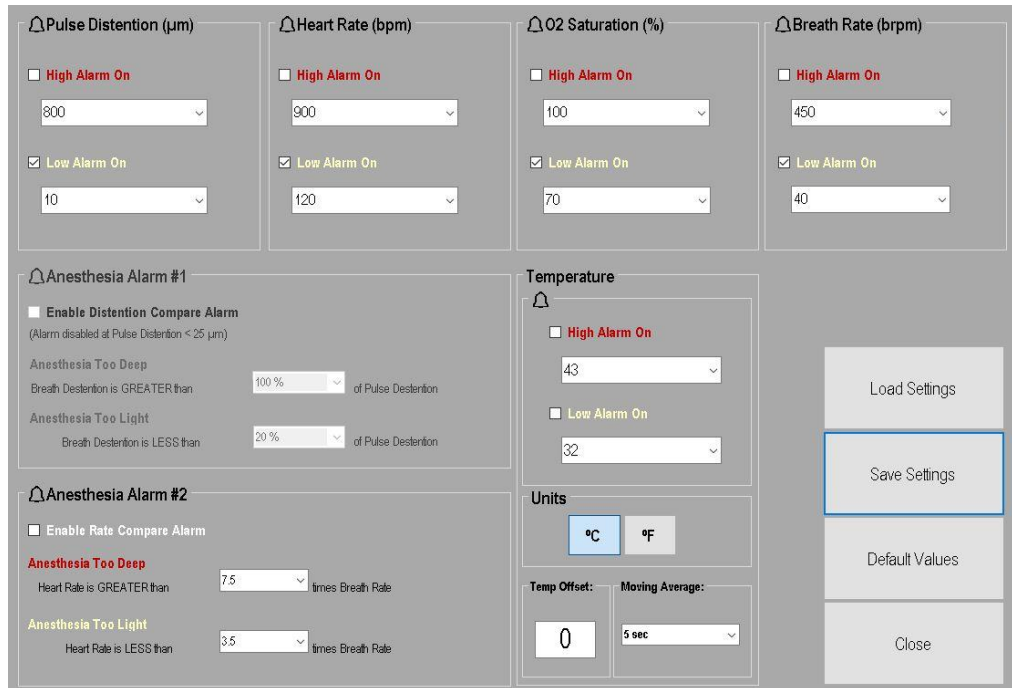
- Threshold Alarms – Set High/Low threshold values for each of 5 parameters
- Comparative/Anesthesia Alarms
    - o Available in Anesthetized Mode
    - o Triggered when relationship between 2 parameters meets preset criteria.

Setting Alarms

You can access Alarm Settings from the MouseOx Main Screen or the Monitor Subject Screen

- Main Screen
    - o Click Settings – Figure A-1 should appear
    - o Access Settings for all Threshold and Comparative alarms

Fig A-1

- Monitor Subject Screen
    - o Click the Anesthesia Alarm button to set the Comparative Alarms
    - o Click the Settings ⚙ icon next to each parameter field to set High/Low Threshold Alarms.

Threshold Alarms

- Choose value from pull down menu or enter custom value
- High Threshold must be greater than Low Threshold
- Check the box next to each Alarm to enable
- Alarms are disabled for each parameter when a parameter specific error code is encountered
- There is currently no alarm for Breath Distension

Threshold Alarm Default Values

High alarm defaults are also the maximum value for each parameter

Parameter	High Alarm	Low Alarm
Pulse Distention	800 µm	10 µm
Heart Rate	900 BPM	120 BPM
Oxygen Saturation	100%	80%
Breath Rate	450 BrPM	40 BrPM
Body Temperature	43 ℃	32 ℃

Comparison/Anesthesia Alarms

The MouseOx® Plus software provides you with two types of alarms that can be used specifically to monitor depth of anesthesia. These are the "Distention Compare Alarm" and the "Rate Compare Alarm". It should be noted that we do not recommend specific values for these alarms, and that they are available for your use based on your own experience. The reason that we do not make specific recommendations is because parameter levels may be dependent on items that we cannot control, such as dosage, time after dosage, type of anesthesia, where it is delivered, etc.

- Threshold Alarms have precedence over anesthesia alarms.
- Comparative Alarms are disabled whenever either parameter is affected by an error code

Distention Compare Alarm

The ratio of (Breath Distention)/(Pulse Distention) serves as a means of monitoring depth of anesthesia. The idea behind this alarm is that excessive anesthesia levels generally tend to suppress breathing. A frequent response to decreased ventilation is gasping which results in an increase in work of breathing. An increase in work of breathing is detectable in the photoplethysmmograph signal and is expressed as Breath Distention. An increase in Breath Distention relative to Pulse Distention indicates increasing depth of anesthesia. Useful setting values are significantly dependent on subject size and physiological state and must be determined empirically. Examples of each type of alarm are given below.

