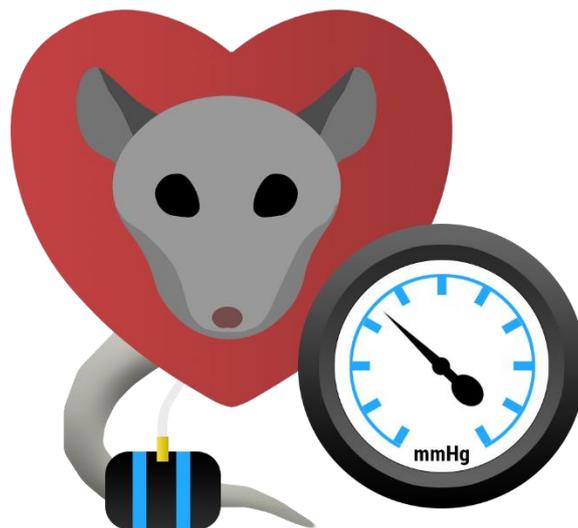


Systole



Moscow, 2021

Before getting started

This document is an operation and maintenance manual for the "Systole" rodent tail systolic pressure research complex.

We recommend that you carefully read and understand this manual before using the product. This manual contains detailed information and instructions necessary for the proper and safe operation of the product.

Due to continuous product improvement, specifications are subject to change without notice.

Please inform the manufacturer of any errors or malfunctions you have encountered while using our products.

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Table of contents

Before getting started	1
Contacts	1
Table of contents	2
Intended use	4
Specifications.....	4
Device composition	5
Preparing the device for the operation.....	7
Preparation for blood pressure measurement on animals.....	8
Performing pressure measurements	9
Manual edit of pressure marks.....	11
Service procedures.....	12
Operating, safety and storage requirements.....	15

Intended use

The “Systole” is a non-invasive blood pressure measurement system intended for use with rats or mice. The system uses a built-in electric air pump to pressurize the tail cuff until blood flow pulsations stop. While slowly reducing the pressure the system subsequently performs an automatic measurement of systolic pressure and calculates diastolic pressure based on the readings of an infrared pulse sensor worn on the tail of the animal following the cuff.

Specifications

Maximum pressure in the cuff	up to 300 mmHg (programmable)
Pressure measurement error	up to 3 mmHg (1% of range)
Types of cuffs	tail Ø5-10 mm (rats) tail Ø3-6 mm (mice)
Pulse sensor	Infrared
Pulse rate	40- 600 bpm
Measuring cycle time	30-50 s (depends on the pressure measuring range)
Start/stop control	Software "Start/Stop" button
Data logging frequency	1000 Hz
Supported OS	Windows 10
Connection interface	USB 2.0
Power interface	USB (+5V, 400 mA)
Dimensions	190 x 100 x 40 mm
Weight	350 g
Warranty period	1 year

Device composition

Main unit

The front panel of the main unit contains the following elements (listed from left to right): Ø3 mm quick coupling for pressure cuff tube, 3.5 mm connector for infrared pulse sensor, LED indicator, control button



The rear part of the main unit contains the following elements (listed left to right): USB cable connector, Ø4 mm quick coupling for device calibration and test.

Pressure cuff

The pressure cuff is designed to compress the vessels in the animal's tail.

During pressure measurement the air is rapidly inflated and slowly deflated, allowing the systolic and diastolic pressures to be determined by means of the IR pulse sensor. The pressure cuff consists of a main part, 2 side inserts, a latex diaphragm and a Ø3 mm transparent tube (1 meter long) for connection to the main unit.



Infrared pulse sensor

The infrared pulse sensor (IR sensor) is designed to measure the amplitude of the photoplethysmogram when measuring the blood pressure.

It consists of a housing with a changeable silicone insert to fit the required diameter of the rat's (mouse's) tail and a 1-meter long cable.

The IR pulse sensor is plugged into the connector on the front panel of the device. The pressure measurement function is not available unless the sensor is connected.



Preparing the device for the operation

WARNING: The device is equipped with quick-release couplings for a $\varnothing 3$ mm transparent cuff tube at the front panel and a special $\varnothing 4$ mm plug at the rear. The tube or the plug should be inserted by about 1 cm inside the coupling. Please note that you might have to apply a slight additional force to do that.

To disconnect (remove) the tube (or plug), press the ring on the end of the quick-release coupling and gently pull the tube (plug).

Do not apply excessive force when pulling out. In case the tube (plug) seems to be stuck check if the ring on the quick-release coupling is pressed all the way in.

1) Assemble the pressure cuff and the pulse sensor. To do this, insert the cuff into the fitting on the pulse sensor as shown in the figure.

2) Insert the 3.5 mm plug of the pulse sensor into the coupling on the front panel of the device.

3) Insert the 3 mm transparent pressure cuff tubing into the quick-release coupling on the front panel of the device.

