

Small Animal Physiological Monitoring System

USER'S MANUAL



Physiological Monitoring System for Mouse
Physiological Monitoring System for Mouse & Rat

75-1500
75-1501



Table of Contents

SUBJECT	PAGE #
Warranty Information	2
Safety Information	3
Product Overview	4
Specifications	5
Parts List	6
Key Features	7
System Setup	8
Setting Up the Monitoring System	8
Setting Up the Android Tablet	8
HA Monitoring Station Application	9-14
Application Windows	9-10
Using the Application	10-14
Physiological Monitoring & Measurements	15-17
Positioning the Animal	15
Taking Physiological Measurements	15
ECG	15
Respiration	15
Temperature	16
Oxygen Saturation	16
Blood Pressure	17
Exhaled CO ₂	17
Head Fixation Device	17
Data Transfer and Analysis	18-20
Cleaning and Troubleshooting Guide	21
Ordering Information	22

Warranty Information

Research Use Only

Harvard Apparatus
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Holliston, MA 01746
Phone: 800-547-6766
Fax: 508-429-5732

Warranty

Harvard Apparatus warranties the Small Animal Physiological Monitoring System for a period of one year from the date of purchase. At its option, Harvard Apparatus will repair or replace the unit if it is found to be defective as to workmanship or materials. This warranty does not extend to any instrumentation which has been (a) subjected to misuse, neglect, accident or abuse, (b) repaired or altered by anyone other than Harvard Apparatus without Harvard Apparatus express and prior approval, (c) used in violation of instructions furnished by Harvard Apparatus. This warranty extends only to the original customer purchaser. **IN NO EVENT SHALL HARVARD APPARATUS BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Some states and regions do not allow exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. **THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR USE, OR OF ANY OTHER NATURE.** Some states or regions do not allow this limitation on an implied warranty, so the above limitation may not apply to you. Without limiting the generality of the foregoing, Harvard Apparatus shall not be liable for any claims of any kind whatsoever, as to the equipment delivered or for non-delivery of equipment, and whether or not based on negligence. Warranty is void if the device is changed in any way from its original factory design or if repairs are attempted without written authorization by Harvard Apparatus. Warranty is void if parts or connections not manufactured by Harvard Apparatus are used with the Small Animal Physiological Monitoring System. If a defect arises within the warranty period, promptly contact Harvard Apparatus by phone at 800-547-6766 or 508-893-8999 or email: support@hbiosci.com.

Goods will not be accepted for return unless an RMA (Returned Materials Authorization) number has been issued by our returns/repairs department. The customer is responsible for shipping charges. Please allow a reasonable period of time for completion of repairs, replacement and return. If the unit is replaced, the replacement unit is covered only for the remainder of the original warranty period dating from the purchase of the original device. This warranty gives you specific rights, and you may also have other rights, which vary from state to state.

Out of Warranty Service

Proceed exactly as for Warranty Service on the left. If our service department can assist you by phone or other correspondence, we will be glad to help at no charge. Repair service will be billed on the basis of labor and materials. A complete statement of time spent and materials used will be supplied. Shipment should be prepaid. Your bill will include return shipment freight charges. Disassembly by the user is prohibited. Service should only be carried out by experienced Harvard Apparatus technicians.

Repair Facilities and Parts

Harvard Apparatus stocks replacement and repair parts. When ordering, please describe parts as completely as possible, preferably using our part numbers. If practical, enclose a sample photo or drawing.

Safety Information

Please read the following safety precautions to ensure proper use of your Small Animal Physiological Monitoring System. If the equipment is used in a manner not specified, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury

Use Proper Cord

Use only the specified line cord for this product and make sure the line cord is certified for the country of use.

Ground the Product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making any connections to the input or output terminals of the product, ensure that the product is properly grounded.

Make Proper Connections

Make sure all connections are made properly and securely. Any signal wire connections to the unit must be no longer than three meters.

Observe All Terminal Ratings

Review the operating manual to learn the ratings on all connections.

Avoid Exposed Circuitry

Do not touch any electronic circuitry inside of the product.

Do Not Operate with Suspected Failures

If damage is suspected on or to the product do not operate the product. Contact qualified service personnel to perform inspection.

Orient the Equipment Properly

Do not orient the equipment so that it is difficult to operate the disconnection device.

Place Product in Proper Environment

Review the operating manual for guidelines for proper operating environments.

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

If there are any questions about the operation of this instrument, call Harvard Apparatus Technical Services at 800-547-6766.

Caution Notice

Harvard Apparatus products are intended for laboratory use only and can be used in research and development applications. These systems have been designed to meet the standards for electromagnetic compatibility (EMC) and safety. This product should not be used in the presence of a flammable atmosphere such as an anesthetic mixture with air, oxygen, or nitrous oxide.



Caution



Protective
Ground Terminal

Product Overview

The Small Animal Physiological Monitoring System is an instrument that measures multiple physiological parameters on one single small platform.

The system comes complete with heated monitoring platform, Android tablet with a protective sleeve and stand, Bluetooth® communication module, rectal probe, and electrode gel. Adapter and USB connection cable for the tablet, and connection cable for the Bluetooth® communication module are included. These components are all supplied in a sturdy case for storage and transport.

The platform includes four electrocardiogram (ECG) surface electrodes, a respiration sensor and a heated surface that can be used at a set temperature or in a homeothermic setup using the rectal probe. Additional options to monitor oxygen saturation (SpO₂), blood pressure and exhaled CO₂ (EtCO₂) can be purchased separately.

The system has many benefits for surgical procedures. It requires less setup time at the beginning of procedures. A single data/power cable connects to a small wireless communication module, reducing the required space and the number of wires around the animal.

Monitoring software is pre-installed on the Android tablet. All data is transferred to the Android tablet by Bluetooth® for display and saving. A real-time display provides numeric values as well as waveforms that can be customized by the user. Multiple signals can be displayed on each of three graphs.

At the end of experiments, recorded data can easily be transferred to any computer for analysis. Scripts and utilities are provided to convert data in LabChart or CSV format and to display signals in Excel® and MATLAB®.



*Small Animal Physiological Monitoring System
(shown with Mouse only platform)*

Specifications

Measured Parameters	
ECG	Display Leads I, II, III, aVL, aVR and aVF Supine or prone position 1 kHz, 24-bit acquisition 3 external electrode connections (2 mm)
Respiration	250 Hz acquisition
Heart Rate	200 to 800 beats/min calculated every second
Breath Rate	25 to 330 breaths/min calculated every second
Warming	Heated surface up to 45°C with 0.1°C resolution
Temperature	Closed loop PID controller keeps the animal within $\pm 0.1^\circ\text{C}$ of set temperature
Blood Pressure	Full waveform display Systolic and diastolic numeric values
SpO ₂	80 to 100% saturation 250 Hz, 24-bit acquisition Red and infrared channel display
Exhaled CO ₂	Connect ventilator directly to the platform (1/8" tubing) 1 Hz refresh rate 0.1% accuracy