Example 1 – Anesthesia Too Deep

> If the Anesthesia Too Deep value is set to 80%, the alarm would be triggered when the Breath Distention becomes greater than 80% of the Pulse Distention.

Example 2 – Anesthesia Too Light

> If the Anesthesia Too Light value is set to 20%, the alarm would be triggered when the Breath Distention becomes less than 20% of the Pulse Distention.

- The alarm settings cannot be set such that there is overlap between the Too Deep and Too Light settings
- Settings are limited to the values in the drop-down menus
- Alarm is automatically disabled if the Pulse Distention drops below 25 µm.

UM-MOX 3.0 / 2.0 Rev 2.0

Rate Compare Alarm

The Rate Compare Alarm is triggered when the ratio of (Heart Rate)/(Breath Rate). The idea behind this alarm is that excessive anesthesia levels generally tend to suppress breath rate relative to heart rate.

Example 1 – Anesthesia Too Deep Rate Compare Alarm

If the Anesthesia Too Deep alarm is set to 7.5, the alarm is triggered when the Heart Rate becomes greater than 7.5 times the Breath Rate.

Example 2 – Anesthesia Too Light Rate Compare Alarm

If the Anesthesia Too Light alarm is set to 3.5, then the alarm is triggered when the Heart Rate becomes less than 3.5 times the Breath Rate.

- Values can be selected from the drop-down menus or entered manually
- The alarm settings cannot be set such that there is overlap between the Too Deep and Too Light settings.

Appendix C – Analog Pulse Signal Output

The Analog Pulse Signal Output (APSO) port provides an analog voltage signal output of the IR/PPG raw cardiac waveform.


Fig B-1
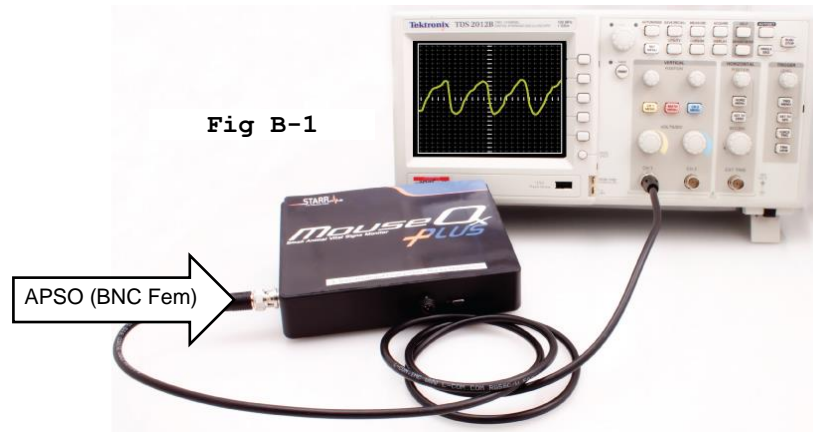
The primary application for the MouseOx® Plus APSO is event triggering. There are some things to be aware of before you use this signal however.

- The signal operates on a floating ground. You must be sure that the device to which you connect the signal has a floating, differential input.
- The output signal from the APSO spans ± 5 volts, but is usually much smaller. It is AC-coupled, indicating that its mean value resides around 0 volts, so it can easily be amplified externally.
- The signal is continuous and has no delay, outside of that associated with both low and high-pass analog filtering. This delay is inconsequential for the purposes of cardiac triggering, although we do not know its magnitude specifically.
- Amplitude is subject to all of the analog amplification methods used by the MouseOx® Plus control system.   Thus, it can suddenly increase or decrease in amplitude as the MouseOx® Plus controller makes its adjustments. You can eliminate these changes by turning off Signal Optimization.
- The signal does undergo the analog filtering and amplification that occurs before we digitize it and use it to calculate the oximetry parameters.

Additionally, the signals are subject to various forms of noise in our system, which includes motion artifact due to animal motion, variations in amplitude due to changes in signal amplification from the MouseOx® Plus controller as we just described, small variations in amplitude due to breathing artifact on the signal and various characteristics of peripheral microvascular physiology that can make the signal shape vary.