4) Connect the USB cable to the device and the computer.



Preparation for blood pressure measurement in animals

1) Place the animal in a restraining container

This is only necessary for conscious animals. Place the animal in the restraining container and adjust the stopper on the front to restrict the animal's forward and backward movements. The container should prevent the animal from rotating around its axis. The animal's tail should protrude freely out of the slot on the rear latch of the container.

2) Remove external stimuli

Abrupt movements and loud noises should be limited as much as possible, as they cause animals to move during pressure measurement. Sometimes covering the top of the restraining container with a cloth helps to reduce exposure to external stimuli.

3) Position the sensor

The pressure cuff should be placed on the proximal end of the tail, with the pulse sensor right behind it. Sometimes the pressure cuff cannot completely compress the tail vessels. In such case move the pressure cuff with the pulse sensor a few millimeters along the tail.

4) Ensure that there are no mechanical vibrations

The IR sensor used to measure the pulse is a highly-sensitive device and might respond to any movement of the animal's tail relative to the sensor due to mechanical vibrations.

5) Preheat the animal

Warming of rats and mice is necessary to perform pressure measurements. Warming ensures stable (with the necessary volume) blood circulation in the tail. Normally the animals should be pre-warmed up to 28-32 °C for 10-15 minutes. The temperature should also be maintained during the whole pressure measurement process.

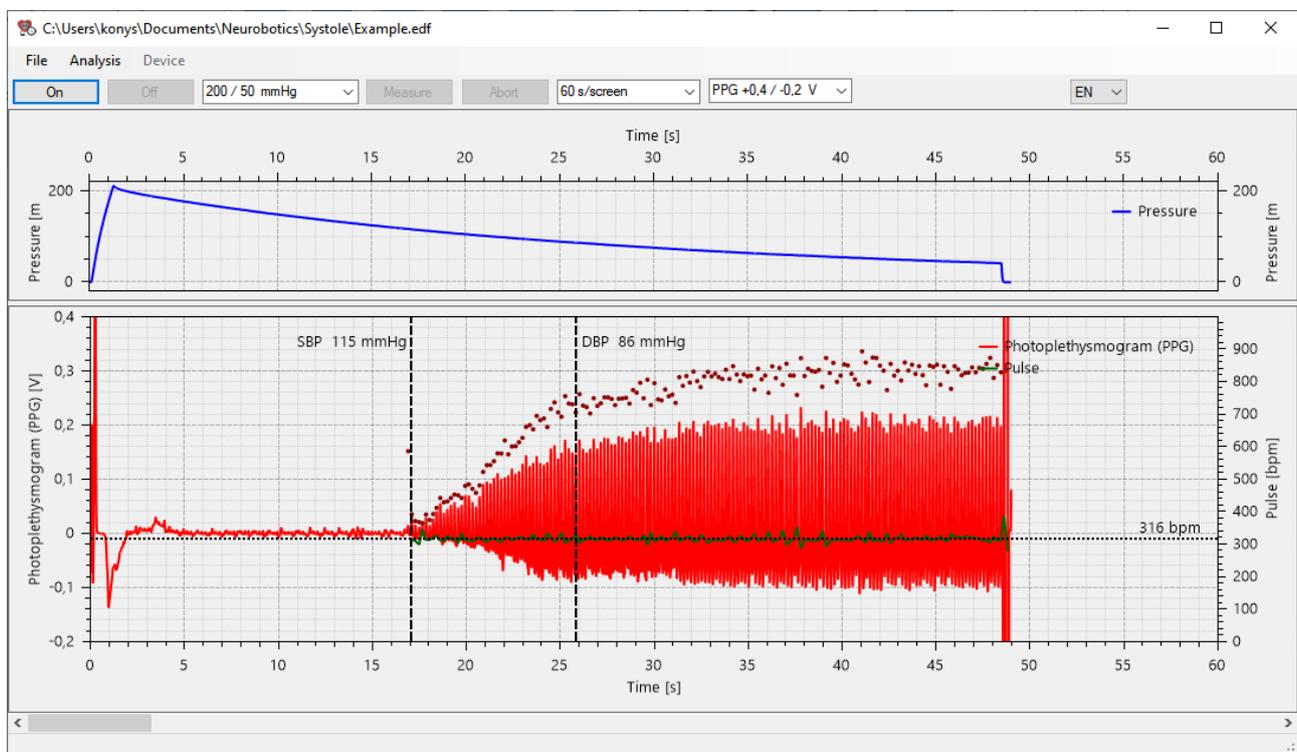
6) Animal acclimatization

Most animals require some preparation and careful handling to get used to the restraining container, long-term heating and subsequent pressure measurement to allow you to obtain reproducible results. Unlike mice, rats are easier to get used to. Several full cycles of training may be required for the animal to become accustomed. Despite all the measures taken, some pressure measurements may be unreliable due to the animal's body and/or animal's tail movements.