Other	
Heated Monitoring Platform (W x L x D)	10 cm x 21 cm x 2.9 cm (mouse) 12 cm x 30.4 cm x 2.9 cm (rat and mouse)
8" Android Tablet	High resolution touchscreen display capacity: over 700 hours of recording Battery life: 5 to 8 hours
Bluetooth® Communication Module	Bluetooth® and analog outputs are in a separate enclosure to avoid interference 9 cm x 11 cm x 2.5 cm 100 to 240 V power supply
Bluetooth® Range	15 to 25 meters typical range between the communication module and the display unit
Analog Outputs	4 configurable output BNC connectors ± 5 V range 1 kHz, 16-bit refresh rate
Data Analysis	.csv conversion tool MATLAB® and Excel® import and display scripts Compatible with third-party analysis software (LabChart)

Parts List

Please check the contents of the shipment for completeness and note whether any damage has occurred during transport. If the contents are incomplete, or if there is damage, notify the supplier from whom you have ordered the device or Harvard Apparatus directly. The shipment includes the items shown in the photo below:



- a: **Heated Monitoring Platform** with easy-to-clean surface
- b: **Android Tablet** with protective case
- c: **User's Manual**
- d: **Rectal Probe**
- e: **Bluetooth® Communication Module**
- f: **Stand** for Android Tablet

- g: **Electrode Gel**
- h: **Power supply and power cord** for the Bluetooth module
- i: **USB Cable and USB Power Adapter** for Android Tablet
- j: **9-Pin** Connection cable
- k: **Storage Case** for complete system

Key Features

Power Supply

The unit is supplied with an approved power supply and region-specific power cord for the monitoring system's communication module as well as a USB adapter and cable for the tablet. Only use the power supplies provided. Lower cost power supplies have been found to add noise in the ECG, SpO₂ and blood pressure signals.

A protection circuit is present on the system. If the detected supply is not between 11 V and 14 V, the system will not start.

Analog Outputs

There are four BNC analog outputs on the Bluetooth® communication module. The outputs are short circuit protected.

- ECG signals are encoded from -5 V to 5 V, where 5 V is 12.5 mV at the default ECG gain of 3. If the ECG gain is changed, the ratio will also change. For example, at a gain of 6, 5 V will represent 6.25 mV.
- Temperatures are encoded from -5 V to 5 V where -5 V is 25°C, 0 V is 35°C and 5 V is 45°C. They increase by 50 mV per 0.1°C.
- Expired CO₂ is encoded from 0 to 5 V, where 0 V is 0% and 5 V is 10%.
- Blood pressure is encoded from -5 V to 5 V, where 0 V is 0 mmHg and 5 V is 400 mmHg. The rest of the signals (respiration and SpO₂) are in arbitrary units.

Main Voltage

The Bluetooth® communication module must be plugged to a 100 to 240 VAC 50/60 Hz main supply. The Android tablet comes with a USB charger, requiring a main power supply as well.

In the advanced settings on the Android tablet, it is possible to select the signals for each of the analog outputs. However, it is not necessary to make any changes to these settings unless preparing to collect data through an external data acquisition system.

Android Device

An Android tablet is supplied with the system; however, any other Android device can be used, as a replacement or in conjunction. It must have Android 4.0.3 or above, a Bluetooth® antenna and a high-resolution display (720 x 1280 and above).

Android Limitations

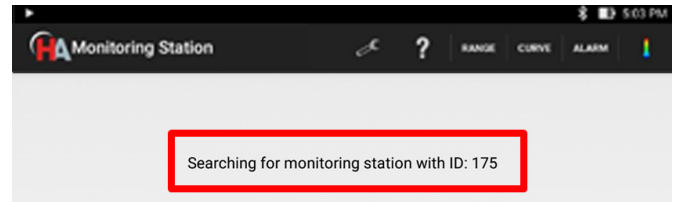
The Android tablet should be kept plugged into its wall charger. Most computer's USB ports don't provide enough power to keep a tablet running and the battery will slowly drain.

Turn off the tablet when it will not be used for a couple of days. If not, the battery will completely drain in 2 to 4 weeks. If this happens, the user must charge it at least 5 minutes before it can be turned on.

On some devices, if the application is not displayed on the screen, the Android tablet might stop it at any moment to free up memory. When saving important results, it is important not to turn off the screen or navigate to other apps. When displaying results, the application prevents the device from going to sleep and the screen will not automatically turn off.

Bluetooth®

Each monitoring station has a unique ID that can be found on the communication module. The purpose of this ID is to link the Bluetooth® communication module with one specific monitoring station.



It is possible to use up to two Android devices to monitor a single monitoring station. If a setting is modified on one device, it will automatically be transferred to the other devices.

Be careful when using two devices at the same time. If one of them gets out of the Bluetooth® range, glitches might occur in the data communication. To prevent this, make sure to close the application from the notification bar or by using the back button before leaving the Bluetooth® emission radius.

Bluetooth® Range

The Bluetooth® connection is typically limited to a range of 15 to 30 meters, depending on the environment. Note that Wi-Fi signals can interfere with Bluetooth®. If there is a wireless router close to the system or high Wi-Fi activity, the range could be decreased. For these reasons, especially when saving important results, it is recommended to keep a maximum distance of 5 meters between the Android device and the communication module.

Data will be lost if the system is too far away. Display and saving will be paused until the system is brought closer. At a certain distance the connection can also be lost, and the application will be closed.

There is a 10-second buffer on the system, which prevents any data loss even if the tablet is out of range for a brief period.

Computer

A computer is required only for advanced data analysis.

A USB port is required to connect the Android tablet for data transfer. Drivers are already installed for Windows® Vista and above.

Java® (JDK 1.6 and above) is required to run the LabChart® and .csv conversion script. Microsoft® Excel® on Windows® is required to run the Excel® display script. MATLAB® is required to run the MATLAB® display script.

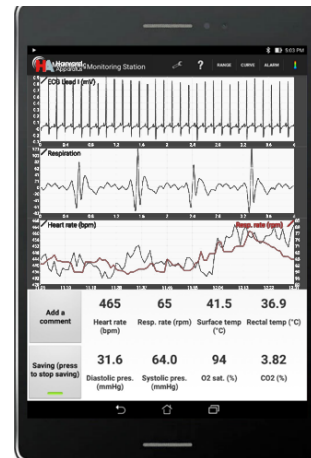
System Setup

Setting Up the Monitoring System

1. Connect the communication module to the monitoring platform using the 9-pin connection cable. Make sure that the cable is screwed tightly on both sides.
2. Plug in the communication module power supply. Turn on the power switch located on the front of the communication module. It powers up the whole system. The power light will illuminate green.

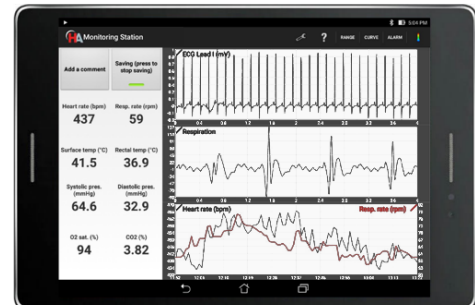
Note: If the power is not turned on, the HA Monitoring Station application on the tablet will not advance past the connection interface.

3. Start the system 5 to 10 minutes prior to positioning the animal to ensure that the platform is fully heated. It is important to note that the platform remembers the last target temperature, even if it was unplugged. This means that if the last user turned off the heating, the platform will not heat by default and the heating feature must be turned back on.