In the following pictures, we see sample signals from the APSO on an oscilloscope in three different time compressions. Note that the signal is not completely repetitive in shape or amplitude as is the case with a pure sine wave. The reason for this is that the signal represents the received infrared light from the photodiode that has not been digitized and undergone the filtering used to optimize the signals to allow measurements to be made from them by the MouseOx® Plus.
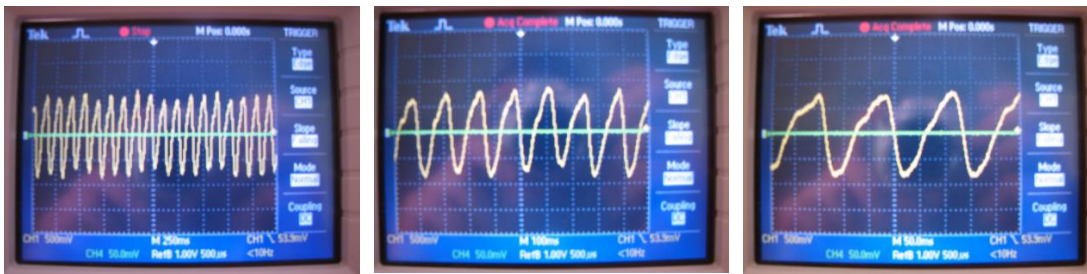
If you observe the figure directly above, you can see that there is a fast downstroke followed by a slow upstroke. The fast downstroke represents increased peripheral blood flow associated with cardiac ejection, or systole. The slow upstroke is associated with diastole. It is our observation that the most repeatable (jitter-free) portion of the signal is the vertical middle of the downstroke, which represents some part in the middle of the cardiac ejection phase. We cannot say exactly what portion this is, since we do not know what delays are associated with blood flow to the periphery. Regardless, it might be best to set the trigger at this point, and add any desired delay externally, if possible.

Recommendations for use as a trigger:

1] Once you get good signals as indicated by the MouseOx® Plus software, turn off the Signal Optimization.

2] Use the middle portion of the downstroke as a trigger point, then delay from that location if necessary.

3] Make sure that the animal is anesthetized or restrained sufficiently to prevent motion from affecting the signal. However, you do not want to over-anesthetize the animal such that it starts to gasp, as this will cause the signal to "jump" at each inhalation.

4] Make sure that the device into which you are plugging the APSO signal has a high input impedance and that it is non-grounded (*i.e.*, has a floating differential input).

STARR

Appendix D – Signal Optimization

Signal Optimization refers to the process by which the MouseOx continually adjusts sensor sensitivity and LED brightness to achieve an optimal signal for a particular subject. The sensor drive parameters are adjusted to adapt to the animal's size, skin/hair color, and amplitude of pulsatile signal. If the Signal Optimization box remains checked after the signal is initially optimized, the MouseOx will continuously make adjustments to ensure valid signal acquisition regardless of physiological variation.

- Signal Optimization should always be on when you start monitoring
- Always leave Signal Optimization on until the signal is fully optimized.
- The signal is fully optimized when
    - Error Code "9 – Signal Optimization" is rarely displayed.
    - The red and yellow waveforms in the PhotoPlethysmoGram (PPG) are consistent, significantly coincident with each other and are not clipped by the upper and lower boundaries of the display.
- Under most circumstances Signal Optimization should be left ON allowing MouseOx to make small continuous adjustments

There are situations in which it can be beneficial to turn Signal Optimization off.
- When using the Analog Pulse Signal Output (APSO) for triggering
- When sudden, large and transient physiological changes can be anticipated,
    - Turning off Signal Optimization prior to a disruptive event can minimize the difficulty reacquiring signal.
    - Signal Optimization can then be turned back ON after the transient effects have subsided.

Two examples of large transient physiological changes:

1) When an animal is conscious and very active, motion artifact can trigger Signal Optimization and change settings that would otherwise still be optimized for the animal immediately following cessation of motion. If Signal Optimization is active this may cause MouseOx to run through the Signal Optimization process causing excess data to be discarded. Turning off Signal Optimization may allow more valid data to be acquired. Since motion artifact only invalidates the signal during the physical motion of the animal, statistical outliers can be manually excluded from data acquired during the period of motion.

2) When an experimental stimulus is administered it may cause a transient physiological response that is unrelated to salient experimental parameters. E.g., the act of injection can cause transient physiological response due to the stress of the needle puncture. That transient disruption can trigger the automatic Signal Optimization and disrupt signal acquisition. Turning off Signal Optimization just prior to the needle puncture can prevent Signal Optimization from straying too far from subsequent optimal settings.