Performing pressure measurements

Launch the *Systole* software and press the *Enable* button to display the pressure curves and photoplethysmographs obtained from the device.

Press the *Measurement* button and the device will rapidly inflate the cuff to the pre-selected pressure. The cuff will compress the vessels in the animal's tail so that the pulse will not be observed on the photoplethysmogram (in this case the only signal observed are the sensor's noise and tail movement artifacts).



Thereon the pressured air in the cuff will start to slowly drain through a special valve inside the device. Once the pressure in the cuff equals the systolic pressure

pulsations become observed on the photoplethysmograph. The amplitude of the pulsations increases as the pressure in the cuff decreases.

The registration finishes automatically once the pressure reaches the minimum value set. Save the data to a file using the *dialog box*.

The photoplethysmogram analysis automatically starts searching for the systolic and diastolic pressure values shown as vertical marks (SBP and DBP respectively). The key value of the SBP is determined as the first pulsations coordinate, whereas for the DBP the key value is determined as the coordinate where the pulse amplitude stops rapidly increasing as the pressure in the cuff decreases (i.e. the amplitude increases rapidly to the left of this point and increases slowly or slightly decreases to the right of the point).

Manual edit of pressure marks

The user is allowed to manually edit SBP and DBP marks to achieve a more accurate determination of systolic and diastolic pressures.

Open the record file by clicking *File -> Open*.

Move the mouse pointer to the random place at the vertical marker and do a left-click. Hold down the left mouse button and move the mark horizontally to a more appropriate location:

- for the SBP – the onset of pulsations on the photoplethysmogram during the pressure release in the cuff;
- for the DBP – the endpoint of the most rapid increase in the amplitude of photoplethysmogram pulsations.

Use the dark red dots displayed above the curve to facilitate the visual detection of photoplethysmogram pulsation amplitude – these dots correspond to the moments of blood flow pulsations.

We recommend being guided by the lower boundary of the pulse curve to determine diastolic pressure. As compared to the upper boundary, it is better to see the moment of pulsation amplitude increase cessation.

Attention: once you have manually edited the marks, it is necessary to save the file. To do this, click *File -> Record*. Click the *Save* button in the *dialog box*.

Service procedures

Tightness check of the cuff and internal parts of the device

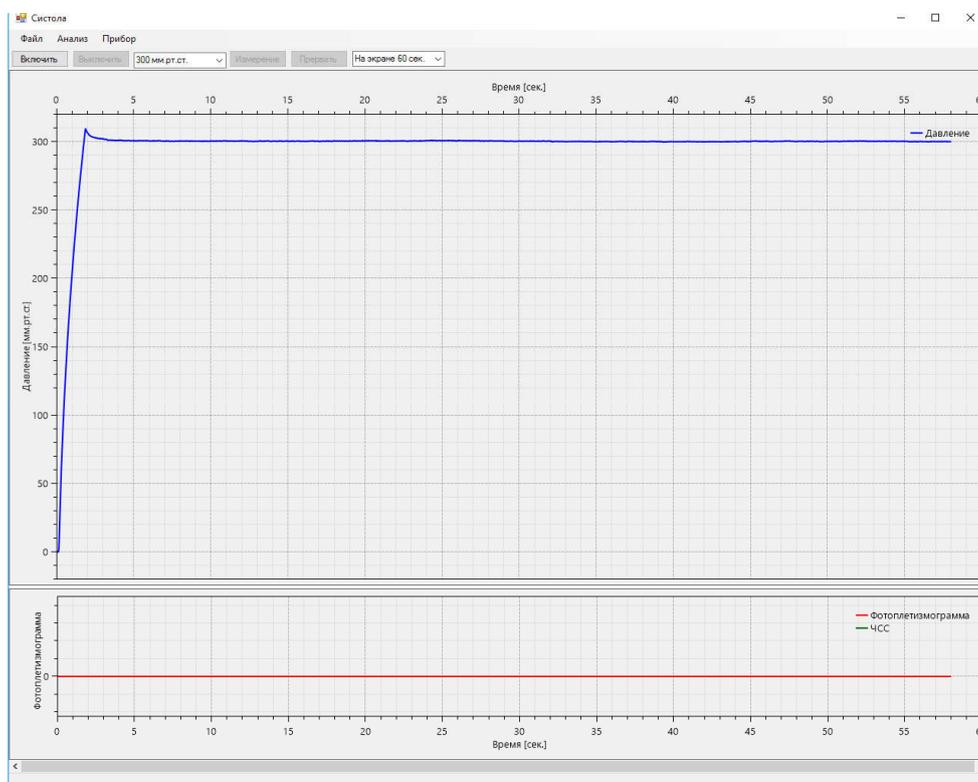
Note: Insert a special 4-mm plug (included in the accessory kit) 1-1.5 cm into the quick-release fitting located on the rear panel of the Systole.