Setting Up the Android Tablet

1. Plug the Android tablet into its wall charger and keep it plugged in during use. The majority of tablets have their USB port on the bottom of the tablet.
2. To use the provided stand, put the tablet on the side or upside down (so that the USB cord does not interfere) and the screen will automatically rotate.
3. Turn on the power by pressing and holding the power button located on the side of the tablet until the screen illuminates and the start-up screen appears.
4. Swipe up to unlock the home screen.
5. The HA Monitoring Station application icon and the File Manager will be seen on the home screen.



Screen Rotation

The Android tablet can be used in portrait or landscape mode, right side up or upside down, depending on preference.

HA Monitoring Station Application

The HA Monitoring Station is an application pre-installed on the Android tablet that collects and saves physiological data from the mouse or rat positioned on the heated monitoring platform.

Application Windows

Single click the HA Monitoring Station icon on the home screen to open the application.

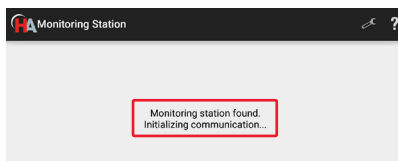
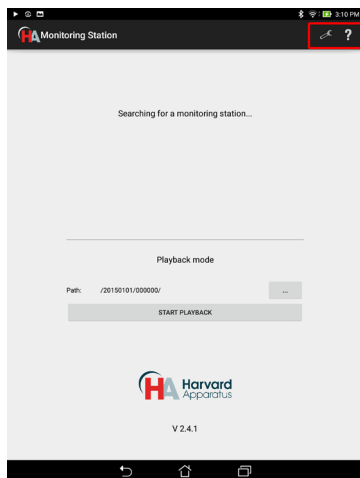


Bluetooth® Connection Interface

The first window that appears is a connection interface displaying the message “Searching for a monitoring station...”. This interface window informs the user about the connection status with the monitoring station and the application.

There are two icons in the menu at the top right of the connection interface window. The “Tools” icon (shown as a wrench) accesses a range of user-selectable settings. The “Help” (shown as a question mark) icon links to the User’s Manual saved on the tablet. The “Tools” icon will be reviewed in detail later in this manual.

If connection between the tablet and the platform is successful, a new window quickly and automatically opens. The application is now in Real Time Display & Recording Mode, from which you observe and can save real-time data. **If you have not turned on the Bluetooth® communication module, the application will not advance past the connection interface window.**



Real Time Display & Recording Mode

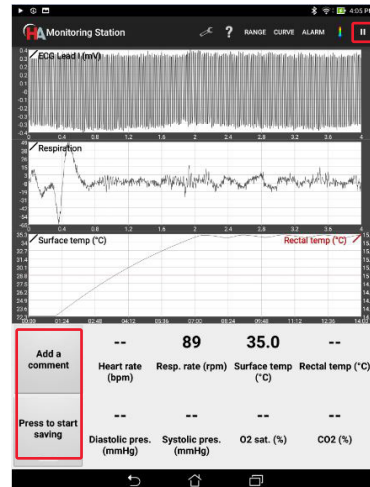
Once the platform and tablet connection is successfully made, the automatically opened window will display physiological data being captured and displayed from the animal positioned on the monitoring platform in real time both in graphic and numeric form.

You have the ability to modify what is being displayed as well as the physiological parameters actually being measured using functions available from the main menu. These are described in detail in the next section.

To save the real-time data being displayed, select “Press to start saving.” You can also “Add a comment” to the data you are saving. Select “Press to start saving” again to stop saving.

Note: Displayed data will not be automatically saved.

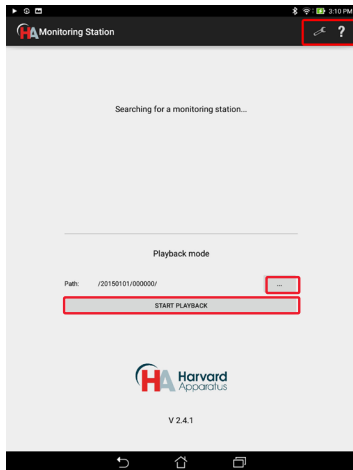
While real-time data is being captured by the application, you can pause the display to view data of interest, save and comment. Restart at any time and data display will continue from the current actual time.



HA Monitoring Station Application

Playback Mode

Playback mode is used to view saved data after selecting a data folder from the “...” dropdown menu and then selecting “START PLAYBACK.” This mode can be accessed from the connecting interface window displayed when you first open the application. **Playback mode only operates when the Bluetooth® communication module is turned off.**

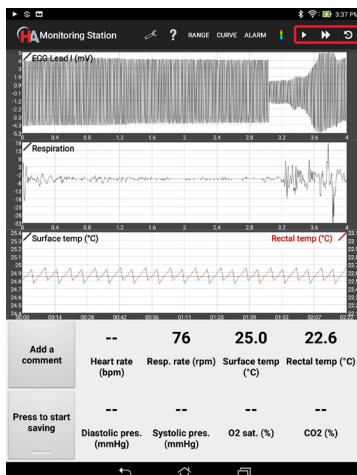


Saved data is displayed in both graphical and numeric form. When the playback loop for the data file you have selected is completed, you will see a message “Playback data completed, looping back to the beginning.”

There are several main menu options available during playback in addition to “Help” and “Tools”. The user can select and adjust playback display options including display ranges (select “RANGE”) and type of curve displayed (select “CURVE”). These are described in more detail in the next section.

The icons on the right side of the menu bar allow you to stop/start playback, advance playback, or rewind playback. These are only available in Playback Mode.

Selected portions of playback data can be saved and comments about observations can be added.

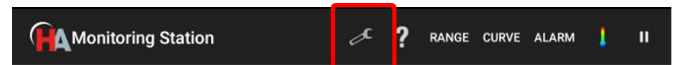


Using the Application

Main Menu

The settings available from the main menu bar in display and playback modes will be discussed in this section.

“Tools” Icon



The “Tools” icon accesses a range of user-selectable measurement parameters and device settings.

The “General settings” change system parameters such as display language and allow updates, such as firmware. All other settings establish the parameters associated with the real-time physiological monitoring and data recording captured from the heated monitoring platform. The parameters that are set remain in use, even for subsequent experiments, until changed by the user.

Note: While data saving is activated, “Advanced settings” within the “Tools” menu cannot be modified for stability considerations and to preserve data integrity.

HA Monitoring Station Application

Tools Menu Settings Options

General settings	
Bluetooth® auto connection	Always selected. Use to disable the Bluetooth automatic connection to current monitoring station, when multiple stations are in the same area.
Monitoring station ID to connect to	If “Bluetooth® auto connection” is disabled, use to select the station ID to connect to.
Reset the monitoring station and software to factory	Not normally done. Closes the software and reset the ‘MonitoringStation’ application to default factory settings.
Firmware update	Updates the firmware of the communication module, the monitoring platform or the Bluetooth® device.
Source path for playback mode	Shows path within the ‘MonitoringStation’ directory.
Enable wider line width	Increases width of graph lines.
Enable high contrast mode	When selected, background of displayed graphs is white. Default is gray.
Reset display	Erases data displayed on the trend graph.
Display language	Monitoring software can be set to either English or French. Application restarts when changed.
Alarm settings	<ul style="list-style-type: none"> • Set low and high limit alarms for heart rate, breathing rate, surface temperature, rectal temperature, SpO₂, CO₂, systolic blood pressure, and diastolic blood pressure. • Set alarm sounds and messages.
Temperature and heater	<ul style="list-style-type: none"> • Set desired and maximum temperature of the monitoring platform. • Set reference temperature as rectal or surface. • Set maximum surface temperature of the monitoring platform.
ECG	<ul style="list-style-type: none"> • Set right leg drive to surface electrodes or external electrodes. • Set heart rate calculation channel (ECG external, Lead I, Lead II or Lead III). • Select mouse or rat electrodes. • Select invert leads for prone or supine animal position. • Select to remove 50/60 Hz in ECG signals. • Set amplifier gain.

Blood pressure	<ul style="list-style-type: none"> • Perform a zero offset calibration and conditions. • Perform a full range calibration and conditions.
SpO ₂	<ul style="list-style-type: none"> • Select to remove high frequency noise in SpO₂ signals. • Select to use ECG to improve saturation calculation. • Advanced settings to set feedback resistor value, feedback capacitor value, stage 2 gain, current (%) in red LED, current (%) in infrared LED.
CO ₂	<ul style="list-style-type: none"> • Perform a nitrogen calibration and conditions. • Set to display CO₂ values in mmHg or %.
Respiration	<ul style="list-style-type: none"> • Set source for respiration signal to central pressure sensor, surface ECG electrodes, or external ECG electrodes. • Select to remove high frequency noise in the respiration signal by applying 25 Hz low-pass filter. • Select to remove drift in respiration signal by applying 2 Hz high-pass filter.
Analog outputs (BNC)	Select BNC connections for ECG leads, SpO ₂ and other measurements.

HA Monitoring Station Application

Screen Contrast/Line Thickness Features

For easier visualization, the background of the graphs can be set to white instead of grey. Simply activate the “Enable high contrast mode” in the “General settings” of the “Tools” menu. The thickness of the graph’s line can also be increased by selecting the “Enable wider line width” option in the “in the General settings” of the “Tools” menu.

“Help” Icon



The “Help” icon links to the User’s Manual.

To return to the prior screen, press the back button when completed.

RANGE Icon



The “RANGE” button allows you to choose the range of the data displayed. It is available in both Recording and Playback Modes.

These settings do not affect the data that are being displayed or that are being saved; they are simply display features. If you change them, the tablet remembers those settings for the next time you open the application.

The range of the signals displayed is automatically set to default settings.

For ECG, respiration, blood pressure, heart rate, respiration rate, temperatures and CO₂, the “RANGE” menu offers the possibility to set display limits manually and avoid automatic rescaling.

To return to the prior screen, press the back button when completed.

CURVE Icon



The “CURVE” button allows you to choose the type of data displayed. It is available in both Recording and Playback Modes.

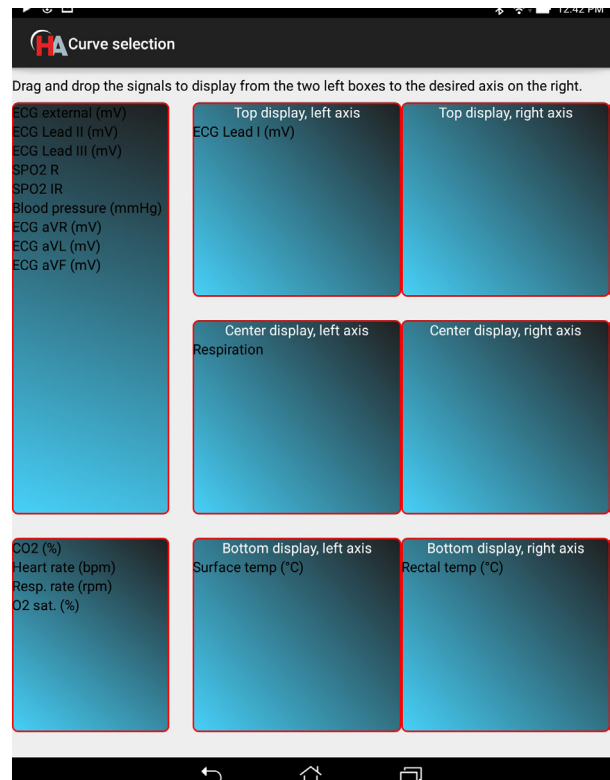
These settings do not affect the data that are being recorded or that have been saved; they are simply display features. If you change them, the tablet remembers those settings for the next time you open the application.

To select which signals are displayed on the graphs, select “CURVE” from the main menu. Each of the three graphs can display up to four different signals each: two on the left axis and two on the right axis. The bottom graph displays low frequency signals and the two others are for high frequency signals.

Simply drag and drop the parameters from the left boxes to the desired axis on the right

Note: The currently selected signal must be dragged back to the left selection box before you can drag a different signal to the desired graph and axis.

To return to the prior screen, press the back button when completed.



On the top two graphs, the duration can be adjusted from 1 to 5 seconds, by increments of 1 second.

For the bottom graph, it can be adjusted from 30 seconds to 30 minutes, by increments of 30 seconds.

HA Monitoring Station Application

ALARM Icon



Multiple alarms are available to inform the user when physiological parameters of interest are out of the desired ranges. Alarm settings are accessed from either the “Tools” icon or the “ALARM” button in the main menu and can be set for any of the numeric parameters displayed. Alarms can be modified for both playback and recording modes. If you change any alarm setting the tablet will remember it.

When an alarm is activated, the numeric value of the off-limit parameter, at the bottom of the screen, turns red and blinks as long as its value is abnormal, as shown in the image. A popup window with an alarm warning also appears with a sound alert prompting you to turn off the alarm. To prevent false alarms, fault condition must last at least 10 seconds before alarm activation.



Beeper

In the “Alarm settings” menu, an option enables a beeper sound following either heart or respiration rate. This setting is used when you might not be able to keep an eye on the tablet’s screen (e.g. during surgery or experimentation). With this feature, users can be notified of changes in physiology without looking at the display. The sound on the Android tablet must be on to hear the beeper.

To return to the prior screen, press the back button when completed.

Temperature Icon



Temperature settings can be modified from the “Temperature” icon or within the “Tools” menu, even while data saving is on. Three parameters can be set:

Desired temperature	Set the desired temperature of the monitoring platform in °C.
Reference temperature	Select Rectal or Surface.
Maximum surface temperature	Set the maximum temperature the surface of the monitoring platform can reach in °C.

Note: The temperature settings cannot be changed if the Bluetooth® Communication Module is turned off.

To return to the prior screen, press the back button when completed.

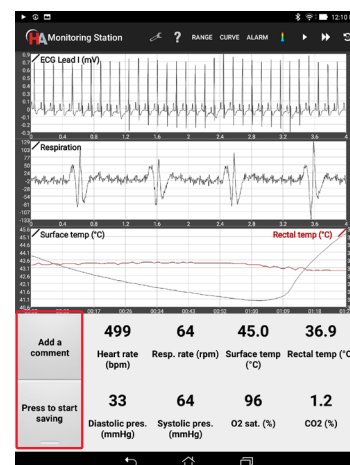
Saving and Adding Comments

In Display or Playback Mode, select “Press to start saving” to save the data. Saving starts immediately indicated by a green bar under the text. When pressed again, a popup will ask you to confirm if you really want to stop saving data. The saving function in the Playback Mode allows you to create a smaller file containing only the section of interest of a much larger recorded file.