Insert the 3 mm transparent tube of the pressure cuff into the quick-release coupling on the front of the device. Insert a thin and round object (such as a pen or pencil) inside the pressure cuff. Note that the object should not contain any sharp parts to avoid damaging the diaphragm.

Start the *Systole* software, switch on the recording by pressing the *ON* button. Perform test inflation to 200 or 300 mmHg by pressing the *Measure* button. The pressure curve should not decrease in a common way (at a rate of 3-6 mmHg per second) and the pressure should decrease very slightly (due to small leaks inside the device). The typical value is less than 4-5 mmHg per 40-50 seconds, i.e. not more than 0.1 mmHg (0.013 kPa) per second.

Otherwise, make sure you have inserted the plug into the fitting on the rear side of the device and check if you have inserted the 3mm clear tube all the way into the device and into the cuff.

Note: once finished, remove the 4-mm plug from the quick-release fitting on the back of the Systole.



Replacing the latex diaphragm of the cuff

A latex cuff membrane might need to be replaced in case it is leaking due to damage or normal wear and tear.

Pressure cuff consists of the main part, 2 side inserts, latex diaphragm and the 1 m long 3 mm transparent tube for connection to the main unit.



1. Remove the 2 side inserts from the cuff. You may need to apply some force to do that. If necessary, use a thin object of some kind for removal.
2. Remove the latex membrane from the main part
3. Prepare a spare latex membrane for replacement
4. Insert the spare latex membrane inside the main part. Then, slide the edges of the diaphragm onto the main part while turning the membrane outward
5. Make sure that no folds were formed on the membrane inside the main part. The inner part should stay flat and loose enough – it should not be stretched out.
6. Place the side inserts into the main part by clamping them to the latex membrane. The inserts have to be inserted tightly, so a certain amount of force must be applied.
7. The side inserts must be pressed all the way into the main body.
8. Check the tightness of the re-assembled cuff

Replacing the silicone insert of the heart rate sensor

Replacement of the silicone insert of the heart rate sensor may be required to adjust the sensor according to the different diameters of the animals' tails. The device supplied with 3 inserts of different sizes for rats – 6, 8 and 10 mm (the 8 mm one is installed by the manufacturer) and 2 inserts for mice – 3 and 5 mm (the 5 mm one is installed by the manufacturer).



1. Disconnect the pressure cuff from the housing on the heart rate sensor
2. Remove the manufacturer's insert by pulling it up out of the sensor and gripping it along the sensor axis
3. Note: The silicone insert has holes for the infrared sensor on its side (besides the tail holes mentioned before). These holes are $\text{Ø}5$ mm for rats and $\text{Ø}3$ mm for mice respectively. Place the inserts with these holes to the side (the holes should be placed opposite to the IR receiver and transmitter) on the pulse sensor
4. The tail holes must be positioned along the sensor axis
5. The insert should be pressed between the positioning notches as shown on the picture to the left
6. Gently install the silicone insert of the desired hole size (the insert slides in with slight friction). It must be plugged all the way down so that the top edge of the insert becomes aligned with the top of the housing

Operating, safety and storage requirements

Do not use the product under conditions of high relative humidity (over 80%), in water or in the rain. Do not allow moisture to enter the interior of the product.

Forbidden to use the device for purposes other than those for which it is intended, in violation of the rules and conditions of use.

Operating environment

After storage in a cold place (less than +5°C) and after transportation at negative temperatures the product should be kept unpacked for several hours at $\geq +10^{\circ}\text{C}$ to avoid condensation inside the product. Operate at +5°C to +40°C and relative humidity of no more than 80%.

Do not use in conditions of precipitation, condensation, salt spray and ozone, in direct sunlight, in explosive environments, in environments with conductive dust, corrosive gases and vapors, and other conditions that do not provide adequate protection against adverse effects.

Transportation

It is allowed to carry the product by any means of transport, except for non-heated compartments of aircraft and sea transport.

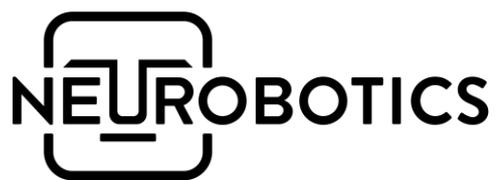
Storage

Store indoors in the transport package of the manufacturer in the warehouses of the supplier and the consumer, except for warehouses of railway stations, at +5°C to +40°C and relative humidity of no more than 80%.

Recycling

Do not dispose with other household waste. The device should be disposed separately from other waste and properly recycled for reuse to avoid harm to the environment or human health from uncontrolled waste disposal.

For more detailed information on disposal of this product in an environmentally friendly manner contact either the retailer or manufacturer of the product.



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