One minute of data uses approximately 0.5 MB of memory. Data is saved as a stream, meaning that unexpected shutdowns (e.g., drained battery) will not affect prior acquired data.

Comments can be linked to the saved data file during acquisition. When adding a comment, a new file named comments.txt is created in the results folder. Each comment is preceded by a time marker, in order to refer the comment to the saved data. If a comment is added when saving is not enabled, this comment is added to the previous saved results.

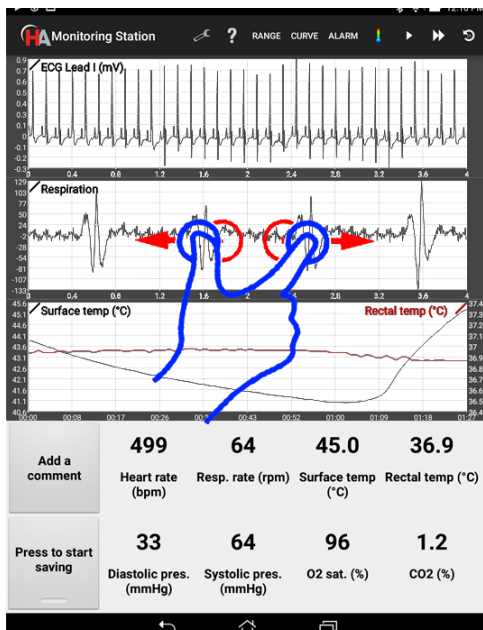
In the dialog window that appears when “Add a comment” has been selected, there will be a list of the last 10 comments added during the acquisition.



HA Monitoring Station Application

Zooming Display

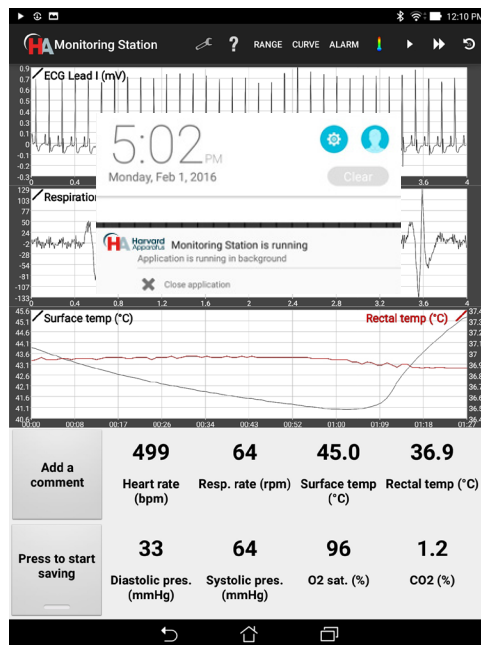
You can zoom in on the displayed signals by pinching on the graphs with two fingers.



Closing the Application

To close the application, press the back button at the bottom of the window. You can also close the application from the notification bar, by swiping down from the top of the screen. The application will automatically be closed if the system is turned off.

Pressing the home button at the bottom of the tablet will put the application in the background and will not close it. This is useful to navigate to other apps, while monitoring an animal and saving data.



Physiological Monitoring & Measurement

Positioning the Animal

After anesthesia induction, place the animal on the monitoring platform with its paws on the metal ECG sensors and make sure to have good contact by covering them with conductive gel. Insert the rectal temperature probe and set the desired temperature from the “Monitoring Station” application’s settings menu.

Taking Physiological Measurements

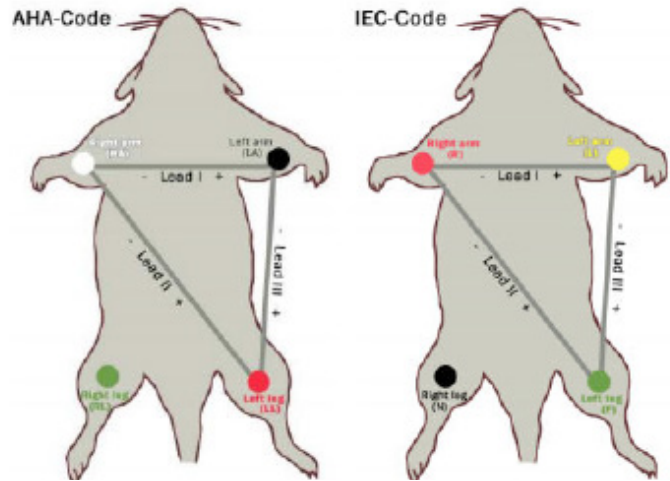
ECG

To improve the signal, place a small amount of the provided conductive gel on each of the surface ECG sensors before positioning the animal; no additional adhesive is necessary, the gel is adequate to ensure a good electrical connection. All four of the animal’s paws must be placed on the corresponding sensor, even if only Lead I (Left Arm – Right Arm) is measured. This is important to ensure that the Right Leg Drive circuit which helps with 50/60 Hz noise reduction works properly.



If the animal is in the supine position, it is strongly urged that external ECG leads be used rather than the surface ECG sensors. The external ECG lead connectors follow the International Electrotechnical Commission (IEC) color coding. To the right is a pictorial and table description of this color coding and how it compares to the American Heart Association (AHA) color coding. The external ECG ports on the platform are 2 mm; adapters are available to 1.5 mm touch proof connectors. External lead electrodes can be ordered separately (73-5019). When the animal is in the supine position it is recommended that the ECG Electrodes Inversion Option be activated in the advanced settings menu, when using surface ECG sensors. The Inversion Option is not necessary for the use of ECG leads. You are responsible for installing the external leads on the proper side of the animal. By turning on this option, hardware switches are activated that ensure that the correct leads are acquired and displayed.

Six main derivations are available (leads I, II & III, aVR, aVL, aVF), as well as external leads. Right Leg Drive (RLD) is activated by default in the settings, to reduce 50/60 Hz noise. When using external leads, RLD should be changed to “External Leads”. RLD can also be turned off, but it would usually add 50/60 Hz noise.



	AHA		IEC	
Right Arm	RA	White	R	Red
Left Arm	LA	Black	L	Yellow
Right Leg	RL	Green	N	Black
Left Leg	LL	Red	F	Green

The ECG gain can also be changed. In the unlikely event where the ECG signal would be saturated and not visible on the screen, the gain can be reduced. The default gain value is 3. The ECG display and saved data represents the value before the amplifier. Thus, the signal amplitude will not change when changing the gain.

An additional cut-band (50/60 Hz, 4th order Butterworth) filter can be applied on all ECG signals before display. It should be enabled when the RLD is not sufficient to reduce the noise. It has no effect on saved data nor heart rate calculation since they use raw data.

The larger platform for rat and mouse includes two sets of surface ECG electrodes – one for adult rat and one for mouse and rat under 20 days old. Select the correct set of electrodes, prior to the beginning of the experiment, in the ECG settings.

Respiration

The respiration sensor is the black diamond on the middle of the device. To work efficiently, it must be placed under the abdomen of the animal.

Two filters are available for the respiration signal before display: a low-pass filter (25 Hz, 4th order Butterworth), and a high-pass filter (2 Hz, 4th order Butterworth). Both filters can be individually disabled, and they have no effect on saved data. It also has no effect on breathing rate, which is computed from raw data.

As an alternative to the respiration sensor, the respiration waveform can be derived from the ECG leads (both internal and external) by selecting the desired option in the respiratory settings. ECG derived respiration is useful during a surgery when the sensor detects noise originating from the surgical procedure.

Physiological Monitoring & Measurement

Temperature

The rectal probe should be inserted in the rectum of the animal so that the metal part is completely inside it. A lubricant is recommended to ease the insertion. Also, for better stability, the probe's cable should be taped to the platform.



For long experiments, it is recommended to cover the animal with a few gauze pads to keep the temperature stable across its body.

The temperature of the heating platform can be controlled in two different modes:

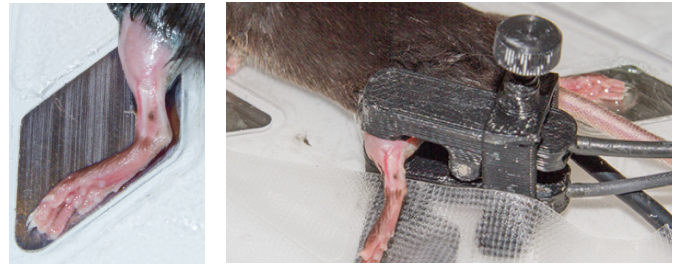
1. A target surface temperature is set, which will fix the temperature of the surface of the platform.
2. A target rectal temperature is set, and the platform temperature will be automatically controlled. Note that in this mode, if the rectal temperature is under 28°C, the system will consider that there is no animal on the platform and the surface temperature will be fixed to 35°C. The controller will maintain the rectal temperature within a tolerance of $\pm 0.1^\circ\text{C}$.

In all modes, the surface temperature is limited to 45°C.

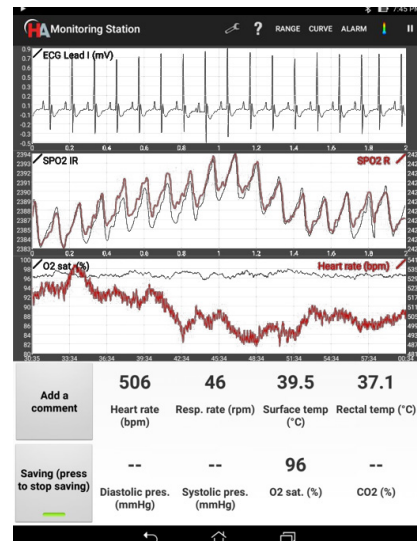
Oxygen Saturation

Oxygen saturation measurement is one of the options available on the monitoring platform. A sensor clip with an optical source-detector pair is supplied.

It is recommended to place the sensor on the left hind leg of the animal. Prior to placement of the sensor, the animal's leg should be carefully shaved so that any fur in the area of contact with the sensor is removed. The clip should be taped to the platform to avoid movement artifacts in the signal. In the same way, the force applied on the spring (through the adjustment of the screw) should be sufficient to stop any leg movements without blocking blood circulation. ECG acquisition of Lead I will continue to work even if the left paw is not on the sensor.



To make sure that the clip is installed properly, display ECG Lead I, SpO₂ IR (infrared) and SpO₂ R (red) on the graphs (as shown on the screenshot below). The DC amplitude of the SpO₂ signals should be between 1,000 and 10,000 with the default parameters. The AC amplitude should be 2 or more.



A low-pass filter (45 Hz, 4th order Butterworth) is applied by default on the SpO₂ signals before display. It can be disabled and has no effect on saved data. It also has no effect on oxygen saturation calculation, which is computed from raw data. Multiple parameters are available in the settings to change gains, filters and LED amplitudes. These parameters should only be modified by experienced users.

Physiological Monitoring & Measurement

Blood Pressure

Blood Pressure measurement is one of the options available on the monitoring platform. A bridge amplifier is built into the platform and the connector is a Redel 5-pin, used on Millar bridge amplifiers. A pressure transducer is not included with this option and must be purchased separately. The APT300 Blood Pressure Transducer is available with the appropriate connector to the interface with the system (73-4905). Alternatively, adapters are available for DIN 8-pin connectors (used on ADInstruments bridge amplifiers) and for Millar's Low Profile (used on Millar catheters).

Blood pressure catheters can have a zero offset of up to ± 50 mmHg. For this reason, it is recommended to perform a calibration each time the catheter is changed by placing it at room pressure. An option is available in the advanced settings for calibration.

Exhaled CO₂

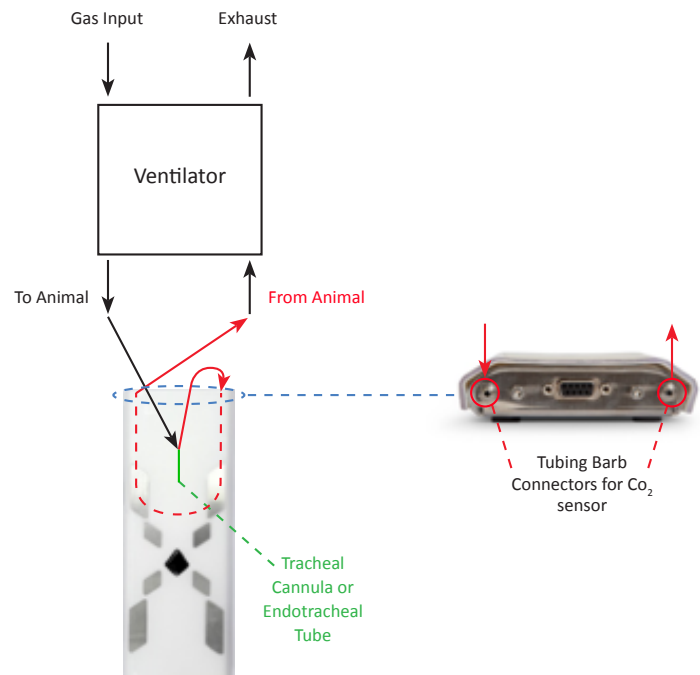
Exhaled CO₂ measurement is one of the options available on the physiological monitoring platform.

If this option is added on after the initial purchase of the system, the system must be returned for the sensor to be installed inside the platform.

To measure the exhaled CO₂, an external ventilator must be used. The ventilator must be connected in series with the CO₂ module. The exhaled gas from the animal must be connected to the 1/8-in input port of the CO₂ module on the platform, which is the one on the right side of the animal. The other 1/8-in port, on the left side, must be connected to the ventilator.

The CO₂ module is factory calibrated. However, a manual calibration can be performed in the advanced settings. To do so, supply a flow of 10 mL/min of nitrogen to the sensor and activate the calibration option. It is recommended to do a manual calibration every year to get the most accurate CO₂ level

The CO₂ measurement can be displayed in either percentage or mmHg, as selected in the CO₂ setting.



Head Fixation Option

Four mouse head fixation kits are available for the monitoring platforms; two for the mouse platform (75-1540 and 75-1541) and two for the rat platform (75-1542 and 75-1543). Each kit includes ear bars and either a gas anesthesia mask or a nose clamp.

The options that fit on the rat and mouse platform are for use with mouse only. The head fixation device is fixed to the platform with M3 screws and it can be easily removed depending on the application.

Other accessories can be used with the head fixation device, such as jaw holders and Bain tube holder. Contact Technical Service for information about additional accessories.



Data Transfer and Analysis

Transfer Saved Data

To transfer saved data to a computer, connect the Android tablet to the computer using a USB cable. A pop-up window will appear: “Use USB for File Transfer?”. Select “Yes” to activate file transfer.

On the computer, navigate to the tablet storage. Browse to the Monitoring Station repository to the “MonitoringStation” folder. In this folder, there will be multiple folders named with the date: YYMMDD. In this sub-folder, folders are named with the starting time: HHMMSS. It contains all the saved data in binary format. Copy and paste the desired folders onto the computer. By default, the folder 20150101 contains the demo data.

If an external SD card is present, data is automatically saved to it. The following table shows information about each saved file.

ECG data is in μV . ECG lead III can be obtained by subtracting lead I from lead II. Respiration varies from -512 to 511. Temperatures can be converted to $^{\circ}\text{C}$ by dividing by 100. Blood pressure can be converted to mmHg by dividing by 100. Exhaled CO_2 can be converted to % by dividing by 1000, or in ppm by multiplying by 10.

Scripts and Conversion Tool

Scripts are available to load, analyze and display all the saved signals in Excel[®] and MATLAB[®]. A cross-platform Java program (Windows[®], Mac[®] and Linux[®]) is also provided to automatically convert the saved files into a LabChart binary file (.adibin) or .csv files. These are in the “MonitoringStation/Admin” folder.

Excel[®] Script

The Excel[®] script will load binary files saved, on the tablet, into separate worksheets of an Excel[®] document. Data can then easily be exported in .csv or displayed on a graph. A simple display code is also provided.

Open the Excel script named ‘LoadBinaries.xlsm’. If prompted, activate macros. The script has 2 main sheets. The first is to display 1 signal on a graph and the second is to display 2 signals on the same graph. The other sheets will contain the loaded data. Click on ‘Load results...’ and navigate to the folder containing a set of data.

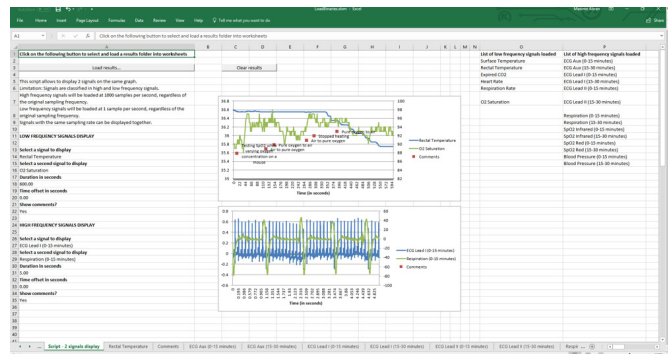
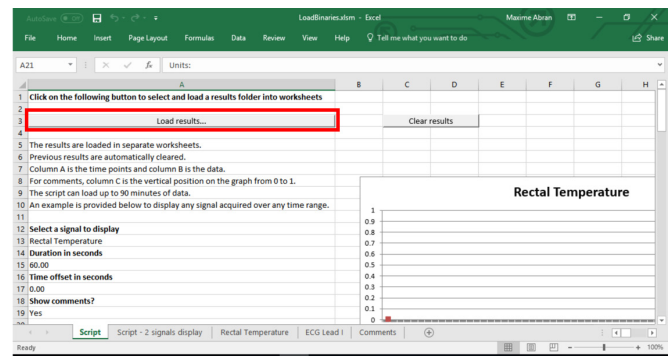
Data will automatically be loaded in the appropriate sheet. Please be patient, as it may take up to 1 minute for large sets of data. Don’t click anywhere during the process.

Data loaded in one of the two Excel sheets can only be displayed in that sheet. In the column ‘A’ of ‘Script sheet’ the user can select the signals to display, the duration and the time offset.

For the signals display the ‘Script- 2 signals display’ sheet, data is divided in low and high frequency signals, each with their display.

An option allows displaying comments added by the user on the Excel graph.

File name (.bin)	Corresponding data	Data format	Sampling frequency
ECGAux	ECG external leads (μV)	Int16	1000 Hz
ECGLeadI	ECG LA-RA (Lead I) (μV)	Int16	1000 Hz
ECGLeadII	ECG LL-RA (Lead II) (μV)	Int16	1000 Hz
Respiration	Respiration	Int16	250 Hz
SpO ₂ Infrared	SpO ₂ Infrared	Int32	250 Hz
SpO ₂ Red	SpO ₂ Red	Int32	250 Hz
BloodPressure	Blood pressure (1/100th mmHg)	Int16	250 Hz
CO ₂	Exhaled CO ₂ (1/1000th %)	Int16	1 Hz
SurfaceTemperature	Surface temperature (1/100th $^{\circ}\text{C}$)	Int16	10 Hz
RectalTemperature	Rectal temperature (1/100th $^{\circ}\text{C}$)	Int16	10 Hz
RespirationRate	Calculated breathing rate (BPM)	Int16	1 Hz
HeartRate	Calculated heart rate (BPM)	Int16	1 Hz
SpO ₂	Calculated saturation (1/10th %)	Int16	1 Hz



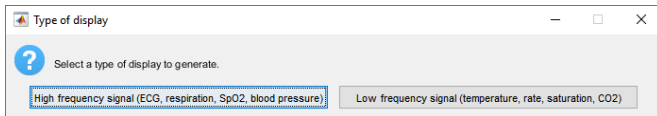
Data Transfer and Analysis

MATLAB® Script

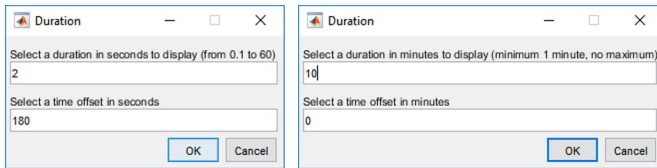
MATLAB® is a powerful and flexible mathematical tool that can analyze complex waveforms. The provided script will load binary files in a MATLAB® workspace and will display signals chosen by the user.

Open and load the script 'LoadBinaries.m'. A popup will appear. Navigate to the folder containing the data and click on 'Select Folder'.

Select which type of display to generate.



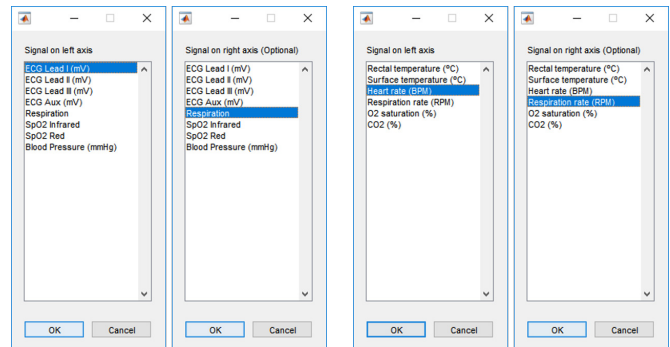
Select the duration and the offset of the display.



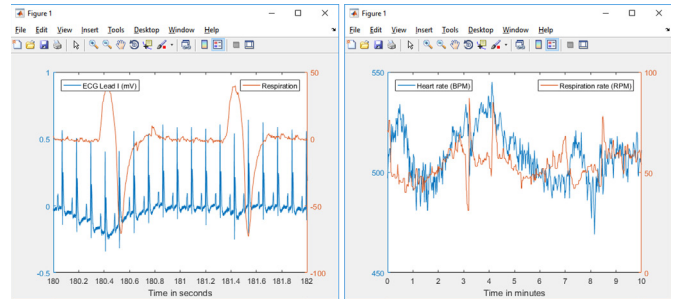
High Frequency Signal

Low Frequency Signal

Select the signal on the left axis, then the one on the right axis (or click 'Cancel' to display only one signal).



A MATLAB® figure will be generated.



High Frequency Signal

Low Frequency Signal

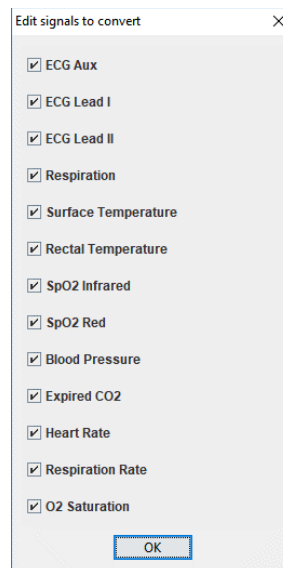
Data Transfer and Analysis

LabChart and .csv Conversion Tool

A cross-platform Java program (Windows®, Mac® and Linux®) is also provided to automatically convert the saved files into a LabChart binary file (.adibin) or .csv files. Java must be installed on the computer.

Open the tool named 'BinaryConverter.jar'. Select either .csv or .adibin. Click on 'Select signals' a pop-up window will appear; uncheck any unacquired signals and click ok.

On the next window click on 'Open...'. and navigate to the folder containing a set of data A '.adibin' file or a 'csv' folder with .csv files will be generated.

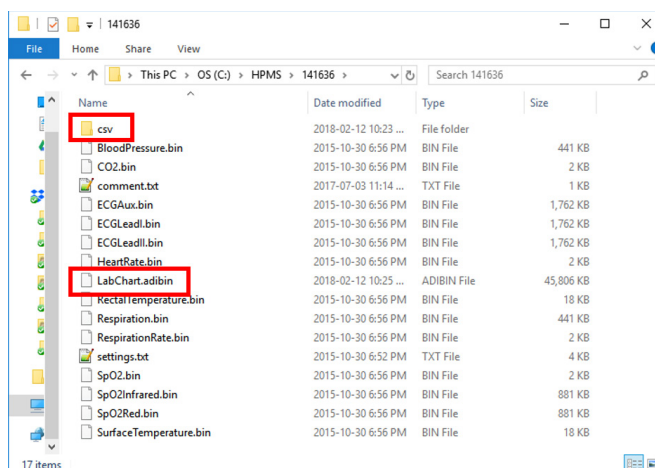


Multiple conversions can be done by clicking on 'Batch Open...' and selecting a repository containing multiple saved acquisitions.

On average, data will use 4 MB/minute for csv conversion and 3 MB/minute for LabChart conversion. An option is available to select certain signals to convert, in order to reduce file size.

When all the signals are selected, the conversion is limited to 3.5 hours of data. Note that Excel® will not be able to load very large .csv files with more than 1 million lines (for example, when loading raw ECG signals of more than 17 minutes). In these situations, use the provided Excel® script.

Contact Technical Service for more information.



Cleaning and Troubleshooting Guide

Cleaning the Device

The platform's surface and the rectal probe can be cleaned with alcohol-based solutions, such as ethanol and isopropanol, and peroxide solutions.

The system is not watertight but is splash proof. Avoid spilling liquids on the side of the platform as it could leak inside.

The communication module, the cables, the oxygen saturation sensors can be cleaned with warm water and a small amount of light detergent.

Troubleshooting Guide

ECG signal is weak	<p>The most common reason for this problem is that there is not enough conductive gel between the paws and the pads of the platform. The gel can dry out during long experiments, so it is recommended to use more gel.</p> <p>Even if only Lead I is measured, it is important to connect all the paws of the animal to the platform, because the Right Leg Drive circuit that helps reduce 50/60 Hz noise will not work properly.</p>
Respiration signal is weak	<p>The sensor on the platform must be placed under the abdomen of the animal for better results. If it is placed under the rib cage, the sensor might also detect the heartbeat.</p>
The tablet is not connecting to the system	<p>Each system has an ID, which is written on top of the communication module. Make sure that the tablet is searching for that ID when trying to connect. If not, change it in Settings — General.</p> <p>If the problem is still present, make sure the system is powered on. There should be a green LED on the communication module. Check that the cable between the communication module and the platform is connected and screwed in.</p> <p>If this problem occurs after a software update or with a new tablet, the Bluetooth® device needs to be paired. On some devices, a “Smart Lock” notification will appear asking to add the Bluetooth® device as a trusted device. Simply confirm this request. Pairing can also be performed from the Android's Bluetooth® settings. Note that pairing sometimes cannot be done while another Bluetooth® device is connected to the monitoring system</p>
The system is not powering	<p>Make sure you are using the correct power supply. A protection circuit is present on the system. If the detected supply is not between 11V and 14V, the system will not start.</p>
The tablet is not recognized by the computer	<p>On the tablet, go in Settings __ Storage, touch the Menu icon and then choose MTP connection. Also, make sure that the tablet is not in USB debugging mode (an icon would appear in the notification bar when the tablet is connected to a computer).</p> <p>If you are using a Mac, you will need to install Android File Transfer.</p> <p>If you are using Windows XP or Linux, ask technical services for assistance.</p>
There is 50/60 Hz noise in the signals	<p>Using a power bar or an extension cable has been found to increase the background noise in critical signals, such as ECG, SpO₂ and blood pressure. Try connecting the system directly in the wall. Make sure the outlet has three prongs, with an earth ground connection. Also make sure you are using the provided power supply.</p> <p>For noise in the ECG signal, make sure that the option Right Leg Drive is activated in the Settings.</p>

Ordering Information

Order #	Product
System and Options	
75-1500 ¹	Physiological Monitoring System for Mouse (10 g to 100 g)
75-1501 ¹	Physiological Monitoring System for Mouse & Rat (10 g to 600 g)
75-1502 ²	Blood Pressure Option
75-1503	End Tidal CO ₂ Option
75-1504	SpO ₂ Option
Accessories	
73-4905	APT3000 Pressure Transducer for Physiological Monitoring System
73-5019	Needle Electrodes, 29 gauge, shielded, 2 mm pin connector, 30 mm length, red, yellow and black
75-1539	Anesthesia Bain Circuit Holder
75-1540	Head Fixation Device with Gas Anesthesia Mask for 75-1500 Platform
75-1541	Head Fixation Device with Nose Cone for 75-1500 Platform
75-1542	Head Fixation Device with Gas Anesthesia Mask for 75-1501 Platform
75-1543	Head Fixation Device with Nose Cone for 75-1501 Platform
75-1552	Blood Pressure Adapter to DIN-8

¹ At the end of the part number add EU for Europe, UK for United Kingdom and CN for China versions.

² Blood pressure transducer needs to be purchased separately.



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